

## I-ReWater:

# Gestión sostenible de los recursos hídricos en la agricultura de regadío en el espacio SUDOE

## E 1.4.1. Analysis of Strategies/Policies for the Use of Reclaimed Water - SUDOE

### Technical Report

April 2025



This study has been carried out within the framework of the project Interreg-Sudoe: I-ReWater, headed by AMB (Área Metropolitana de Barcelona), with the participation of the following partners: USC (Universidad de Santiago de Compostela), ADN (Águas do Norte), INIAV (Instituto Nacional de Investigação Agrária e Veterinária), and INRAE (Institut National de Recherche pour l'Agriculture l'Alimentation et l'Environnement). And the collaboration of the partners: HOPEN (HOPEN – Terre de Houblon), GESTAGUA (Gestión y Técnicas del Agua, SA) and Govern d'Andorra.

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## Synthesis

I-ReWater INTERREG SUDOE project titled: **Sustainable water resources management in irrigated agriculture in the SUDOE area**, is fund by European Regional Development Fund (ERDF) in the framework of program INTERREG SUDOE (2021-2027). I-ReWater analyses the current state of water resources in the SUDOE area paying special attention to the use of reclaimed water in irrigated agriculture, and its effects on the production and quality of crops, promoting the resilience and security of water supply. In this project a strategic plan (RCO83) at transnational level for the incorporation of reclaimed water for irrigation will be developed (WP 1), which will release conventional water resources, reduce the pressure on the water bodies, improve the quality and water resources availability for other uses (circularity). The design of the strategy is based on the study of available water resources (Activity A1.1), potential demands, the evaluation of the environmental impact of irrigation with reclaimed water using the Life Cycle Analysis (LCA) methodology (Activity A1.2), and the socio-economic analysis (technical, economic, regulatory and political dimensions) (Activity A1.3).

This technical report corresponds to the first deliverable of activity A1.4 called '**Development and implementation of the strategy for the use of reclaimed water in irrigation – SUDOE area**'. Specifically, it consists of a review of international and European policies regarding the use of reclaimed water in agriculture, together with an analysis of strategies at international and European level, and a comprehensive review of legislation from the international to the regional level. The necessary sources of information and the methodology for drafting the report 1.1. 'Strategy to increase the use of reclaimed water in agriculture' are collected, and the interrelations with the rest of activities of WP 1.

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## Chapter 1. Framework. Previous official International and European documents related to water reuse in agriculture

Water reuse regulations and guidelines at European Union (EU) level were missing in the XX century. Despite this lack, a Directive was issued: Urban Wastewater Treatment Directive (91/271/EEC) [1]. This Directive mentions that “treated wastewater (TWW) shall be reused whenever appropriate” and “disposal routes shall minimize the adverse effects on the environment” (Sanz & Gawlik, EC-JRC, 2014) [2]. In the beginning of the XXI century, the EU legislation presented the Water Framework Directive (WFD, 2000/60/EC) [3] to guarantee sufficient quantities and good quality water for the different uses. The WFD included some objectives related to water reuse practices. Over the following years some EU documents were determinant to establish better practices of WW use and contributed to the main EU regulation on minimum requirements for water reuse (Regulation (EU) 2020/741) [4].

It is worth mentioning documents related to groundwater (Directive 2006/118/EC) [5] and soil protection (Thematic strategy COM(2006) 231) [6], the ‘A Blueprint to Safeguard Europe’s Water Resources’ (EC communication-2012) [7], which points to the need to create an instrument to regulate standards at Union level, or the ‘Closing the loop – An EU action plan for the Circular Economy’ (EC communication-2015) [8] involving actions to promote TWW and the development of a legislative proposal on minimum requirements for water reuse. In addition, some international standards such as the ‘Guidelines for the safe use of wastewater in agriculture’ (WHO, 2006) [9], or the “Guidelines for treated wastewater use for irrigation projects” (ISO 16075) [10] shall be mentioned\*<sup>1</sup>.

<sup>1</sup> Note – A Regulation (law, decree, directive) is defined as a mandatory application. A Standard is a reference document approved by a recognized standardization institute (international or national) to define characteristics and rules applicable to voluntary activities, regarding the level of quality, safety, compatibility and acceptable environmental impact of products, services and practices (Lazarova, 2015) [11].

## Chapter 2. Strategies analysis (2005-2024)

### 2.1. International

Water management is a crucial cross-sectional topic in all sectors of sustainability (economic, environmental and social). The development of the agricultural activity, as a relevant part of those sectors, must implement water use solutions with integrated approaches such as the nexus water-energy-food-environment, the impact of water use on a soil-plant-atmosphere system, or the yield-water relationship affected by climate change. Climate change conditions create huge risks to agriculture and forestry practices (e.g. irrigation). In this respect, most scenarios of water use predict an increasing demand for freshwater, whilst its availability is expected to decrease in almost all regions. Water reuse practices, with improved technologies to reduce pollution risks, are an option of water supply, thus contributing to solving freshwater shortage conditions. Consistently, such practices are recognized as adaptation measures to climate change, promoting the availability of water, as well as better sanitary, human health and ecosystems conditions.

The role of research in this scenario includes the improvement of agricultural and water management strategies to tackle the most important constraints and uncertainties observed by stakeholders. The wastewater management shall be part of sectorial and national strategies and research programmes. Technical and scientific documents from international agencies (e.g. EEA, FAO, JRC, UN) are key factors to ensure the adequate implementation of the goals of policies related to non-renewable water resources and agriculture. In agreement with published information, TWW shall be an important water and nutrients source for agriculture farmers, but it is also required to ensure the agroecosystems protection from harmful substances.

Involved with various goals of the ‘2030 Agenda for Sustainable Development by United Nations’ (UNGA, 2015) [1], water management is referred to in several thematic areas, concerning the food production, best agricultural practices, ecosystem services or climate change adaptation, among others. In the scope of this project, the Sustainable Development Goal (SDG)-6 of the 2030 Agenda requires particular attention (Figure 1).



Figure 1. Sustainable Development Goals (<https://www.un.org/sustainabledevelopment>)<sup>2</sup>

The SDG-6 goal comprises several targets to comply until 2030, regarding the improvement of water management and services. In addition, through the UN-Water Integrated Monitoring Initiative for SDG 6 (IMI-SDG6), the United Nations seeks to support countries in monitoring water and sanitation related issues and in compiling data to reports (Figure 2). One should highlight the Sustainable Development Goal (SDG) target 6.3, pointing to the need for a reduction of untreated wastewater discharged into water bodies and an increase of water-use efficiency across all sectors, in seeking solutions to water scarcity issues. It includes an important indicator (6.3.1) to monitor the proportion of wastewater flows safely treated from households, services, industries and agriculture, in compliance with national or local standards (UN-Water, 2017) [2].

<sup>2</sup> The content of this publication has not been approved by the United Nations and does not reflect the views of the United Nations or its officials or Member States.

INDICATORS	CUSTODIANS
6.1.1 Proportion of population using safely managed drinking water services	WHO, UNICEF
6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water	WHO, UNICEF
6.3.1 Proportion of domestic and industrial wastewater flows safely treated	WHO, UN-Habitat, UNSD
6.3.2 Proportion of bodies of water with good ambient water quality	UNEP
6.4.1 Change in water-use efficiency over time	FAO
6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources	FAO
6.5.1 Degree of integrated water resources management	UNEP
6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation	UNECE, UNESCO
6.6.1 Change in the extent of water-related ecosystems over time	UNEP, Ramsar
6.a.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan	WHO, OECD
6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management	WHO, OECD

**Figure 2.** Indicators of UN-Water Integrated Monitoring Initiative for SDG 6 (IMI-SDG6).

Source: UN, 2015 [1]

The XI report of the SDG indicator 6.3.1, concerning the progress on wastewater (WW) treatment, presents a summary of available data on total WW flows generated and treated in 2015, as well as disaggregated analyses on flows from industrial sources in 2015 and households in 2020 (UN Habitat and WHO, 2021, 2024) [3][4]. The household WW analysis is based on data from the UNSD/UNEP and OECD/Eurostat international questionnaires. This report reveals that the development of improved strategies, monitoring programmes and investments, in both centralized (urban) and decentralized WW conveyance and treatment

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systems, are still needed in many countries. Also, the monitoring of WW flows is required to the enforcement of regulation and TWW are a basic support to circular economy, sustainable water resources management and safe WW strategies.

SDG indicator 6.3.1 tracks the percentage of WW flows that are safely treated before discharge or reuse, and are classified into three main categories: (i) total, (ii) industrial, and (iii) households.

Total TWW are only reported and validated in 42 countries and industrial TWW in 60 countries. The analysis of WW generated by households shows that the proportion of flows collected and safely treated in the countries of the project, ranged between 80 and 100% in 2022 (Table 1). For countries of Europe and Northern America the average value of TWW is 87% and globally the TWW reaches 58%, also in 2022.

**Table 1.** Household wastewater generation and treatment. 2020 & 2022

Country or Region or World	Total household wastewater generated (million m <sup>3</sup> )		Total household wastewater collected (million m <sup>3</sup> )		Total household wastewater safely treated (million m <sup>3</sup> )		Proportion of household wastewater safely treated (%)	
	2020	2022	2020	2022	2020	2022	2020	2022
<b>Andorra</b>	23.5	17.2	23.5	17.2	23.5	17.2	100.0	100.0
<b>France</b>	2,839.9	2,774.0	2,627.0	2,583.2	2,627.0	2,582.4	92.5	87.9
<b>Portugal</b>	483.4	470.0	382.6	436.3	355.7	411.3	73.6	87.5
<b>Spain</b>	2,425.0	2,410.0	2,126.2	2,118.1	2,085.9	1,925.7	86.0	79.9
<b>Europe &amp; Northern America</b>	42,769.8	70,003.6	38,826.2	66,342.1	34,405.4	60,535.6	80.4	86.5
<b>World</b>	270,674	267,734	157,340	169,022	150,232	154,729	55.5	57.8

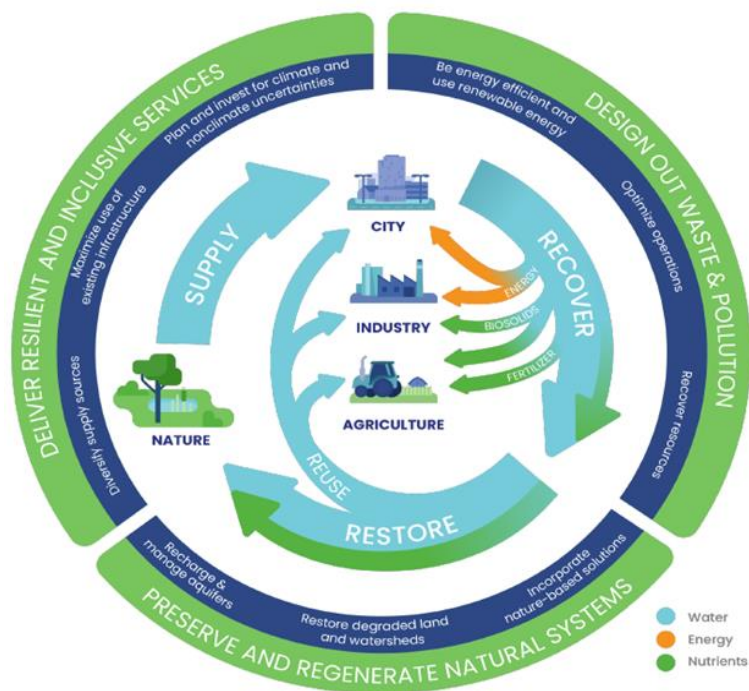
Sources: UN Habitat and WHO, 2021, 2024 [3][4], & Govern Andorra [5]

Regarding the 2030 Agenda goals, safe reuse of WW is also a contribution to the transition to a circular economy (SDG 12), and to solutions to water scarcity induced by climate change (SDG 13).

Circular-based approaches involve the development of products which seek to reduce the use of natural resources and to provide a better use of waste. Those approaches are currently increasing in agricultural activities, with particular focus on the capacity to reduce the use of

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freshwater, thus, benefiting water and nutrients balances, or soil and biodiversity protection. Moreover, there are circular economy principles as a response to the unsustainable model of “take, make, consume, and waste”. This circular approach included in the WICER Framework (Figure 3) shows that the reuse and recycling of materials is an integrated part of the choices made during the production and use phase. In the case of irrigation, water reuse can also establish the recover of nutrients from the TWW to the crops, along the different stages requiring the application of fertilizers. According to the WICER the beneficial use of water, nutrients and energy is associated to the wastewater. Even though such principles are consistent with the best practices of water use, water management strategies are not systematically included in discussions (WICER, 2024) [6].



**Figure 3.** Water in Circular Economy and Resilience (WICER) - Framework. World Bank Initiative. <https://www.worldbank.org/en/topic/water/publication/wicer>

The principles and goals of water reuse are being incorporated into standards documents to facilitate the water market in all sectors. Even though on a voluntary basis, it is recognized this market asks for an inherent link between harmonized classifications of the level of quality, impact and risk of TWW application and the practical conditions of stakeholders (producers

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and users). There are several steps to comply with a standard development related to a specific thematic. A national standardization authority calls various experts (e.g. authorities, consumers, research, business) to form specialized teams. Then, at international level, a secretariat proceeds with the distribution of report reviews among the national delegations until the thematic guidelines are subject to final approval. Examples of standardization processes are ISO (International Organization for Standardization) or CEN (European Committee for Standardization). As an example, the basic principles for development of the ISO Water Reuse Guidelines for Irrigation (ISO 16075) [7], includes:

- 1) a multi-barrier approach (a guidance for water quality, treatment level, irrigation practices and other protection measures);
- 2) a definition of 5 water quality levels (depending on health risks, related to public access, type of irrigated crops, irrigation technologies);
- 3) recommended good practices for safe and beneficial water reuse; and
- 4) additional protection measures to avoid negative impacts on soil, crops, groundwater and surface water (Lazarova, 2015) [8].

In terms of regulations, it must be stressed that the implementation of risk management procedures to local conditions, is a basic component to guarantee the safe use of TWW, ensuring protection of the environment and of human and animal health (Rebelo et al., 2020) [9]. Furthermore, specific risk management options shall be defined according to multi-barrier and fit-for-purpose approaches, and include monitoring control actions.

*'...adopting sustainable agricultural practices can help reduce stress on freshwater supplies, and improving water supply can ensure that everyone has access to vital resources in the future ..... sustainable, affordable, and scalable water solutions must become a priority'*

UN 2023 Water Conference in New York [10].

## 2.2. Europe

Water shortage and droughts are natural phenomena observed in Europe, with higher impact on Mediterranean climate regions. For this reason, irrigation related conditions and how they can be controlled should be assessed according to climate conditions. Consistently, innovative strategies and measures, to overcome water scarcity in the agriculture and forestry sector, must be proposed in European policies, but also regarding geographical and socioeconomical diversification. Several EU policies to promote the sustainability of water use and agriculture in Europe until 2030 are agreed in strategic programmes such as, the European Green Deal (which includes the Farm to Fork and the Circular Economy Action Plan), the Bioeconomy Strategy and the Common Agricultural Policy (Figure 4).

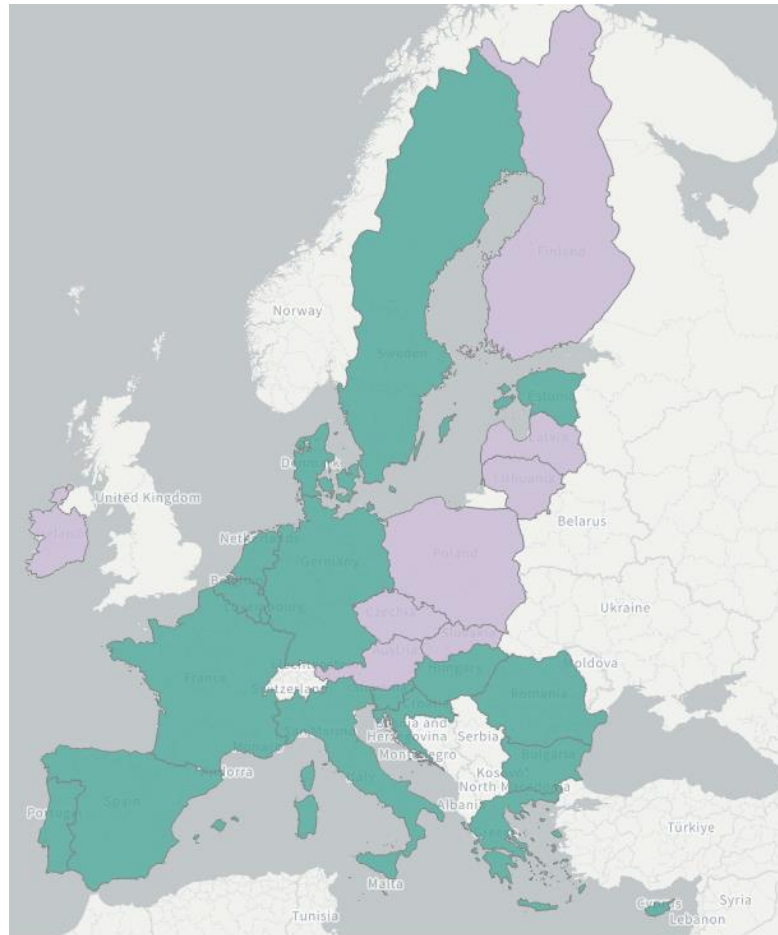


**Figure 4.** Key policy objectives of the CAP 2023-27. <https://agriculture.ec.europa.eu/>

Policies to achieve a reliable water management are establishing innovative procedures based on “circular water management”, especially where main sources of freshwater supply are in danger due to imbalances between availability and exploitation rates or quality degradation. The benefits of these procedures include the increase of water application efficiency and water-saving, a reduction in the use of renewable water resources and in the case of treated TWW, the production of biosolids and bioenergy.

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The Regulation on minimum requirements for water reuse for agricultural irrigation entered into force in May 2020 (Regulation (EU) 2020/741) [11]. The new rules will apply from 26 June 2023 and are expected to stimulate and facilitate water reuse in the EU.



**Figure 5.** Member States where water reuse for agricultural irrigation is allowed (October 2024). <https://environment.ec.europa.eu/topics/water/water-reuse>

More than 40,000 hm<sup>3</sup> of wastewater is treated in the EU every year, but only 2.4% is further treated to use. According to the EU:

*'the purpose of this Regulation is to guarantee that reclaimed water is safe for agricultural irrigation, ensuring a high level of protection of the environment and of human and animal*

*health, promoting the circular economy, supporting adaptation to climate change, and contributing to addressing water...’.*

**REGULATION (EU) 2020/741 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 May 2020 on minimum requirements for water reuse**

Reuse of treated wastewater can be considered a reliable water supply, quite independent from seasonal drought and weather variability and able to cover peaks of water demand. This can be very beneficial to farming activities that can rely on reliable continuity of water supply during the irrigation period, consequently reducing the risk of crop failure and income losses. Appropriate consideration for nutrients in treated wastewater could also reduce the use of additional fertilisers resulting in savings for the environment, farmers and wastewater treatment.

The Regulation sets out:

- Harmonised minimum water quality requirements for the safe reuse of treated urban wastewaters in agricultural irrigation;
- Harmonised minimum monitoring requirements, notably the frequency of monitoring for each quality parameter, and validation monitoring requirements;
- Risk management provisions to assess and address potential additional health risks and possible environmental risks;
- Permitting requirements;
- Provisions on transparency, whereby key information about any water reuse project is made available to the public.

The new rules are to be situated in the context of the "Circular Economy Action Plan" adopted in 2020, which includes the implementation of the new Regulation amongst Europe’s priorities for the circular economy. The Action Plan also announces that the Commission will facilitate water reuse and efficiency in other sectors, including in industrial processes.

### 2.3. Portugal

The reuse of treated wastewater is increasingly important as an alternative source of water and as a relevant contribution to the integrated and efficient management of water resources and increased water resilience in regions in scenarios of increasing scarcity and competition for water demand.

In Portugal, the reuse of treated wastewater has shown low levels (around 1.1%) and lower than the European Union (EU) average values (2.4% at <https://water.europa.eu/freshwater/europe-freshwater/water-reuse>). Although these values cannot be directly compared since the concept of reuse is not standardized among the various Member States, it is clear that there is an enormous potential for growth in reuse activity in Portugal that must be promoted. The reuse of treated wastewater is undoubtedly an adaptation measure and a good water management practice, particularly to face the increased frequency and intensity of periods of drought and water scarcity, allowing to increase the resilience of counting systems. among the measures provided for in the Action Program for Adaptation to Climate Change (P-3AC). Water reuse has been growing, and there are currently several success stories spread across the five continents.

The field of water production for reuse has registered important advances with the approval of the respective legal regime through Decree-Law No. 119/2019, of August 21<sup>st</sup> [12]. In the context of a circular economy, in which economic development is balanced with the protection of natural resources and environmental sustainability, Water for Reuse represents a widely available and valuable resource.

The volumes reused from the WWTP in the Trás-os-Montes Region, in parallel with the established goals, it appears that the reuse rates fall far short of the values defined in the National Strategy for Water Reuse (10% in 2025 and 20% in 2030) and that the effort to achieve these values must be quantified and its impact assessed on the level of activity and sustainability of the respective Management Entities.

In this regard, the legal diploma Decree-Law No. 16/2021, of February 24 [13], confers responsibilities in the development of this activity on the Multimunicipal Systems for the

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collection, treatment and rejection of effluents within the scope of their main activities, passing to Águas do Norte to have this obligation within the scope of the multi-municipal water supply and sanitation system in the North of Portugal.

Águas do Norte implemented the Regional Action Plan for Water for Reuse, which establishes objectives that promote increases in the consumption of Water for Reuse internally and the possibility of extending it to external use, in addition to identifying treatment facilities with production viability of reused water and identify potential uses as well as respective investments to ensure a level of treatment compatible with legal quality requirements.

Within the scope of the activities dependent on the action of the company Águas do Norte to enhance the reuse rate, which includes the internal use of Water for Reuse, it aims to reach 90% of the total water needs of its WWTP in the Trás-os-Montes to be supplied using Water for Reuse, which, internally, is tremendously more ambitious than the target of 10% and 20%, but in line with the average levels seen in the various companies of the Águas de Portugal Group, and which constitutes, in itself, an excellent example of trust and good practices in society.

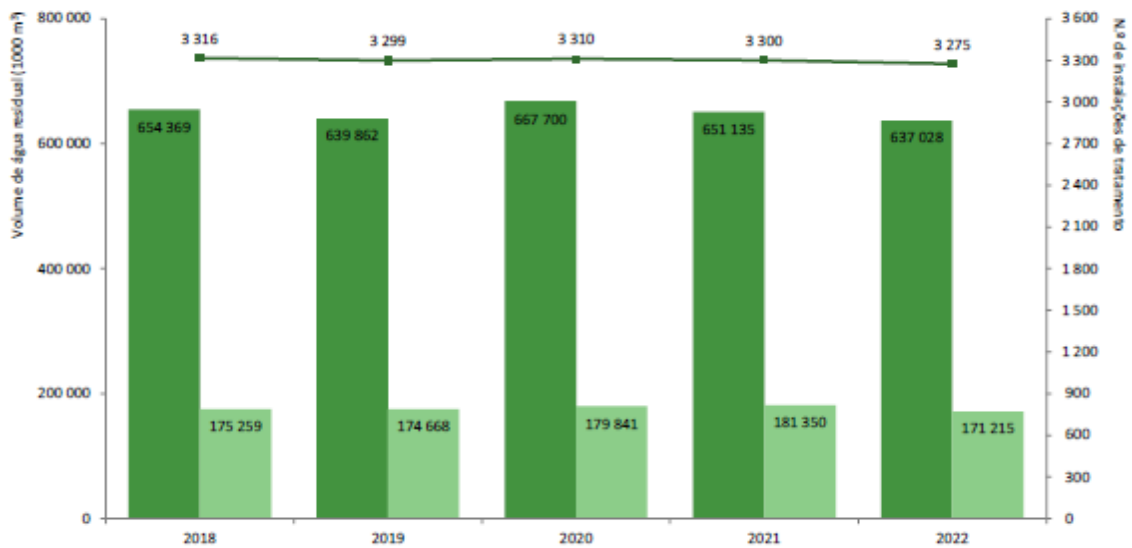
Naturally, the fulfilment of this objective was accompanied by studies and actions with a view to identifying the WWTP of the system that prove to be viable, so that the internal use of Water for Reuse reaches an internal reuse rate equal to or greater than the target of 90% of all the water used in said installations.

At the same time, the achievement of this internal objective makes it possible to subsequently leverage the supply of Water for Reuse for external uses, maximizing the use of quantitative and qualitative training for the production of Water for Reuse, with the corresponding necessary investments, so that it can be used and made available to demand. external, namely for urban use and agricultural irrigation.

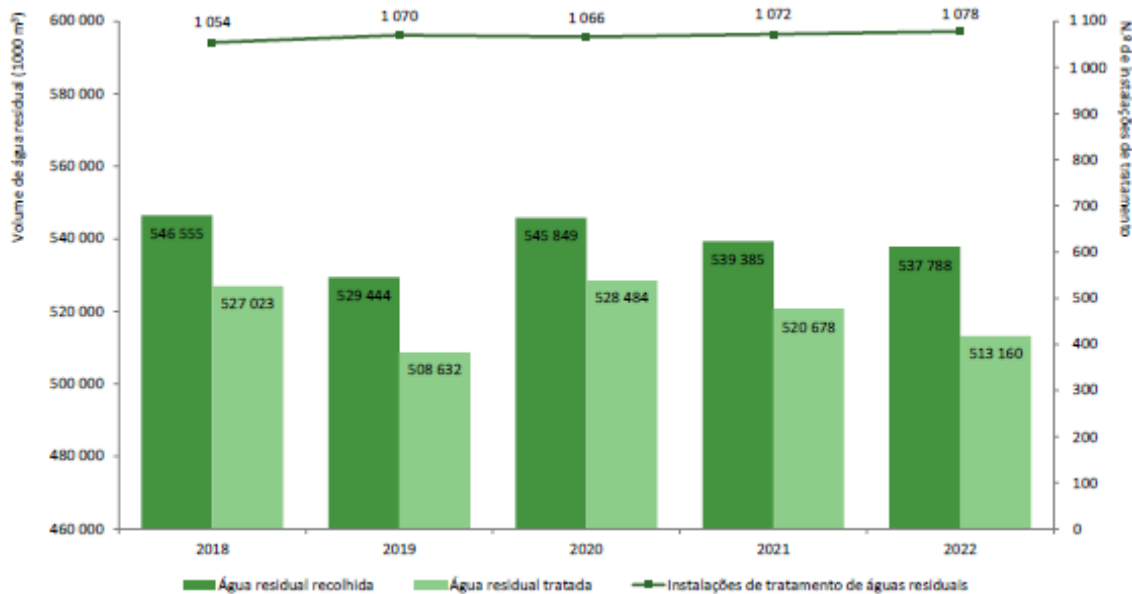
Along last five years (Figure 6A, 6B) we find that there have been around 1200 hm<sup>3</sup> of wastewater (WW) collected (650 hm<sup>3</sup> - “low level sector” and 550 hm<sup>3</sup> - “high level sector”) and almost 700 hm<sup>3</sup> (around 60%) of treated WW (TWW), ranging from 180 hm<sup>3</sup> to 520 hm<sup>3</sup> under “low” and “high” level sectors, respectively. Currently, only 1.2% of the WW volume from waste

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water treatment plants (ETAR-WWTP), where reused, mostly (86%) for own use (ERSAR, 2024) [14]. Regarding “household” WW in 2022, the volumes were: 470 hm<sup>3</sup> (generated), 436 hm<sup>3</sup> (collected) and 411 hm<sup>3</sup> (safely treated) in the proportion of 87.5% from the generated volume (UN Habitat and WHO, 2021, 2024) [3] [4].



a)



b)

**Figure 6.** Evolution of the number of treatment plants and the volume of collected and treated wastewater under a) low level sector, and b) high level sector (ERSAR, 2024) [14]

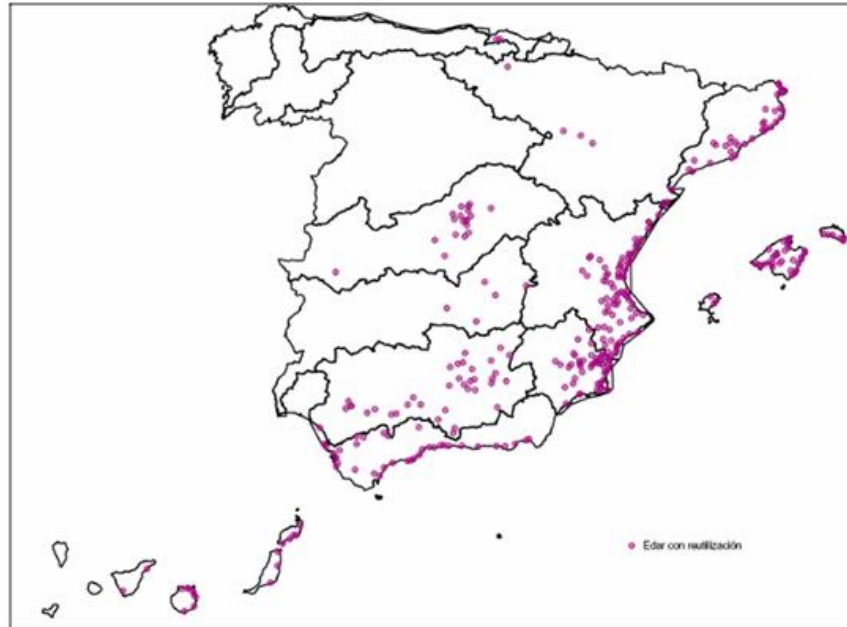
## 2.4. Spain

The distribution of water resources in Spain presents great contrasts, being scarce in large regions with significant agricultural development and sometimes coinciding with a growing demand for water by the tourism sector (Gómez-Ramos, Blanco-Gutiérrez, Ballesteros-Olza, & Esteve, 2024) [15], (MITECO, 2010) [16]. In addition, rivers are practically regulated in Spain, so a significant increase in the amount of stored water is not foreseeable and the underground resources existing in the aquifers are subject to problems of overexploitation, contamination and salinization. Added to this issue are the consequences of climate change, which leads to a foreseeable decrease in resources and the intensification of drought episodes (MITECO, 2020) [17].

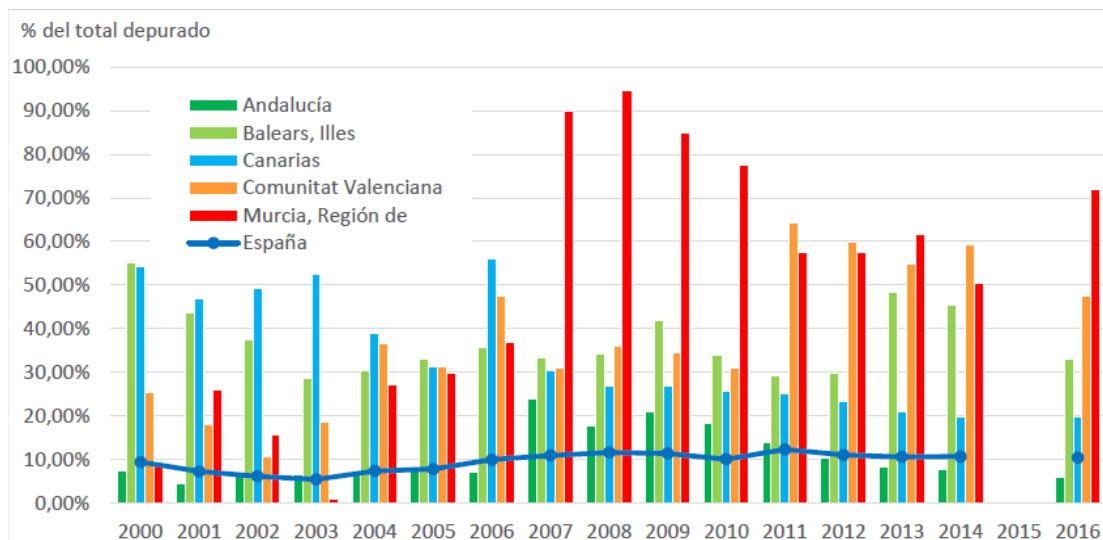
This scenario has led to the development of alternative sources of water and legislative advances that have supported it. The regulatory framework in Spain began with Royal Decree 1620/2007 [18], which instituted the legal regime for the reuse of treated water and was a landmark in the promotion of the reuse of wastewater in this country. It establishes the administrative requirements for obtaining the concession and the enabling title, responsibilities, controls, permitted uses (urban, agricultural, industrial, recreational and environmental uses) and quality criteria. Subsequently, in 2010, the application guide for this Royal Degree was published (MITECO, 2010) [19], which has as its main objective to facilitate its compliance, but also the promotion and dissemination of the use of reclaimed water. In addition, this guide analyses the different existing alternatives for financing actions within the framework of the reuse of wastewater. All of this has allowed a gradual growth of facilities (Figure 7) and the use of reclaimed water, which in 2022 reached the figure of 343 Hm<sup>3</sup> (AEAS-AGA, 2022) [20].

It is also worth noting that the diversity that characterises the different regions of Spain explains why the use of reclaimed water is highly variable and is concentrated mainly in areas of the Mediterranean arc and islands where water stress is more pronounced. The Valencian Community is the one that uses the largest amount and the Community of Murcia the one that does so in the highest percentage, reaching 90% of the use of the wastewater generated (MITECO, 2020) [17] (Figure 8).

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**Figure 7.** Distribution of the number of reuse systems (MITECO, 2010) [16]

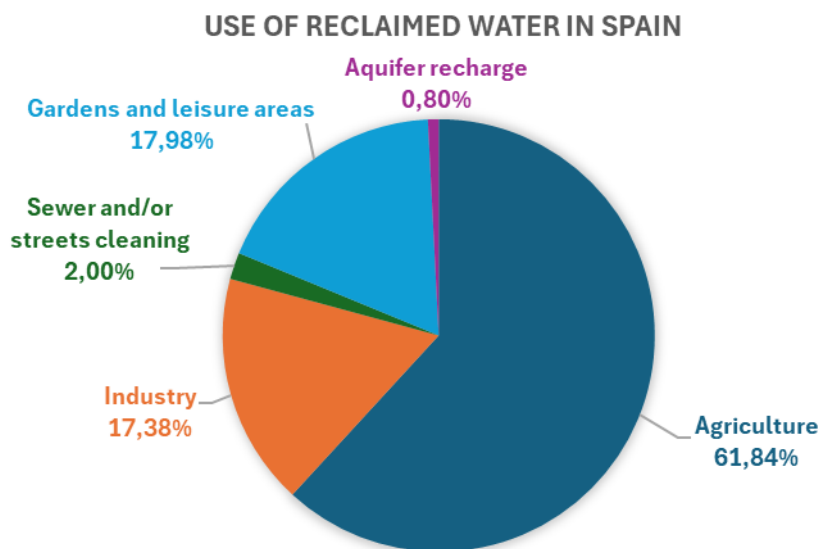


**Figure 8.** Evolution in percentage of regenerated water over treated wastewater water by Autonomous Communities (MITECO, 2020) [17]

The use of reclaimed water has been reinforced by actions such as the 2020 “Recovery, Transformation and Resilience Plan” (PRTR), which articulates the management of Next

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Generation EU funds in Spain, where the preservation of coastal space and the conservation of water resources is one of the thirteen components that articulate different investment initiatives (C5-R1). Finally, Royal Decree 1085/2024, of October 22 [21], approves the Water Reuse Regulation. This regulation is based on risk management; therefore, the Reclaimed Water Risk Management Plan (PGRAR) is considered a fundamental part in the management of the reuse system. In addition, it is seen as a priority to promote reuse by improving the quality of water associated with discharges and promoting it through initiatives of the Administrations that seek to promote the circular economy and adaptation to climate change. Despite the great advances made in recent years, only between 7% and 13% of all wastewaters are reused (AEDyR, 2019) [22]. The final destination is the agricultural irrigation (Figure 9) with a percentage exceeding 60%, followed by recreational uses (irrigation of golf courses) and municipal uses (irrigation of green areas, street cleaning...) and, to a lesser extent, industrial uses. Environmental uses are also generating interest for their use in aquifer recharge, wetlands restoration or maintaining ecological flows.



**Figure 9.** Use of reclaimed water. Source: AEAS-AGA (2022) [20]

## 2.5. France

The volume of treated wastewater produced annually in mainland France is estimated at 8.4 billion cubic meters (Database on Urban Wastewater from the Ministry of the Environment, 2015). Assuming an average rate of 20% of reused water annually at the treatment plant level, corresponding to the seasonality of most uses, the potentially exploitable volume of treated wastewater could be 1.6 billion cubic meters per year (CEREMA, 2020) [23], or approximately 19%. However, less than 1% of treated wastewater is currently recycled, and 0.1% is reused for irrigation in agriculture (<https://water.europa.eu/freshwater/countries/uwwt/france>). Between 2015 and 2017, 73 REUSE projects were identified as operational in mainland France (excluding private treatment plants and industry): more than half were implemented for agricultural irrigation, while the majority of the remaining cases were for golf course watering (CEREMA, 2020) [23]; (Lombard-Latune & Bruyère, 2023) [24]. Between 2017 and 2022, 13 new operational projects were identified (Lombard-Latune & Bruyère, 2023) [24]. In 2022, the two primary uses of treated wastewater were agricultural irrigation and watering of green spaces. Irrigation uses appear to have diversified beyond cereal crops to include market gardening, arboriculture, and short-rotation coppices. However, the share of agricultural uses declined between 2017 and 2022 due to both the lack of new agricultural projects and the discontinuation of some operational projects. This decline was offset by an increase in projects related to urban green space irrigation and maintenance. Between 2022 and 2023, 15 projects were launched, potentially driven by the 2022 drought and the 2023 Water Plan (CGAAER, IGAS & IGEDD, 2023) [25]. The mission shows that many treatment plants are multi-purpose, targeting the following priorities in order: plant cleaning, green space irrigation, agricultural irrigation, golf course watering, and street cleaning. Moreover, more than 200 projects are under consideration, while around ten have been abandoned due to the lack of water users. The French government supports a political momentum favouring REUSE development, aligning with both climate change adaptation strategies and support for the circular economy. The promotion of REUSE was first driven by regulatory measures that, as early as the 1990s, included the possibility of REUSE in legislation and established technical requirements based on authorized uses to ensure minimum health and environmental safety. Lawmakers later sought to diversify authorized uses, such as street cleaning, and to simplify administrative and

technical procedures to facilitate the implementation of projects. The late 2010s marked a political will to scale up the use of treated wastewater, as illustrated by the 2019 Assises de l'eau, which formalized the goal of tripling the volume of non-conventional water by 2025 (French Government, 2019) [26]. In 2022, the Varenne Agricole de l'Eau operationalized the objectives of the Assises de l'eau for the agricultural sector, committing to support experimentation through an observatory to capitalize on feedback, a decree, and funding for innovative projects (French Government, 2022) [27]. In 2023, the national Water Plan presented by the President of the Republic set a goal of 10% reuse of non-conventional water by 2030, aiming for 1,000 REUSE projects by 2027 (French Government, 2023) [28]. The development of REUSE is prioritized downstream of treatment plants discharging into coastal areas because, in this case, reuse is considered a substitution for freshwater abstraction. Additionally, coastal water demand increases due to summer tourism activity. For the government, these factors justify prioritizing treated wastewater reuse in coastal areas. An "acceleration" mechanism dedicated to coastal municipalities was implemented to provide quick financial and technical support. In 2024, the ministry responsible for the environment established a resilience plan for the Pyrénées-Orientales department, a territory particularly affected by climate change. Three coastal REUSE projects were selected to receive government support for rapid implementation, aided by new funding and regulatory facilitations (Ministry of Ecological Transition and Territorial Cohesion, 2024) [29]. In conclusion, several strategies support and organize the implementation of REUSE in France: national action plans, territorial action programs, targeted calls for projects and water agency subsidies, capitalization on feedback, involvement of water industry consortia, a single submission portal for project applications, regulatory adjustments, or derogatory regimes, among others.

## 2.6. Andorra

The Government of Andorra is currently working on a new Water Law, which plans to include a regulatory framework for the use of reclaimed urban water.

To date, the production and use of this new resource in the Principality of Andorra is not covered by current legislation, although it is an issue already addressed in the government's strategy to address an environmental problem and a need affecting the general population due

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to water scarcity. Participation in I-ReWater, particularly in the development of the Strategy, as well as existing regulations and European Union standards, will form the basis for the new law.

### 2.7. Germany

Climatic changes are increasing the pressure on water resources in Germany and Europe. To counteract this pressure, Regulation (EU) 2020/741 [11] sets minimum requirements for the use of reclaimed wastewater for agricultural irrigation.

This regulation try to define the risk assessments on the use of reclaimed wastewater in agriculture. Uniform minimum requirements for the safe reuse of reclaimed urban wastewater are intended to facilitate implementation by EU member states and ensure a high level of protection for the environment and for human and animal health. The German Federal Institute for Risk Assessment (BfR) therefore assesses the health risks of using reclaimed wastewater for the irrigation of fruits, vegetables and fresh herbs (food safety challenges)(BfR, 2022)[30].

In particular, the presence of pathogens, drug residues and perfluorinated and polyfluorinated alkyl substances (PFAS) in reclaimed wastewater is a major food safety challenge. Pathogenic bacteria, viruses and parasites can get into or onto plants through irrigation with reclaimed wastewater and cause human diseases by consuming them. In addition, the direct spread of resistant bacteria can occur. Drug residues can also promote the emergence and spread of resistant bacteria due to selection pressure. In several opinions, the BfR examines the question of whether and how pathogens can get onto or into the plants to be irrigated via reclaimed wastewater in concentrations that are of concern to consumers, and what measures are required to protect against diseases.

The industrial chemicals PFAS can also enter municipal wastewater due to their wide range of uses in industrial processes and consumer products. They pose a particular technical challenge for the treatment of wastewater. In addition, they are well absorbed by plants. The BfR deals with the question of the transfer of PFAS along the food chain in various working groups and projects and has already issued opinions and publications on this subject.

## Chapter 3. Relevant legislation

The relevant legislation on the use of reclaimed water is analysed, mainly focusing the analysis on current regulations for agricultural use.

### 3.1. International Regulations

The use of reclaimed water is currently in a phase of increasing implementation, although one of the main barriers it faces is the non-existence of global standards worldwide.

The absence of harmonized regulations for reclaimed water is largely due to its multiple uses, to the fact that it is a relatively recent activity and that its use in many cases responds to local problems that are difficult to extrapolate to other cases. This fact greatly difficult the optimal development of strategies for the use of reclaimed water given that without clear quality guidelines, the development of effective purification technologies is more complicated and greatly hinders the public perception of reclaimed water as a safe resource.

As a global regulation or guideline, recommendations developed by the World Health Organization (WHO) in its guides initially focused on the use of regenerated water for agriculture and aquaculture (WHO, 2006) [1] have been largely adopted, as well as the one published later in 2017 for the safe production of drinking water both through direct and indirect reuse (WHO, 2017) [2]. These guides, focused from a preventive management framework, include the evaluation of facilities treatments, concepts such as public acceptance and guidelines for the control and guarantee of water quality based on requirements such as the reduction and monitoring of pathogens or, on a smaller scale, organic and inorganic contaminants, under the health risk management concept and using estimations based on person per year (PPY) and disability adjusted life years (DALY).

At an international level, we can also find the ISO/TC 282 committee [3], which proposes standards including technical, economic, environmental and social aspects for any type of use of regenerated water, but the levels and parametric limits of the substances to be controlled are not included, referring to governments or, in their absence, intentional organizations such as the WHO to establish them.

More recently, the UNE ISO 16075 [4] published the “Guidelines for the use of treated wastewater in irrigation projects”, which provide specifications for the development and implementation of treated wastewater projects, design and quality criteria for agricultural irrigation.

In the United States, the Environmental Protection Agency (EPA) published the Guide for water reuse in 2004, which was revised in 2012 (EPA 2004, 2012, 2017 US EPA Potable Reuse compendium) [5], which establishes the criteria for different uses of reclaimed water. New uses were also included such as indirect reuse and industrial uses and new technologies proposed for the reduction of pathogens and other contaminants, including for the first time emerging contaminants. At the same time, different states also published their own guides, among them the state of California, a pioneer in the use of reclaimed water, through resolutions that have been modified and updated (Tittle 22) until the most recent Regulation that establishes the criteria for the direct reuse of reclaimed water for drinking water production (SBDDW-23-001) [6]. This guide has been used as reference guide in other countries instead of the WHO guide, for example in Saudi Arabia or the Arab Emirates, despite the fact that its application results in very high costs in terms of facilities, treatments and technologies and establishes much stricter control criteria than those established in the WHO guide.

Australia also has its “Australian Guidelines for Water Recycling: Managing Health and Environmental Risks” (EPHCA, 2006) [7] which covers all uses for reclaimed water, promoting the prevention and characterization of risks and establishing methods for the identification of these risks from the DALYs calculation.

Other international guidelines and regulations can be found in Russia (SanPiN 2.1.7.573–96 Hygienic Requirements to Wastewater and Sewage Sludge Use for Land Irrigation and Fertilization” in 1996 (MHR, 1996) [8], Israel (Public Health Ordinance: Effluent Quality Standards and Rules for Sewage Treatment) [9], Jordan (“Water Substitution and Reuse Policy Jordan” (MW&I, 2016) [10]), China has develop several actions from 1981, with standards about reclaimed water classification and marking, water quality for different reuse purposes, and benefit evaluation of reclaimed water use. Actually, a recent Standard to reclaimed water

grade classification for the urban recycling water P.R.C. (SAC) (2021) [11] was published. Finally, in Japan a quality standards for reclaimed water were fixed in 2005 (MLIT, 2005) [12].

This short review of international standards and guides shows that despite having local guides used at a global level, there is no single reference guide nor agreed criteria for the management of reclaimed water at a global level. The need to establish universal standards for the use of reclaimed water that improve the acceptance of reclaimed water by society and increase and enhance technologies related to the production and control of this resource is therefore mandatory.

### 3.2. European regulations

At European level there are multiple regulations that have been configured as the need to protect bodies of water and establish reliable criteria for protecting health and the environment as well as avoiding overexploitation of available resources has become evident (Figure 10). Among them, and as precursors of the regulation of reclaimed water in Europe, we can find the directive on drinking water (80/778/EC) [13], which includes the criteria that drinking water must meet to consider it suitable for consumption. And, overall, the directive on urban wastewater treatment (91/271/EC) [14], later modified by the Directive 98/15/EC [15], which raises the need to introduce secondary treatment to avoid the negative effects of the discharge of untreated wastewater. Article 12, of this Directive, also refers to the reuse of wastewater when necessary, as well as methods to minimize the adverse effects of its discharge into the environment. Recently, in November 2024, the new European Directive 2024/3019 was approved [16] which proposes placing more emphasis on the control of pollution at discharging sources, the introduction of new pollutants, and also expands the scope of application of the Directive to cities with more than 1,000 inhabitants, as well as the use more effective and sustainable technological innovations.

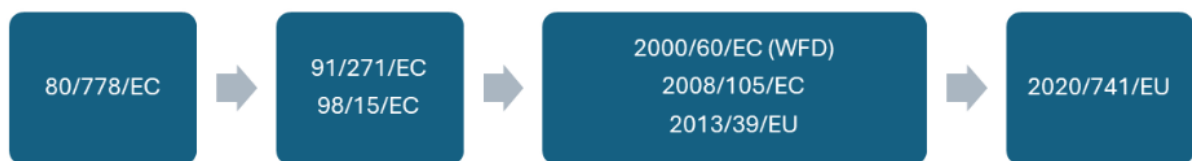


Figure 10. Evolution of European regulations link with the water reuse

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For its part, the Water Framework Directive (2000/60/EC, WFD) [17], reformulated in 2014 (2014/101/EC) [18], established standards for the protection of all bodies of water, and through directive 2006/118 /EC [19] limits and quality standards were set for biological and chemical contaminants to ensure the protection of these water bodies. In the WFD, Annex VI refers to the reuse of water for environmental use, including the quality limitations set to protect the receiving water masses. Other directives were published in 2008 and 2013, affecting to water policy in the European Union (Directive 2008/105/EC and Directive 2013/39/EU) [20] [21].

Other directives, guides or communications published by the European Union and that have constituted references for the development of current legislation are the groundwater directive 2006/118/EC [19], which includes criteria for the protection of these bodies of water against contamination. Specifically, with regard to artificial recharge, which would include recharge schemes with regenerated water, it must be ensured that the objectives GWD from the WFD. The Directive 91/676/EEC [22] concerning the protection of waters against pollution caused by nitrates from agricultural sources also poses the control on reclaimed waters enriched by these substances to avoid water and soil contaminations.

On the other hand, the 2007 Communication on Water Scarcity and Droughts stresses [23] that appropriate measures should take account of a ‘water hierarchy’, which emphasizes the need to address water saving and efficiency as a priority. Specifically, water reuse was highlighted as an important measure for further EU action in the 2012 [24] Water Blueprint, and in the 2015 Communication “Closing the loop - An EU action plan for the Circular Economy” [25] the Commission stated to take actions to promote the reuse of treated wastewater.

In June 2020, the European Union established, through Regulation (EU) 2020/741/EC [26], the minimum quality requirements for reclaimed water for agricultural use, effective as of June 2023, as a measure to proactively promote the use of reclaimed water among the member states. The purpose of this directive is to guarantee the quality and safety of regenerated water for irrigating crops by establishing requirements depending on the type of crop and irrigation carried out. For this, four different qualities of regenerated water are established (A-D) with different quality requirements (Table 2).

**Table 2.** Reclaimed water quality requirements for agricultural irrigation

Reclaimed water quality class	Indicative technology target	Quality requirements				Other
		<i>E. coli</i> (number/100 ml)	BOD <sub>5</sub> (mg/l)	TSS (mg/l)	Turbidity (NTU)	
A	Secondary treatment, filtration, and disinfection	≤ 10	≤ 10	≤ 10	≤ 5	<i>Legionella</i> spp.: < 1 000 cfu/l where there is a risk of aerosolisation Intestinal nematodes (helminth eggs): ≤ 1 egg/l for irrigation of pastures or forage
B	Secondary treatment, and disinfection	≤ 100	In accordance with Directive 91/271/EEC (Annex I, Table 1)	In accordance with Directive 91/271/EEC (Annex I, Table 1)	-	
C	Secondary treatment, and disinfection	≤ 1 000			-	
D	Secondary treatment, and disinfection	≤ 10 000			-	

This European regulation is of direct enforcement, so all EU state member must fulfil it without transposing it, repealing any previous legislation on the use of reclaimed water for agricultural irrigation that may be in force at the time of its approval. Even so, there are many other regulations at the local European level for the management of reclaimed water and which are detailed below by countries included in this I-ReWater project.

### 3.3. Spanish Regulations

The reuse of water in Spain is included for the first time in Water Law 29/1985 [27], which already included the basic standards for the direct reuse of water. This law, updated by Royal Legislative Decree 1/2001, approved the consolidated text of the Water Law (TRLA) [28], which establishes a regulatory framework by fixing basic conditions for the water reuse, as well as the administrative framework for its approval, granting and use. It also establishes incentives and aid to promote the use and production of regenerated water.

Subsequently, Law 11/2005 [29] refers to reuse as a recommended alternative for demand management and RD 907/2007 [30] includes reuse as a strategy for estimating agricultural, industrial and energy uses.

The non-existence of specific legislation on reclaimed water, together with the introduction into water laws of the concept of reclaimed water uses, led to the Royal Decree 1620/2007 [31], which establishes the legal regime for the reuse of reclaimed water. This regulation, currently in force, includes the quality requirements, risk management and non-compliance, as well as the legal regime for the use of regenerated water for urban, industrial, recreational and environmental use. This standard also includes agricultural use, derogated by the publication of European regulation 2020/741/EC [26].

A recent new regulation has replaced RD 1620/2007 [31], the Royal Decree 1085/2024, of October 22 [32], this new framework and include more innovative approaches in terms of risk management and promotion of the use of regenerated water.

Due to the water delegations of the Spanish autonomous communities, they also have specific regional regulatory frameworks that contemplate the reuse of water with different scopes. For example, in Catalonia, Legislative Decree 3/2003 [33], of November 4, which approves the consolidated text of the legislation on water matters in Catalonia, includes measures for the management of regenerated water in the territory or in the case of Andalusia the Law 9/2010 [34] is in force.

The rest of the Spanish autonomous communities in which the I-Rewater project is being developed haven't specific regulations on reclaimed water, although in La Rioja its use is mentioned in Law 5/2000 [35] about sewerage systems and wastewater treatment, an issue that will take on greater prominence with the application of Decree 39/2018 [36], which approves the sewerage systems and wastewater treatment master plan. Also in Galicia, the regeneration service of treated wastewater is mentioned as an integral part of the hydrological cycle Law 1/2022 [37], to improve the management of the integral water cycle.

### 3.4. Portuguese Regulations

A Portuguese technical standardization committee (CT 90) coordinated by the Portuguese Institute for Quality (IPQ) issued the NP 4434 2005, a standard related to the "Reuse of reclaimed urban wastewater for irrigation" (Monte, 2007) [38]. The technical guide comprises standards on wastewater reuse to support the implementation of water reuse projects. Criteria are related to analytical parameters, maximum limit values, monitoring protocols and preventive measures for health and environment protection. Analytical parameters consider nitrogen forms, total phosphorus, including toxic substances. Basic classifications to risk evaluation considered various types of crops such as consumed raw, cooked, processed, vineyards and cereals, as well as irrigation methods: sprinkler and drip. Some important notes were addressed to farmers using an allowed TWW: 1) the major adverse effects are observed in food crops consumed raw and when edible parts are in contact with the wetted soil; 2) drip

irrigation provides better conditions to avoid a direct contact between plants and the water applied.

The CT90 also participates as a member of the International Organization for Standardization (ISO), integrating the ISO/TC282 committee to develop guidelines in the scope of wastewater. This committee includes a subcommittee (SC1) and work groups to deal with irrigation, responsible for publishing the ISO 16075 – “Guidelines for treated wastewater use for irrigation projects” and the ISO 20419:2018 – “Guidelines for the adaptation of irrigation systems and practices to treated wastewater” [39].

More recently, with some support from ISO guidelines, namely the ISO 16075, Portugal approved a policy for the production and use of TWW (Decree-law 119/2019) [40] which sets a system of classifications to provide information related to urban and agricultural origins, treatment level, water quality, health risks, type of crops and irrigation projects and restrictions. A plan for the use of TWW, with good practices to prevent adverse impacts on health and environment, includes a risk assessment associated with fit-for-purpose approach, multi-barrier management and monitoring actions.

Additionally, the National Climate Change Adaptation Planning and Strategies report refers the Portuguese National Adaptation Plan (NAP) for Climate Change (P-3AC) adopted to the period 2020-2030 and includes a plan for Water Reuse. Finally, the Decree-law 16/2021 [41] defines conditions for collecting wastewater and producing TWW, as a public service of wastewater sanitation. In this regard, this legal diploma confers responsibilities in the development of this service on the Multi-municipal Systems for the collection, treatment and rejection of effluents within the scope of their main activities, passing to Águas do Norte to have this obligation within the scope of the water supply and sanitation system in the North of Portugal.

### 3.5. Andorra Regulations

The reuse of water in Andorra is not contemplated in current legislation. The Police and water protection Law (1985) [42] and the Regulation of control of wastewater and protection of surface waters (1996) [43] don't include the reuse of the wastewater. The Government is

working in a new Water Law in which is planned to include the framework for the reuse and reclaimed water.

### 3.6. French Regulations

In France, TWW has been governed by specific legislation since 2010: it allows wastewater to be used for agricultural crops and green spaces. Since 2022, TWW has been possible for many uses other than irrigation and watering green spaces, in particular urban uses by local authorities (road cleaning, firefighting, watering networks).

The legal harmonization of the requirements of European regulation 2020/741 [26] with those of existing French decrees was completed in December 2023. While the European regulation applies without prior transposition into French law, the methods for controlling contamination must be consistent between the various possible reuse contexts in France (agricultural irrigation, watering of green spaces and new contexts such as urban uses). In addition, the 'Water Plan' presented by the French President on 30 March 2023 encourages the development of the use of non-conventional water, a category that includes REUT water and rainwater. The plan aims to achieve 10% water savings by 2030 and to reuse 10% of wastewater, i.e. 300 million m<sup>3</sup>, with the objective of facilitating the implementation of at least 1,000 REUT projects, particularly in coastal areas. It speeds up legislative changes in France and aims to simplify the regulatory process for project developers.

The French decrees taking account of the European regulation (2020/741) [26] were published in December 2023. One governs agricultural irrigation, the other the watering of green spaces open to the public. They determine the quality thresholds to be respected, below which the opinions of health agencies are not mandatory. There are a few differences with the European regulations, such as the concentration of *Clostridium perfringens* and coliphages, which must also be monitored for qualities B, C and D, and not just for quality A. The performance of the treatment should also be monitored for more water qualities, not just quality A. The French decrees also take into account the recommendations of the French health agency to guarantee the health safety of products and the environmental safety of agricultural soils. A decree was also published in August 2023 (2023/835) [44] to clarify the scope of possible uses for treated

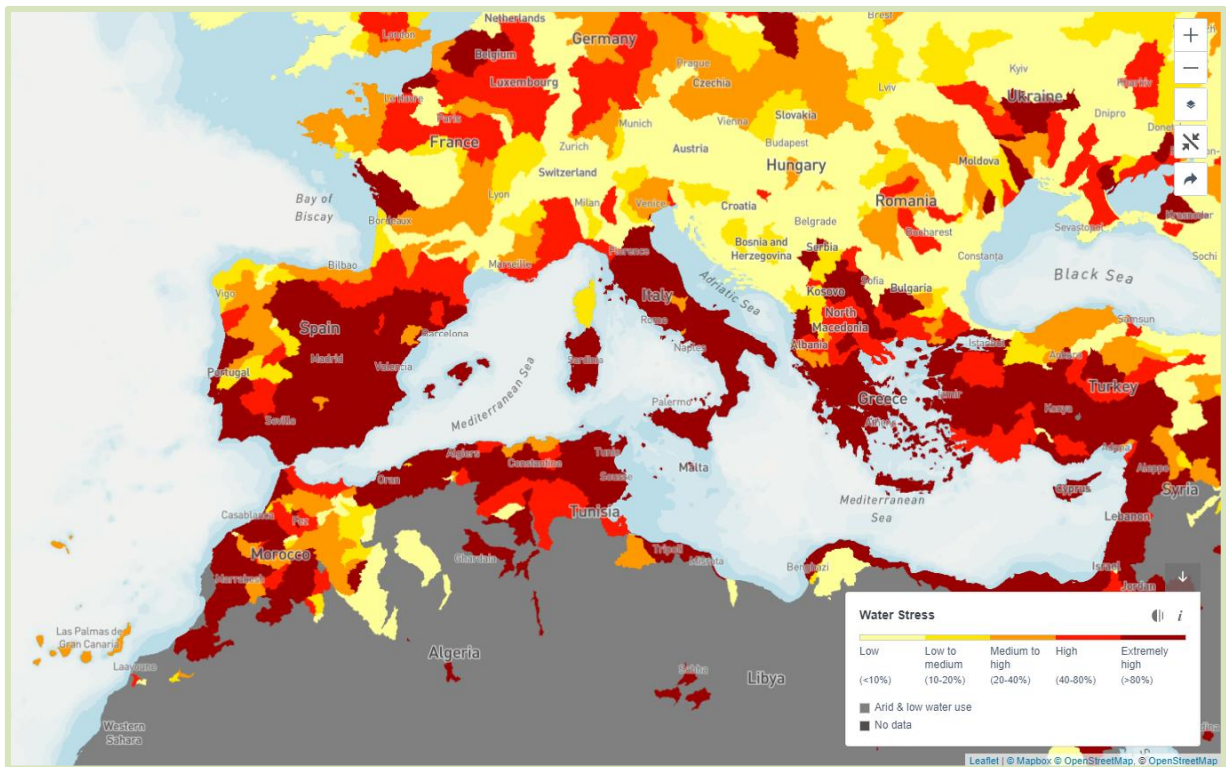
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wastewater and simplify authorization, while respecting the health of populations and ecosystems.

Since the publication of these new legal texts, a number of measures have been taken to facilitate the use of TWW. The use of treated wastewater is no longer conditional on the quality of the sludge produced by the treatment. In addition, barriers can be put in place if the quality of the water falls below the thresholds and are therefore supposed to facilitate the use of wastewater. It is the responsibility of the petitioner to demonstrate to the competent authorities, through a risk assessment and management process, that the quality of the treated wastewater is compatible with the desired uses and that the proposed requirements are sufficient to control the identified risks. The decrees provide for a commitment document between the parties involved (producer, manager of treated wastewater storage facilities and distribution network, users) to determine the responsibilities of each of these parties. In the final analysis, the procedures for monitoring and using TWW are adapted on a case-by-case basis depending on the project and the area concerned. These procedures are set out in the prefectural orders, which are authorizations issued by the prefect at local level.

## Chapter 4. Methodology

Water is a scarce and valuable resource. In the current context, with an increase in demand, a worsening of quality (U.N., 2021 [1]; CEDEX, 2010 [2]; Bates et al., 2008 [3]) and the effects of climate change lead to a future in which the management of water resources is expected to be extremely complicated. The different projections made suggest a worsening in terms of resource availability, in this way, based on studies carried out by the World Resource Institute (2024) [4], it is expected that in 2050, 5 billion people will live in areas with extremely high water stress (Figure 11).



**Figure 11.** Future baseline water stress (competition for water resources) in the Mediterranean arc to 2050 using the scenario (SSP3 RCP7.0). Aqueduct water risk Atlas. Source: World Resources Institute (2024) [4]

The Mediterranean arc is one of the areas that already suffers from high water stress with clear forecasts of worsening. (Llop and Ponce-Alifonso, 2016) [5]. And one of the sectors expected

to be most affected is agriculture, with a drastic drop in production of certain crops due to prolonged periods of drought.

For all these reasons, and in a climate emergency context with an increase in dry spells, torrential rains, and rising temperatures, water management and governance tools must adapt swiftly and adopt measures that allow for effective management of the use of available water and its distribution to release higher-quality resources. Among these measures, the use of reclaimed water appears to be an effective and immediate alternative for freeing up resources, especially in the agricultural context, where this release of resources would be highly effective in terms of water volumes used, sustainability, and resilience of the activity.

Faced with a scenario of climate change and pressures on water resources, the development of strategies with a holistic and cross-cutting approach is essential, especially the development of common strategies that allow for focusing efforts on the most relevant aspects of resource management and establishing universal criteria that allow for economizing efforts and leveraging transnational knowledge and experiences. Thus, within the framework of the Activity 1.4.1, I-ReWater project aims to develop a consensual strategy for the use of reclaimed water, based on the strategies of the beneficiaries/partners and national and European policies. In this case, the participants involved respond to a common problem of resource scarcity and are comprised of actors with diverse concerns, such as public administrations, research institutes, technology centers and universities, and public and private water managers and distributors. This configuration of actors and issues allows for the establishment of strategies with a broad, cross-cutting vision.

#### 4.1. Drivers and Barriers analysis

As a preliminary step to developing this strategy for using reclaimed water, specifically for agricultural irrigation, it is necessary to establish the fundamental axes or aspects on which to identify the motivations and barriers ('Barriers and Drivers') that will determine the development of a successful strategy. There are numerous studies and projects in the literature that work on this basis, adopting, for example, the PESTLE (Lee and Jepson, 2020 [6]; Fernandes and Cunha Marques, 2023 [7]) or SWOT analysis (Mainali et al., 2011 [8]; Michailidis et al., 2015 [9]; Mesa-Perez et al., 2020 [10]; Starkl et al., 2013 [11]; Nagara et al.,

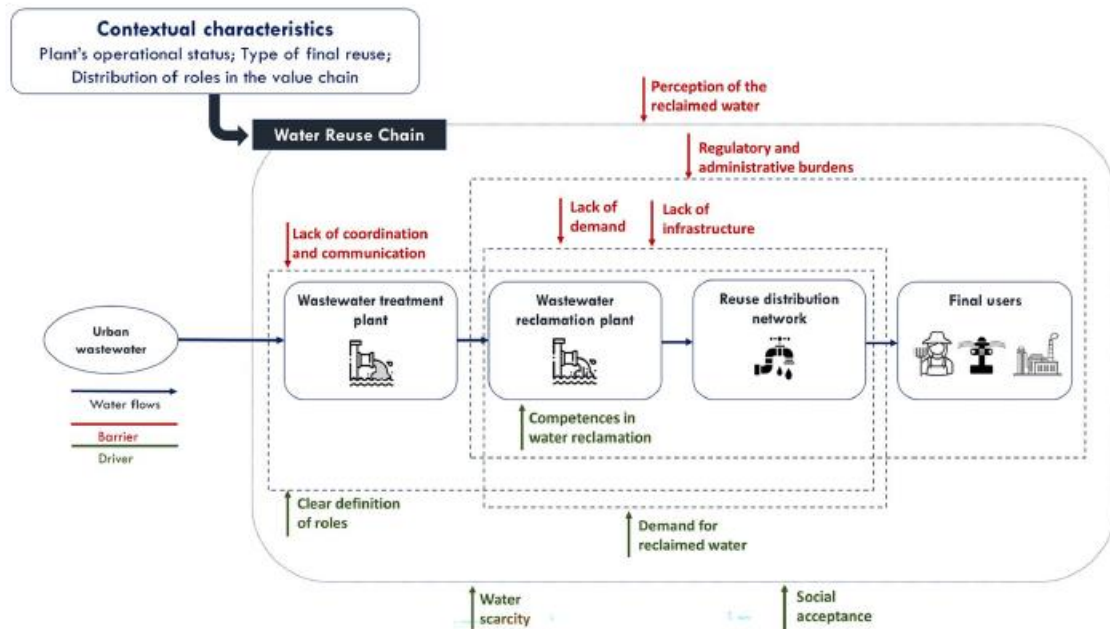
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2015 [12]). PESTLE analyses allow you to examine a project along six basic axes (Figure 12): Political, Economic, Social, Technological, Legal and Environmental.

<b>P</b>	<b>Political</b>	Political factors are government, trade and tax policies, general political issues, changes in leadership, regulation, and political trends.	
<b>E</b>	<b>Economic</b>	Economic factors may include inflation, interest rates, exchange rates, economic growth and unemployment levels.	
<b>S</b>	<b>Social</b>	Social factors are cultural trends and patterns in society. They may include lifestyle trends, age distribution, and consumer behavior.	
<b>T</b>	<b>Technological</b>	Technological factors may include technological advancements and developments, innovation and scientific breakthroughs.	
<b>E</b>	<b>Environmental</b>	Environmental factors may include climate change, environmental regulations, waste management policies and consumer environmental awareness.	
<b>L</b>	<b>Legal</b>	Legal factors may include labor and consumer laws, market and import/export regulations, health and safety policies and guidelines.	

**Figure 12.** PESTLE factors and description. Source: <https://pestleanalysis.com/what-is-pestle-analysis/>

Studies that have applied this approach to the use of reclaimed water for different uses have identified the most studied barriers as social and economic, while economic factors in terms of financing constitute the most studied motivations (SUWANU-EUROPE, 2019) [13].



**Figure 13.** Barriers and drivers to development the water reuse chain (Neri et al., 2024) [14]

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Even so, there are few studies that fully evaluate the use of reclaimed water from a PESTLE perspective, leaving the evaluation and interactions between actors as the main gaps to be covered in a comprehensive and complete study of all barriers together, given that most studies focus on the end-user perspective, the limited participation of government agencies, limited studies in the global European context and the fact that there is much more information on barriers than on motivational factors (Neri et al., 2024) [14] (Figure 13 and Table 3). The studies carried out summarize the following factors (Neri et al., 2024) [14]:

**Table 3.** Driver and Barriers to use reclaimed water. Adapted from Neri et al. (2024) [14]

Aspect	Barrier	Driver
<b>Political</b>	Lack of guidelines	Relevant Laws
	Government reliability	Incentives tax
<b>Environmental</b>	No scarcity	Scarcity
	No Environmental concern	
<b>Social</b>	Health risk	Scarcity
	Yuck Factor	
<b>Technological</b>	Insufficient facilities/Infrastructures	Innovative technologies
	Water quality	
	Insufficient technical resources	
<b>Legal</b>	Lack of regulations	Regulations
	Institutional support	Water quality standards
	Institution coordination	Institution coordination and support
	No stakeholders involvement	
<b>Economic</b>	Initial investment	Financing instruments
	Operating cost and recovery	Market
	Limited Market	

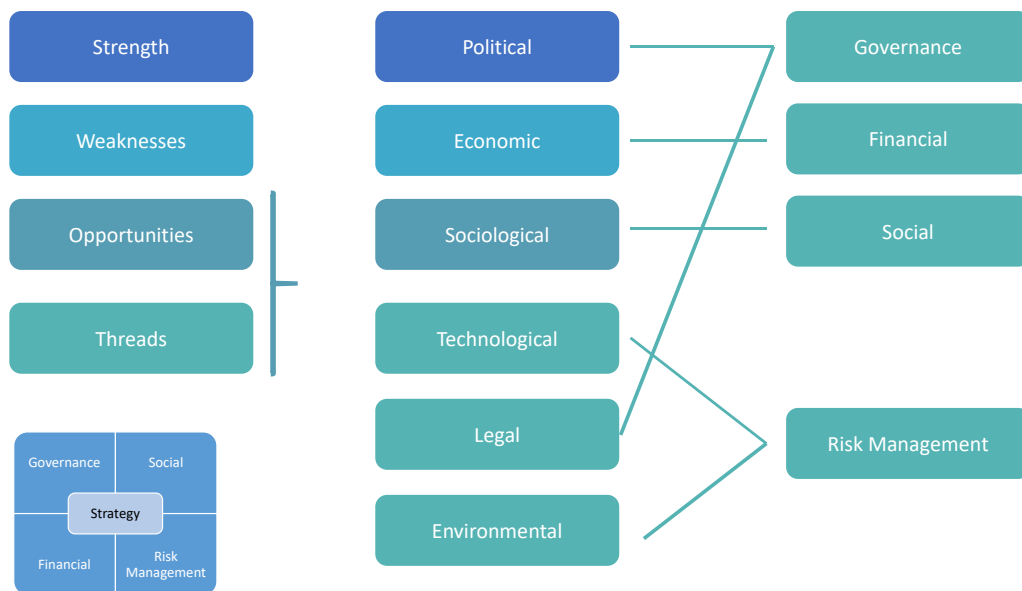
On the other hand, the approach to the strategy for the use of reclaimed water using SWOT analysis (strengths, weaknesses, opportunities and threads) allows to evaluate the problem from a more localized management perspective. There are different studies that apply this approach, it is worth highlighting the one developed within the framework of the SUWANU-Europe (H2020) project [15] where the SWOT analysis is combined with the PEST (political, economic, social and technological) for the evaluation of the use of reclaimed water for agricultural use in different countries of the European Union. The evaluation was carried out independently from a more internal approach by country (SWOT) and among the conclusions obtained it was evident that those countries with greater availability of natural resources such as Belgium or Germany focus on social, governance and market aspects while those with scarcity problems (Mediterranean) on economic aspects and social acceptance. A similar

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study carried out in Italy (Canaj et al., 2024) [16], based on the tools proposed by the SUWANU project (Table 4), showed that the barriers identified in the territory include technological or infrastructure impediments, insufficient involvement of administrations, ineffective regulations and problems with investments, thus focusing the main aspects on governance and economic aspects.

**Table 4.** SWOT analysis of reclaimed water. Adapted from SUWANU [15]

Strengths	Weakness	Opportunities	Threads
Previous success sites	Public opinion	Regulation	Distributors acceptance
Resource availability	Costs	Social concern	Social acceptance
Regulations	Lack facilities	Surface shortage	Bureaucracy
Quality and safety	Water distribution	Quality standards	Costs
Mixed resource	Storage	Scarcity	Cost effectiveness
Climate Change	Energy consumption	Groundwater salinization	Lack political empowerment
Good environmental practices	Short production	Zero market strategy	Water alibi
Alternative resource	Market	Previous knowledge	Urban and industrial uses prioritization



**Figure 14.** Main aspect/factors selected to implement the study in I-ReWater

Within the framework of the I-ReWater project, the initial need arose to select the main aspects or categories on which to build the proposed strategy. To this end, the approaches proposed

in the studies and projects described above were analysed, and a decision was made to implement a combined PEST analysis with the opportunities and threats identified in the SWOT analysis to define the main aspects that would inform this cross-cutting strategy (Figure 14).

The four key aspects selected to develop the reclaimed water management strategy for agricultural use are: governance, financial sustainability, social aspects, and risk management (Table 5). For each of these, a prior assessment of the identified barriers and opportunities will be conducted, and based on these, a consensus will be reached on the strategic aspects that this cross-cutting strategy should address. As can be seen, in some cases it is deemed appropriate to unify aspects to avoid duplication of opportunities or barriers described, which may refer to more than one. This is the case with the political and legal aspects, which are grouped under the concept of governance, or the technological and environmental aspects, which are unified under risk management.

**Table 5.** Template to analysis the ex-ante situation per beneficiary/associate member

Aspect	Barrier	Driver
Governance		
Financial		
Social		
Risk Management		

#### 4.2. Integration of results from water resources, life cycle analysis and socio-economic analysis

Based on the joint analysis of the results incorporated by each beneficiary/partner (Section 4.1), the results derived from the remaining WP1 activities will be integrated: water resources (A1.1.), LCA (A1.2.), and socioeconomic analysis (A1.3.). This process will be carried out

throughout 2025 and the first half of 2026, a period during which the WP1 activities will be completed.

The analysis of potential water resources available for irrigation will be integrated into the Risk Management analysis, as an environmental aspect. The definition of an order of action for the actions to be carried out to implement the Strategy will be determined by the demand for water resources and the potential for reclaimed water available in the hydrographic unit studied (basin, district, unit), as well as the future pressures to which it will be subjected, primarily in the area surrounding irrigated areas.

Similarly, the life cycle analysis (LCA) carried out in the different I-ReWater pilots, including the reclaimed water generation process and the results derived from its use in the pilots, will be integrated into the Risk Management analysis, as an environmental aspect. The environmental impacts of using reclaimed water compared to the impacts of using conventional resources incorporate a detailed environmental vision into the strategy design, focusing on ten impact categories: Global Warming (GW), Stratospheric Ozone Depletion (SOD), Terrestrial Acidification (TA), Freshwater Eutrophication (FE), Marine Eutrophication (ME), Terrestrial Ecotoxicity (TET), Freshwater Ecotoxicity (FET), Marine Ecotoxicity (MET), Mineral Resource Scarcity (MRS) and Water Scarcity (WS). The impact values are obtained using the AWARE (Available WATER REMaining) method v1.04 (Boulay et al., 2018) [17], the others were quantified using the ReCiPe 2016 v1.06 Hierarchist Midpoint World (2010) method (Huijbregts et al., 2017) [18].

Finally, Activity A1.3 (socio-economic analysis) is integrated into two of the aspects considered for the development of the Transnational Strategy: Financial and Social. The basic study of the socio-economic aspects in all the pilot actions implemented in I-ReWater (WP2), gathering basic information on all of them and expanding and detailing it with the case study of those pilots that are at a more mature level (INRAE, AMAYA, and AMB), allows for the incorporation of aspects that are not usually studied into the design of the Strategy. Indeed, the general question that Activity A1.3 seeks to answer is: how does REUSE become a legitimate solution for adapting to water scarcity in the SUDOE area? To address this, the socio-economic method is divided into two main axes:

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- The first axis involves cataloguing the policies and support mechanisms for the development of REUSE, with a focus on their alignment with existing frameworks, such as climate change adaptation policies or support for the circular economy. This phase aims to identify the sociotechnical tools that promote project development and provide a framework for implementation. It is based on a documentary analysis of a corpus composed of European and national action plans, parliamentary or expert organization reports, territorial action programs (integrated water management, land planning, etc.), calls for projects, and intervention programs by water agencies. The characterization of these documents helps identify the leading organizations and their motivations for promoting REUSE, as well as the specific forms of support provided (targeted users, mobilized funds, project qualification criteria, procedures used, such as administrative facilitation or legal exemptions).
- The second axis consists of the empirical study of several REUSE cases at different stages of advancement, aiming to identify the modalities of operational implementation of the projects. Qualitative interviews are conducted with all stakeholders involved in implementing a REUSE project: local authorities, regulatory agencies, consultancies, backers, sanitation services, and treated wastewater beneficiaries such as municipalities, farmers, irrigators, and municipal technical service employees. A generic interview guide focuses on sociological and economic questions. First, the interviews aim to highlight the interests, expectations, and concerns of each type of stakeholder regarding the use of treated wastewater. For farmers, they help characterize irrigation or non-irrigation practices before the REUSE project, other adaptation solutions considered, their adherence (or lack thereof) to the REUSE project, farm-level scaling, and the expected added value for their activities. Furthermore, the economic analysis of Activity A1.3 differs from a financial analysis that is solely focused on the private sector's perspective. The objective is to understand the collective interest in deploying REUSE projects. Economic questions focus on the scope of the REUSE project, such as the characteristics and constraints of the area, the gap between expected and actual beneficiaries, funding prospects and their probabilities, support for operating costs, timeframes, and alternative solutions considered. Economic inquiries also aim to identify the nature of expected impacts recognized by stakeholders, including amenities (tourism or residential appeal), implications for agriculture (agricultural models, organic certifications), ecological damages, health risks, and, more broadly, knock-on effects.

## Chapter 5. Key strategies lines, Action Plan. Disclosure and implementation process

### 5.1. Strategic lines and Action Plan

The key strategies lines shall be analysed through a framework of best water management practices in agriculture; In particular, involving cross-relationships among water sources, hydroclimatic indicators and water reuse standards for irrigation. Thus, it was objectively necessary to define key strategies in I-ReWater integrating water reuse thematic with other water-related issues such as: 1) renewable water resources availability (ground and surface water); 2) water balances (demand and supply), storage and distribution at various scales; 3) scarcity, drought and aridity indicators regarding historical and future scenarios; 4) primary resources use efficiency and quality; 5) climate change adaptation measures; 6) water circular economy; 7) crop water requirements and deficit irrigation. Consistently, some of those strategies are also being approached by a broad set of research projects (e.g. TARGET, MAR 2 Protect, SOLLAGUA, Nat-MED) to support practical actions and policy recommendations, in line with priority scientific areas such as climate change, environmental protection and socio-economic development.

Moreover, Junta de Andalucía has approved a recent agreement to prepare a Strategy about unconventional water resources in Andalucía [1], which should be include these minimum contents:

1. Diagnostic of the regulatory, technological, and economic framework for unconventional water resources.
2. Analysis of the contribution of unconventional resources to water planning and management objectives.
3. Diagnostic of the potential for water regeneration and desalination.
4. Definition of scenarios for promoting the production and use of unconventional resources.

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On this way, the defined strategic lines will, in turn, allow for the development of an action plan that establishes the basic guidelines for the use of reclaimed water in agriculture. The action plan should include, along with the defined key lines, the activities to be carried out within a limited timeframe and the resources needed to achieve the stated objectives.

There are different methods for designing and monitoring an action plan, given that in the specific case of reclaimed water for agricultural use, this action plan must be based on efficient management of the resource.

A widely used method that can be applied to this case study is Management for Development Results (MfDR), also known as Results-Based Management (RBM), which is defined as:

*‘A management strategy by which all actors, contributing directly or indirectly to achieving a set of results, ensure that their processes, products and services contribute to the desired results (outputs, outcomes and higher level goals or impact)’<sup>3</sup>*

This strategy, therefore, focuses on the achievements or goals the plan intends to achieve and then establishes a series of strategic and operational levels that allow for planning the fulfilment of the established achievements.

The tools that can be considered include Strategic Planning, the Logical Framework Approach (LFA), Results Frameworks (Results Chain), Results-Based Budgeting, Performance Monitoring, etc. All these methods are integrated into the model to configure an action plan oriented toward traceable results.

In the case of the action plan for this project, once the main strategic lines have been established, the action plan should focus on establishing the various consecutive steps to follow, starting from the initial objective, which in this case should focus on implementing the use of reclaimed water for agricultural purposes in the case study. Next, a thorough analysis of the actors involved must be carried out, an analysis of the problems and objectives using

<sup>3</sup> United Nations Development Group, 2011, “Results-based management handbook: harmonizing RBM concepts and approaches for improved development results at country level”, p. 2

tools such as those proposed in point 4 of this document, as well as a study of alternatives using theory of change type approaches that allow us to establish a logical framework matrix, directly linked to the results obtained in activities 1.1, 1.2 and 1.3 developed in the project, as well as including a battery of indicators that allow us to establish traceable and rigorous quantification tools to establish the elements of intermediate evaluation and monitoring.



## 5.2. Divuligation and Implementation

A complex strategy, as describe in the previous chapter require the participation of different stakeholders (multiactor approach). Final implementation involves multiple stages, including assessing the feasibility, ensuring proper infrastructure, involving stakeholders, and promoting the initiative to encourage adoption, as explained in chapter 4 and 5.1.

All actions defined in I-ReWater are aimed at improving the status of reclaimed water use in agriculture in the SUDOE area. Technical aspect are develop to obtain information about the water resources availability, along with the study of environmental impacts through life cycle assessment, and the socio-economical study, as explained in detail in subsection 4.2. Moreover, 15 action pilots are implemented throughout the SUDOE space (WP2-I-ReWater), in collaboration with different stakeholders (public authorities, water utilities companies, farmers, R&D entities), analysing and monitoring woody and horticulture crops using different irrigation systems schemes. During the project's implementation, a series of outreach activities are carried out to raise awareness of the importance of reclaimed water in agriculture and other sectors. The dissemination of the document and the actions outlined below are key aspects to facilitate the adoption of the Strategy designed in different areas of the region.

The first aspect is to achieve an operational situation in which the necessary infrastructure exists to be able to use reclaimed water safely, complying with all the regulatory aspects reflected in the current regulations (Chapter 3), with a continuous monitoring and maintenance.

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In relation to installation of infrastructure, two key aspects should be analysed: a) Water Storage and Treatment Systems, and b) Irrigation System Integration. At the same level, water quality monitoring and ongoing maintenance of equipment (wastewater treatment plants and irrigation system) processes will be defined.

In this way, actions must be carried out that allow build or adapt storage facilities or transport the reclaimed water directly for injection into the irrigation network through separate networks to handle reclaimed water, ensuring it's treated to a level suitable for agricultural use. Retrofit or create irrigation systems capable of utilizing reclaimed water, such as drip irrigation or sprinkler systems, ensuring optimal water efficiency and crop coverage, are necessary to could increase the use of reclaimed water in agriculture. To achieve safe use of the resource, regularly test must be taken to ensure the water quality required agricultural standards. A continuous monitoring system to track parameters such as salinity, pH, and nutrient levels, irrigation water and soil, must be configured using technology that allows access to all users, as well as facilitating decision-making, in relation to irrigation management (DSS-I-ReWater).

The successful implementation of a Strategy requires the participation of all stakeholders, gathering their commitment and collaboration to successfully achieve its implementation. Since the primary end beneficiary is farmers, their commitment must be fostered through:

- Educational Workshops and Demonstrations: Inform farmers about the potential benefits (nutrients), such as water conservation, reduced reliance on potable water, and possibly lower water costs.
- Collaborative Pilot Programs: Start with small-scale pilot projects to demonstrate the efficacy and benefits of reclaimed water use on crops.

The availability of reclaimed water requires participation (agreements) with water management entities and public authorities where the following are encouraged:

- Collaboration with Municipalities or Water Treatment Agencies: Establishing partnerships to ensure a consistent supply of reclaimed water, proper treatment, and distribution to farmers.
- Incentives and Support Programs: Government bodies or water providers may offer financial incentives, subsidies, or technical assistance to farmers adopting reclaimed water systems.

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Dissemination processes are key to achieving public acceptance of the use of a resource that is often considered waste, so creating social awareness on the matter is necessary. Dissemination and presentation of the actions to be developed in the Strategy must be disseminated from the outset, avoiding medium-term problems that could generate rejection among society and/or intermediaries prior to the final sale of the product. To achieve this, dissemination campaigns, fostering community engagement, and disseminating success stories and case studies are necessary. Some of these processes are adopted at I-ReWater through outreach/communication activities that the various beneficiaries and partners will carry out during the project.

One of the critical actions, it's obtain the positive respond from the society in general, this question will be resolve, through public information campaigns, using media channels like social media, local news, and public service announcements to inform the community about the benefits of reclaimed water in agriculture, such as sustainability, drought resilience, and environmental protection. I-ReWater will develop brochures, websites, or videos explaining the process, the benefits, and how farmers can get involved, as educational materials. These actions will facilitate information to companies, irrigation communities', municipalities, governments during the initial stage. These measures are companied by incentivize adoption of water reclaimed in agriculture, with subsidy or grants programs. Governments or private entities can offer financial support for farmers to adopt reclaimed water practices.

Finally, the community engagement should be pursued with the participation of farmers, environmental groups and public in general. Directly to farmers and technician, local workshops and field visits where farmers can visit successful operations using reclaimed water could help to understand all complex process of include reclaimed water into their irrigation practices. Technical training sessions and Q&A to address concerns will complement the local actions. An open stakeholder consultation, including the presentation of final products (foods or raw materials) are critical to position the use of reclaimed water aligned with the different visions of all stakeholders and society in general. Involve farmers, local government officials, environmental groups, and the public in discussions about water conservation and the role of reclaimed water in sustainable agriculture will help to obtain a good success, especially in the preliminary steps, in areas with no previous cases of water reclaimed use in agriculture.

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Good acceptance by farmers can be supported through success stories and case studies. I-ReWater implemented 15 pilots with farmers involve, these cases can inspire others farms by demonstrating real-world examples of how the strategy improves crop yields, reduces costs (nutrients), or helps with drought resilience. The use of testimonies from early adopters of their experiences, sharing success stories, from farmers who have seen tangible benefits from using reclaimed water in their agriculture practices, will support through I-ReWater project and contribute to achieve final goal, which is focus into increase reclaimed water use in the agriculture. Different social media actions will be implemented in collaboration with all stakeholders involve in I-ReWater project.

**The successful adoption of the strategy in the SUDOE space will depend on the proper implementation of the designed actions and the participation of the stakeholders involved. The current document includes all the critical aspects that must be considered, although it is open to the incorporation of new factors (legal, environmental, social, etc.) that may arise throughout the development process of the final Strategy in 2026.**

## References

### CHAPTER 1. Framework

1. Council of the European Communities. Council Directive 91/271/EEC of 21 May 1991 Concerning Urban Waste-Water Treatment. 1991. Available online:
2. Sanz, L. A., & Gawlik, B. M. (2014). Water reuse in Europe. Relevant guidelines, needs for and barriers to innovation. A synoptic overview, European Commission, Joint Research Centre and Institute for Environment and Sustainability, Ispra.
3. European Parliament and Council. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy. Off. J. L 2000, 327, 1–73. Available online: <https://eur-lex.europa.eu/eli/dir/2000/60/oj>
4. Regulation (EU) 2020/741 of the European parliament and of the council of 25 May 2020 on minimum requirements for water reuse. <https://eur-lex.europa.eu/eli/reg/2020/741/oj>
5. European Parliament and of the Council. Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration. 2006. Available online: <https://eur-lex.europa.eu/eli/dir/2006/118/oj>
6. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. 2006. Thematic Strategy for Soil Protection, COM(2006) 231 final. Available online: [http://ec.europa.eu/environment/soil/pdf/com\\_2006\\_0231\\_en.pdf](http://ec.europa.eu/environment/soil/pdf/com_2006_0231_en.pdf)
7. European Commission (2012). A Blueprint to Safeguard Europe's Water Resources. COM (2012) 673.
8. European Commission (2015). Closing the loop – An EU action plan for the Circular Economy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM(2015) 614/2.
9. World Health Organization. (2006). Guidelines for Safe Use of Wastewater, Greywater and Excreta (Vol. 2). Geneva, Switzerland. Available online: <https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/sanitation-safety/guidelines-for-safe-use-of-wastewater-greywater-and-excreta>
10. ISO- International standardization Organization. (2020). Guidelines for the use of treated wastewater in irrigation projects. ISO 16075-1. 2020. Geneva, Switzerland Spain. Available online: <https://www.une.org/encuentra-tu-norma/busca-tu-norma/iso?c=073482>
11. Lazarova, V. 2015. ISO standards on water reuse for irrigation. June 25th, 2015 - Suez Environment Presentation.

### CHAPTER 2. Strategies

1. United Nations General Assembly (UNGA). (2015). Transforming our world: The 2030 agenda for sustainable development. Resolution adopted by the General Assembly on

## I-ReWater

- 25 September 2015 (A/RES/70/1). Retrieved November 27, 2018, from <https://sustainabledevelopment.un.org/post2015/transformingourworld>
- UN-Water (2017). Integrated Monitoring Guide for Sustainable Development Goal 6 on Water and Sanitation — Targets and global indicators. Available online: [https://www.unwater.org/sites/default/files/app/uploads/2017/10/G2\\_Targets-and-global-indicators\\_Version-2017-07-14.pdf](https://www.unwater.org/sites/default/files/app/uploads/2017/10/G2_Targets-and-global-indicators_Version-2017-07-14.pdf)
  - United Nations Human Settlements Programme (UN-Habitat) and World Health Organization (WHO). (2021). Progress on wastewater treatment—Global status and acceleration needs for SDG indicator 6.3.1. UN-Habitat and WHO. [https://unhabitat.org/sites/default/files/2021/08/sdg6\\_indicator\\_report\\_631\\_progress\\_on\\_wastewater\\_treatment\\_2021\\_english\\_pages.pdf](https://unhabitat.org/sites/default/files/2021/08/sdg6_indicator_report_631_progress_on_wastewater_treatment_2021_english_pages.pdf)
  - United Nations Human Settlements Programme (UN-Habitat) and World Health Organization (WHO). (2024). Progress on the proportion of domestic and industrial wastewater flows safely treated. Mid-term status of SDG Indicator 6.3.1 and acceleration needs, with a special focus on climate change, wastewater reuse and health. UN-Habitat and WHO. [https://www.unwater.org/sites/default/files/2024-08/SDG6\\_Indicator\\_Report\\_631\\_Progress-on-Wastewater-Treatment\\_2024\\_EN\\_0.pdf](https://www.unwater.org/sites/default/files/2024-08/SDG6_Indicator_Report_631_Progress-on-Wastewater-Treatment_2024_EN_0.pdf)
  - El pla de sanejament. Govern d'Andorra. (2024). <https://www.govern.ad/ca/tematiques/medi-ambient-i-sostenibilitat/aigua/el-sanejament/el-pla-de-sanejament>
  - Delgado, A., Rodriguez, D. J., Amadei, C. A., & Makino, M. (2021). Water in Circular Economy and Resilience (WICER). World Bank, Washington, DC. <http://hdl.handle.net/10986/36254>
  - ISO- International standardization Organization. (2020). Guidelines for the use of treated wastewater in irrigation projects. ISO 16075-1. 2020. Geneva, Switzerland Spain. Available online: <https://www.une.org/encuentra-tu-norma/busca-tu-norma/iso?c=073482>
  - Lazarova, V. 2015. ISO standards on water reuse for irrigation. June 25th, 2015 - Suez Environment Presentation.
  - Rebelo, A. et al., 2020. Rebelo, A., M. Quadrado, A. Franco, N. Lacasta, P. Machado. 2021. Water reuse in Portugal: New legislation trends to support the definition of water quality standards based on risk characterization. Water Cycle 1 (2020) 41–53.
  - UN 2023 Water Conference in New York (22-24 March, 2023). <https://www.unep.org/un-2023-water-conference>
  - Regulation (EU) 2020/741 of the European parliament and of the council of 25 May 2020 on minimum requirements for water reuse. <https://eur-lex.europa.eu/eli/reg/2020/741/oj>
  - Decreto-Lei n.º 119/2019. Diário da República n.º 159 – Série I, pp. 21-44. Lisboa, 21 de Agosto de 2019. Available online: <https://diariodarepublica.pt/dr/detalhe/decreto-lei/119-2019-124097549>
  - Decreto-Lei n.º 16/2021. Diário da República n.º 38 – Série I A. Artigo 7º. Lisboa, 24 de Fevereiro de 2021. Available online: <https://diariodarepublica.pt/dr/detalhe/decreto-lei/16-a-2021-158316443>
  - ERSAR, 2024. Relatório Anual dos Serviços de Águas e Resíduos em Portugal – RASARP-2024. Available online: <https://www.ersar.pt/pt/publicacoes/relatorio-anual-do-setor>

## I-ReWater

15. Gómez-Ramos, A., Blanco-Gutiérrez, E., Ballesteros-Olza, M., & Esteve, P. (2024). Are Non-Conventional Water Resources the Solution for the Structural Water Deficit in Mediterranean Agriculture? The Case of the Segura River Basin in Spain. *Water*, 16(7)(929). doi:10.3390/w16070929
16. MITECO (2010). Plan Nacional de Reutilización de Aguas. Versión preliminar, Madrid. Available online: [https://www.miteco.gob.es/content/dam/miteco/es/agua/participacion-publica/version\\_preliminar\\_pnra231210\\_tcm30-136850.pdf](https://www.miteco.gob.es/content/dam/miteco/es/agua/participacion-publica/version_preliminar_pnra231210_tcm30-136850.pdf)
17. MITECO (2020). FOMENTO DE LA REUTILIZACIÓN DE LAS AGUAS RESIDUALES (Borrador). Informe complementario, Madrid. Available online: [https://www.miteco.gob.es/content/dam/miteco/es/agua/temas/concesiones-y-autorizaciones/6\\_ic\\_reutilizacion\\_1\\_tcm30-514162.pdf](https://www.miteco.gob.es/content/dam/miteco/es/agua/temas/concesiones-y-autorizaciones/6_ic_reutilizacion_1_tcm30-514162.pdf)
18. Royal Decree 1620/2007, de 7 de diciembre, por el que se establece el régimen jurídico de la reutilización de las aguas depuradas. 2007. Madrid, Spain. Available online: <https://www.boe.es/eli/es/rd/2007/12/07/1620/con>
19. MITECO (2010). Guía para la Aplicación del R.D. 1620/2007 por el que se establece el Régimen Jurídico de la Reutilización de las Aguas Depuradas. Madrid. Available online: [https://www.miteco.gob.es/content/dam/miteco/es/agua/temas/concesiones-y-autorizaciones/GUIA%20RD%201620\\_2007\\_tcm30-213764.pdf](https://www.miteco.gob.es/content/dam/miteco/es/agua/temas/concesiones-y-autorizaciones/GUIA%20RD%201620_2007_tcm30-213764.pdf)
20. AEAS-AGA. (2022). XVII Estudio Nacional de Suministro de Agua Potable y Saneamiento en España 2022. Available online: <https://www.aeas.es/component/content/article/52-estudios/estudios-suministro/301-xvii-estudio-nacional-aeas-aga?Itemid=101>
21. Royal Decree 1085/2024, de 22 de octubre, por el que se aprueba el Reglamento de reutilización del agua y se modifican diversos reales decretos que regulan la gestión del agua. Available online: <https://www.boe.es/eli/es/rd/2024/10/22/1085/con>
22. AEDyR (2019). Cifras de reutilización de agua en España 2019. AEDyR. Asociación Española de Desalación y Reutilización. Available online: <https://aedyr.com/cifras-reutilizacion-agua-espana/>
23. Center for Studies and Expertise on Risks, Environment, Mobility, and Urban Planning. (2020). Reuse of Treated Wastewater: The French Overview. Knowledge Collection, Cerema, 46 p.
24. Lombard-Latune, R., & Bruyère, M. (2023). Overview of the Reuse of Treated Wastewater in France in 2022. Epnac.
25. General Council for Food, Agriculture, and Rural Areas (CGAAER), General Inspectorate of Social Affairs (IGAS), & General Inspectorate of the Environment and Sustainable Development (IGEDD) (2023). Facilitating the Use of Non-Conventional Water: Flash Mission. Paris: Government.
26. French Government. (2019). Water Assizes: Summary of Work and Measures for Sustainable Water Management.
27. French Government. (2022). Conclusions of the Agricultural Water Summit and Adaptation to Climate Change.
28. French Government. (2023). Water Plan: A National Strategy for Sustainable Water Resource Management.
29. Ministry of Ecological Transition and Territorial Cohesion. (2024). Resilience Plan for the Pyrénées-Orientales.

30. BfR. (2022). Reclaimed wastewater in agriculture: health risk from pathogens on fruit and vegetables? German Federal Institute for Risk Assessment (BfR). Available online: [https://www.bfr.bund.de/en/press\\_information/2022/28/reclaimed\\_wastewater\\_in\\_agriculture\\_health\\_risk\\_from\\_pathogens\\_on\\_fruit\\_and\\_vegetables\\_-304028.html](https://www.bfr.bund.de/en/press_information/2022/28/reclaimed_wastewater_in_agriculture_health_risk_from_pathogens_on_fruit_and_vegetables_-304028.html)

### CHAPTER 3. Legislation

1. World Health Organization. (2006). Guidelines for Safe Use of Wastewater, Greywater and Excreta. Geneva, Switzerland. Available online: <https://www.who.int/teams/environment-climate-change-and-health/water-sanitation-and-health/sanitation-safety/guidelines-for-safe-use-of-wastewater-greywater-and-excreta>
2. World Health Organization. (2017). Potable reuse: Guidance for producing safe drinking-water. Geneva, Switzerland. Available online: <https://www.who.int/publications/i/item/9789241512770>
3. ISO- International standardization Organization. (2013). Standardization of water reuse of any kind and for any purpose. ISO/TC 282. Geneva, Switzerland. Available online: <https://www.iso.org/committee/4856734.html>
4. ISO- International standardization Organization. (2020). Guidelines for the use of treated wastewater in irrigation projects. ISO 16075-1. 2020. Geneva, Switzerland Spain. Available online: <https://www.une.org/encuentra-tu-norma/busca-tu-norma/iso?c=073482>
5. Environmental Protection Agency (EPA). (2017). Potable Reuse Compendium. Washington D.C., USA.. Available online: [https://www.epa.gov/sites/default/files/2018-01/documents/potablereusecompendium\\_3.pdf](https://www.epa.gov/sites/default/files/2018-01/documents/potablereusecompendium_3.pdf)
6. SBDDW-23-001 (2023). California State Water Resources Control Board. Direct Potable Reuse Regulations (SBDDW-23-001). California, USA. Available online: [https://www.waterboards.ca.gov/drinking\\_water/certlic/drinkingwater/dpr-regs.html](https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/dpr-regs.html)
7. EPHCA (2006). Water Quality Australia. Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (EPHCA, 2006). Adelaide, Australia. Available online: <https://www.waterquality.gov.au/sites/default/files/documents/water-recycling-guidelines-full-21.pdf>
8. MHR (1996). Hygienic Requirements to Wastewater and Sewage Sludge Use for Land Irrigation and Fertilization. Moscow, Rusia. Available online: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC091914/>
9. AMP EID (2010). Effluent Quality Standards and Rules for Sewage Treatment. Israel. Available online: <https://ampeid.org/documents/israel/effluent-quality-standards-and-rules-for-sewage-treatment-2010%22/>
10. MW&I. (2016). Water Substitution and Reuse Policy. Ministry of Water and Irrigation Jordan. Available online: <https://www.fao.org/faolex/results/details/en/c/LEX-FAOC169805/>
11. P.R.C.(SAC) (2021). Water reuse guidelines-water quality management for water reclamation plants (GB/T 41018-2021). Available online: <http://std.samr.gov.cn/gb/search/gbDetailed?id=D4BEFFF4EAD8B241E05397BE0A0AF581>

## I-ReWater

12. MLIT (2005). Ministry of Land Infrastructure Transport and tourism (MLIT). 下水処理水の再利用水質基準等 マニュアル. Available online: <https://www.mlit.go.jp/kisha/kisha05/04/040422/05.pdf>
13. Council of the European Communities. Council Directive 80/778/EEC of 15 July 1980 relating to the quality of water intended for human consumption. 1980. Available online: <https://eur-lex.europa.eu/eli/dir/1980/778/oj>
14. Council of the European Communities. Council Directive 91/271/EEC of 21 May 1991 Concerning Urban Waste-Water Treatment. 1991. Available online: <http://data.europa.eu/eli/dir/1991/271/oj>
15. Commission of the European Communities. Commission Directive 98/15/EC of 27 February 1998 amending Council Directive 91/271/EEC with respect to certain requirements established in Annex I. 1998. Available online: <http://data.europa.eu/eli/dir/1998/15/oj>
16. European Parliament and Council. Directive 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment. <https://eur-lex.europa.eu/eli/dir/2024/3019/2024-12-12>
17. European Parliament and Council. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 Establishing a Framework for Community Action in the Field of Water Policy. Off. J. L 2000, 327, 1–73. Available online: <https://eur-lex.europa.eu/eli/dir/2000/60/oj>
18. Commission Directive 2014/101/EU of 30 October 2014 amending Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for Community action in the field of water policy. Text with EEA relevance. Available online: <https://eur-lex.europa.eu/eli/dir/2000/60/2014-11-20>
19. European Parliament and of the Council. Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration. 2006. Available online: <https://eur-lex.europa.eu/eli/dir/2006/118/oj>
20. European Parliament and of the Council. Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council. Available online: <http://data.europa.eu/eli/dir/2008/105/oj>
21. European Parliament and of the Council. Directive 2013/39/EU of the European Parliament and of the Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy Text with EEA relevance. Available online: <http://data.europa.eu/eli/dir/2013/39/oj>
22. European Parliament and of the Council. Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. 1991. Available online: <https://eur-lex.europa.eu/eli/dir/1991/676/oj>
23. European Commission. Water scarcity and droughts. 2007. Available online: [https://environment.ec.europa.eu/topics/water/water-scarcity-and-droughts\\_en](https://environment.ec.europa.eu/topics/water/water-scarcity-and-droughts_en)

## I-ReWater

24. European Commission. A water blueprint for Europe. 2012. Available online: <https://op.europa.eu/en/publication-detail/-/publication/4890db5a-ddc9-4181-9d39-8a277faef30b>
25. European Commission. Closing the loop - An EU action plan for the Circular Economy. 2015. Available online: [https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC\\_1&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF)
26. European Parliament and of the Council. Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse. Available online: <http://data.europa.eu/eli/reg/2020/741/oj>
27. BOE. Ley 29/1985, de 2 de agosto, de Aguas. 1985. Madrid, Spain. Available online: <https://www.boe.es/eli/es/rdlg/2001/07/20/1/con>
28. BOE. Real Decreto Legislativo 1/2001, de 20 de julio, por el que se aprueba el texto refundido de la Ley de Aguas. 2001. Madrid, Spain. Available online: <https://www.boe.es/buscar/act.php?id=BOE-A-2001-14276>
29. BOE. Ley 11/2005, de 22 de junio, por la que se modifica la Ley 10/2001, de 5 de julio, del Plan Hidrológico Nacional. 2005. Madrid, Spain. Available online: <https://www.boe.es/buscar/doc.php?id=BOE-A-2001-13042>
30. BOE. Real Decreto 907/2007, de 6 de julio, por el que se aprueba el Reglamento de la Planificación Hidrológica. 2007. Madrid, Spain. Available online: <https://www.boe.es/eli/es/rd/2007/07/06/907>
31. BOE. Real Decreto 1620/2007, de 7 de diciembre, por el que se establece el régimen jurídico de la reutilización de las aguas depuradas. 2007. Madrid, Spain. Available online: <https://www.boe.es/eli/es/rd/2007/12/07/1620/con>
32. Royal Decree 1085/2024, de 22 de octubre, por el que se aprueba el Reglamento de reutilización del agua y se modifican diversos reales decretos que regulan la gestión del agua. Available online: <https://www.boe.es/eli/es/rd/2024/10/22/1085/con>
33. DOGC. Decreto Legislativo 3/2003, de 4 de noviembre, por el que se aprueba el Texto refundido de la legislación en materia de aguas de Cataluña. 2003. Barcelona, Spain. Available online: <https://www.boe.es/buscar/doc.php?id=DOGC-f-2003-90016>
34. BOJA. Ley 9/2010, de 30 de julio, de Aguas para Andalucía. 2010. Sevilla, Spain. Available online: <https://www.boe.es/eli/es-an/l/2010/07/30/9/con>
35. DOR. Ley 5/2000, de 25 de octubre, de saneamiento y depuración de aguas residuales de La Rioja. Logroño, La Rioja. Available online: <https://web.larioja.org/normativa?n=42>
36. DOR. Decreto 39/2018, de 2 de noviembre, por el que se aprueba el Plan Director de saneamiento y depuración 2016-2027 de la Comunidad Autónoma de La Rioja. Available online: <https://web.larioja.org/normativa?n=dyn-na02561>
37. DOG. Ley 1/2022, de 12 de julio, de mejora de la gestión del ciclo integral del agua. [https://www.xunta.gal/dog/Publicados/2022/20220812/AnuncioC3B0-210722-0001\\_es.html](https://www.xunta.gal/dog/Publicados/2022/20220812/AnuncioC3B0-210722-0001_es.html)
38. Monte, M.H.F.M. (2007). Guidelines for Good Practice of Water Reuse for Irrigation: Portuguese Standard NP 4434. In: Zaidi, M.K. (eds) Wastewater Reuse—Risk Assessment, Decision-Making and Environmental Security. NATO Science for Peace and Security Series. Springer, Dordrecht.
39. ISO 20419:2018. Treated Wastewater Reuse for Irrigation — Guidelines for the Adaptation of Irrigation Systems and Practices to Treated Wastewater. International

- Organization for Standardization. Geneva. Available online: <https://www.iso.org/standard/67959.html> ISO 20419:2018
40. Decreto-Lei n.º 119/2019. Diário da República n.º 159 – Série I, pp. 21-44. Lisboa, 21 de Agosto de 2019. Available online: <https://diariodarepublica.pt/dr/detalhe/decreto-lei/119-2019-124097549>
41. Decreto-Lei n.º 16/2021. Diário da República n.º 38 – Série I A. Artigo 7º. Lisboa, 24 de Fevereiro de 2021. Available online: <https://diariodarepublica.pt/dr/detalhe/decreto-lei/16-a-2021-158316443>
42. BOPA. M.I. Consell General. Llei de Policia i Protecció de les Aigües (1985). 1985. Andorra. Available online: <https://www.mediambient.ad/images/stories/PDF/departament/Lleidaigues19852.pdf>
43. BOPA. Reglament de control de les aigües residuals i de protecció de les aigües superficials. 1996. Available online: <https://www.bopa.ad/Documents/Detail?doc=44FE>
44. JORF. Décret n° 2023-835 du 29 août 2023 relatif aux usages et aux conditions d'utilisation des eaux de pluie et des eaux usées traitées. 2023. Paris, France. Available online: <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000048007367>

#### CHAPTER 4. Methodology

1. U.N. (2021). Valuing water, The United Nations world water development report. Available online: [https://unhabitat.org/sites/default/files/2021/07/375724eng\\_1.pdf](https://unhabitat.org/sites/default/files/2021/07/375724eng_1.pdf)
2. CEDEX (2010). Evaluación del impacto del cambio climático en los recursos hídricos en régimen natural. Available online: [https://www.miteco.gob.es/content/dam/miteco/es/cambio-climatico/publicaciones/publicaciones/Memoria\\_encomienda\\_CEDEX\\_tcm30-178474.pdf](https://www.miteco.gob.es/content/dam/miteco/es/cambio-climatico/publicaciones/publicaciones/Memoria_encomienda_CEDEX_tcm30-178474.pdf)
3. Bates, B.C., Kundzewicz, Z.W., Wu, S., & Palutikof, J.P. Eds., (2008). El Cambio Climático y el Agua. Documento técnico del Grupo Intergubernamental de Expertos sobre el Cambio Climático, Secretaría del IPCC, Ginebra, 224 págs. Available online: <https://archive.ipcc.ch/pdf/technical-papers/ccw/climate-change-water-sp.pdf>
4. World Resources Institute (2024). Aqueduct: Aqueduct Water Risk Atlas. Accessed: December 2024 <https://www.wri.org/applications/aqueduct/water-risk-atlas>
5. Llop, M., & Ponce-Alifonso, X. (2016). Water and agriculture in a Mediterranean region: The search for a sustainable water policy strategy. *Water*, 8(2), 66.
6. Lee, K., & Jepson, W. (2020). Drivers and barriers to urban water reuse: A systematic review. *Water Security*, 11, 100073
7. Fernandes, E., & Cunha Marques, R. (2023). Review of water reuse from a circular economy perspective. *Water*, 15(5), 848.
8. Mainali, B., Ngo, H. H., Guo, W. S., Pham, T. T. N., Wang, X. C., & Johnston, A. (2011). SWOT analysis to assist identification of the critical factors for the successful implementation of water reuse schemes. *Desalination and Water Treatment*, 32(1-3), 297-306.
9. Michailidis, A., Papdaki-Klavdianou, A., Apostlidou, I., Lorite, I. J., Pereira, F. A., Mirko, H., ... & Lopez, A. L. (2015). Exploring treated wastewater issues related to agriculture in Europe employing a quantitative SWOT analysis. *Procedia Economics and Finance*, 33, 367-375.

10. Mesa-Perez, E., Exposito, A., Casielles, R., & Berbel, J. (2020). SWOT Analysis of Reclaimed Water Use for Irrigation in Southern Spain. *Water Reuse Within a Circular Economy Context*, 2. United Nations Educational, Scientific and Cultural Organization (UNESCO), pp. 141–153.
11. Starkl, M., Amerasinghe, P., Essl, L., Jampani, M., Kumar, D., & Asolekar, R. S. (2016). Rapid assessment and SWOT analysis of non-technical aspects of natural wastewater treatment systems. *Natural Water Treatment Systems for Safe and Sustainable Water Supply in the Indian Context: Saph Pani*, IWA Publishing, London, 283-300.
12. Nagara, G., Lam, W. H., Lee, N. C. H., Othman, F., & Shaaban, M. G. (2015). Comparative SWOT analysis for water solutions in Asia and Africa. *Water Resources Management*, 29, 125-138.
13. SUWANU Europe. The Project. 2019. Available online: <https://suwanu-europe.eu/water-reuse-projects-europe/>
14. Neri, A., Rizzuni, A., Garrone, P., & Cagno, E. (2024). Barriers and drivers to the development of an effective water reuse chain: insights from an Italian water utility. *Clean Technologies and Environmental Policy*, 1-21.
15. SUWANU Europe. Deliverable 2.1-Report on SWOT and PEST Analyses for Implementation of Reuse Practices. Málaga (Spain). 2020. Available online: <https://suwanu-europe.eu/portfolio/suwanu-europedeliverable-2-1/>
16. Canaj, K., & Mehmeti, A. (2024). Unveiling drivers and barriers in advancing agricultural wastewater reuse in Southern Italy: A SWOT analysis informed by stakeholder insights. *Cleaner Water*, 1, 100008.
17. Boulay, A. M., Bare, J., Benini, L., Berger, M., Lathuillière, M. J., Manzardo, A., ... & Pfister, S. (2018). The WULCA consensus characterization model for water scarcity footprints: assessing impacts of water consumption based on available water remaining (AWARE). *The International Journal of Life Cycle Assessment*, 23, 368-378.
18. Huijbregts, M. A., Steinmann, Z. J., Elshout, P. M., Stam, G., Verones, F., Vieira, M., ... & Van Zelm, R. (2017). ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. *The international journal of life cycle assessment*, 22, 138-147.

## CHAPTER 5. Key strategies lines, Action Plan. Disclosure and implementation process

1. BOJA. (2024). Acuerdo de 19 de noviembre de 2024, del Consejo de Gobierno, por el que se aprueba la formulación de la Primera Estrategia de Recursos Hídricos no Convencionales de Andalucía. Consejería de Agricultura, Pesca, Agua y Desarrollo Rural. Junta de Andalucía. Available online: [https://www.juntadeandalucia.es/boja/2024/228/BOJA24-228-00005-54443-01\\_00311390.pdf](https://www.juntadeandalucia.es/boja/2024/228/BOJA24-228-00005-54443-01_00311390.pdf)