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Choice Tree

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Main Authors	Alice LABOURET		
Contributors	Mery VASQUEZ Claire ALBASI Magali GERINO Irea TOUCHE Antonina TORRENS		

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1. Introduction

1.1 Context of the choice tree

The growing pressure on freshwater resources is one of the major challenges of the 21st century, particularly for the agricultural sector, which is the world's largest consumer. Increasing droughts, greater variability in rainfall due to climate change, and competition between different uses are exacerbating tensions over this strategic resource. In this context of scarcity, the REUSE of treated water is emerging as a promising and necessary adaptation solution. By replacing part of the freshwater withdrawals with an alternative, purified and locally available resource, the REUSE of Treated Water is fully in line with the principles of the circular economy, which aims to "close the loop" on water and nutrients. While pioneering countries such as Israel and Singapore are demonstrating the feasibility of this approach by recycling up to 90% of their effluents, France, with a REUSE of Treated Water rate of less than 1%, reveals considerable untapped potential and persistent reluctance. Spain and Portugal are already in this adaptation with slightly higher percentages of recycled water.

1.2 The problematics of the "choice tree tool"

The transition from technical demonstration to widespread adoption of REUSE of treated water in agriculture faces a complex set of barriers. On a technical level, the diversity of treatment methods, from conventional "grey" processes (activated sludge, membrane bioreactors) to extensive "green" solutions based on nature (lagooning, constructed wetlands), makes choosing the optimal chain particularly difficult. This decision must take into account multiple parameters: the physicochemical and microbiological quality of the source of raw water, the type of crops to be irrigated, the available surface area, and the investment and operating costs. On the regulatory front, although Regulation (EU) 2020/741 has established a harmonized framework at the European level with a risk-based approach and the "fit-for-purpose" principle, its national transposition in France, Spain, and Portugal introduces specificities and differentiated requirements, creating a complex regulatory landscape that is difficult for project developers to navigate. Finally, on a socio-cognitive level, the adoption of REUSE of treated water by farmers and local authorities is hampered by a lack of knowledge about purification performances, a perception of health risks that is often greater than the actual risks, and a glaring lack of operational tools to guide decision-making.

It is precisely to address these issues that the European Interreg SUDOE SOLLAGUA project ("Solutions based on Nature and Living Labs for rural water REUSE of Treated Water") has been set up. This project aims to co-develop and deploy resilient water management strategies based on Nature-Based Solutions (NBS) and a Living Lab approach, focused on the user and experimentation

in real-world conditions. In this context, the design of a decision support tool (DST) in the form of a choice tree is a key part of Work Package 1. Its purpose is to translate complex scientific and regulatory expertises into structured and accessible decision-making tools. This choice tree helps stakeholders identify wastewater treatment methods that are suited to their needs and the quality of the water to be recycled. This tree should provide a set of possible solutions of water treatment that belong from green and grey solutions. The next step of the stakeholder approach that related to the choice of the best option between green and grey solutions after the decision tree output, will be made with the help of other tools such as life cycle analyses (LCA) of green and grey solutions (Deliverable 1.4)

1.3 Choice Tree, an innovative term for a user centered tool

The choice of the term "Choice Tree" rather than "Decision tree" is deliberate and semantically rich. It reflects a user-centered design philosophy and recognizes the complexity of REUSE of treated water projects, where the "best" solution is often contextual and multidimensional. "Choice tree" follows a deterministic and prescriptive logic. A classic "choice tree," in the field of decision support, generally follows a binary logic (yes/no) that leads to a single, optimized solution considered to be the final "decision." It is a classification tool that aims to reduce uncertainty in order to arrive at a prescription. In the context of REUSE of treated water, this could imply that there is only one ideal treatment pathway for a given situation, which is rarely the case.

The term "Choice Tree," on the other hand, follows a logic of exploration and informed compromise. The Choice Tree aims to present a range of possible and relevant solutions at the end of each stage. It does not prescribe a single decision, but shows the panel of options available to the user, explaining the associated compromises. Its role is to broaden the field of possibilities. By presenting several treatments (for example, an extensive one such as a planted filter, a conventional one such as a membrane bioreactor, and a hybrid one), the tool avoids technological bias and encourages consideration of alternative solutions. In the literature, several decision support systems (DSS) have been developed to help stakeholders in the treatment option choice for green and grey solutions. Usually, most of these previous DSS are focusing on only one type of green solutions (NBS) or grey solutions. Despite their potential, most DSS for selecting technologies for wastewater treatment primarily focus on conventional (grey) technologies. For instance, a recent review of 24 sanitation DSS tools revealed that none of them specifically addressed NBS (Ddiba et al., 2023). Only recently in 2023, to facilitate treatment wetlands implementation, a first decision-support tool was developed within the MULTISOURCE European Project (https://multisource.eu/, based on Acuña et al. (2023)) intending to establish the relationship between TW designs and treatment performances.

In 2026 the Nat4Wat decision- support system (DSS) was developed to help stakeholders selecting, comparing, and evaluating NBS options for wastewater treatment and stormwater management (Pueyo-ros et al. 2026). However this type of tool centered on one type of technology is not helpful for selecting the several options that objectively are available and adapted among green and grey solutions. The originality of the Sollagua choice tree is the mixture of NBS and "traditional" grey treatment systems in the provided solutions , leaving the users in the position of selection regarding other economic and carbon footprint criteria with information coming from other sources. This choice highlights the multidimensional nature of the decision: the "best" treatment is not just a question of purification performance. It is a trade-off between technical, economic (CAPEX/OPEX), environmental (LCA), available space, maintenance complexity, and social acceptability criteria. The Choice Tree structures technical and regulatory information, but leaves the end user responsible for the final trade-off based on their own constraints and priorities. The additional criteria which may be subjective (e.g., alignment with agroecological values, economic values, carbon footprint, etc..) should come from external sources or Sollagua LCA for comparison between green and grey solutions (Deliverable 1.4). This also promotes ownership and co-construction because, by offering choices, the tool positions itself not as an expert imposing a solution, but as an assistant facilitating reflection. This approach is perfectly aligned with the Living Lab methodology of the SOLLAGUA project, which advocates co-design with stakeholders. This Living Lab (LL) approach, i.e., an open innovation system, is centered on users and stakeholders, with experimentation in real-world contexts playing a central role (Janin et al., 2013). The term "Living Lab" was first used in 1996 by William Mitchell of the Massachusetts Institute of Technology (MIT) (Béjean et al., 2021). It is a space for testing new services, tools, or uses on a "full scale" by exposing them to different panels of users. The Water Oriented LL strategy for Nature Based Solution adoption is described in the Sollagua deliverable 2.2.

Inspired by the methodological principles identified in scientific literature, the adopted approach for the choice tree building was based on an iterative process combining design phases, user feedback, adjustments, and new experiments. The goal is to promote an inclusive partnership approach between the public, private, and citizen spheres to accelerate innovation (Bardey, 2021). As part of the SOLLAGUA project, this method made it possible to gradually build a decision-making tool on wastewater REUSE of treated water, adapting to the real needs of stakeholders in the field, local authorities, farmers, and technical experts, and taking into account local specificities. By making the user involved in the whole process of solution identification, the end-users are remaining in control of its decision and this strategy favors the adoption of the selected solution. In the reverse way, a

solution that would arrive to a stakeholder from top-down decision would enhance the chance of project's abortion or interruption.

1.4 Objectives of this deliverable

The objective of task D1.2 is to show the methodology, iterative construction, the contain and validation field of this choice tree. It details how, based on an in-depth technical and regulatory state of the art, an alpha version was designed, then enriched and transformed into a beta version through a co-construction process with stakeholders in the Couserans region and beyond. This Living Lab approach, combining semi-structured interviews, user testing, and rapid prototyping, made it possible to tailor the tool to the real needs and practical constraints of farmers and managers. Finally, this work describes the automation of the tool through the development of a Python script, the first step towards its sustainability as an interactive platform. The last step of toll transcription into a numerical version to make it available on Sollagua platform is not included in this deliverable. Thus, this deliverable does not merely describe a theoretical tool; it reports on the creation of an operational instrument designed to provide concrete support to regional stakeholders in making informed choices about appropriate treatment methods, thereby helping to accelerate the transition to more resilient agriculture and circular water resource management.

2. Tool design framework

2.1 Positioning within the project

Within the SOLLAGUA project, the Choice Tree is not limited to being a simple technical tool for process optimization. It occupies a strategic position at the interface between technological innovation, water governance, and the agro-ecological transition of territories. Its role goes beyond the mere selection of treatment processes to become part of a systemic vision of sustainable water resource management.

The Choice Tree is a tool for technological democratization of water REUSE of Treated Water from domestic and rain waters. By presenting conventional ("grey") processes and Nature-Based Solutions ("green") such as constructed wetlands or lagooning on an equal footing, it actively contributes to the promotion of the latter. It thus removes a major obstacle to their adoption: their lack of recognition by traditional players in the agricultural and water management sectors. By quantifying their treatment performance using simulation matrices and integrating them into credible treatment chains, the tool gives them technical legitimacy equivalent to conventional solutions, thereby promoting their consideration in regional projects.

The agro-ecological transition involves rethinking material and energy flows. The Choice Tree perfectly embodies this principle by transforming wastewater, perceived as waste, into a resource. By guiding users towards REUSE of treated water solutions, it contributes to closing local water and nutrient (nitrogen, phosphorus) cycles. It thus equips territories, particularly rural ones, in their quest for greater water autonomy facing climate variability, a fundamental pillar of agro-ecological resilience. The iterative design of the tool, using the Living Lab methodology, makes it a vehicle for dialogue and awareness-raising. The testing process with farmers not only served to improve ergonomics; it also provided an opportunity for discussion and education on REUSE of treated water. By making the possibility of safely reusing water tangible and understandable, the Choice Tree helps to change mindsets and overcome psychological and cultural barriers, which are often the main obstacle to the adoption of innovative practices.

The SOLLAGUA project aims to create synergies between stakeholders (research, local authorities, farmers). The Choice Tree acts as a translator or a boundary object: it formalizes complex scientific expertises (regulations, process performance) into a more simple language and structure that can be used by local authority technicians or agricultural advisors or farmers themselves. It thus facilitates the exchange of knowledge and better coordination between the different levels of decision-making, from the farm to inter-municipal water management.

It is the common thread that links the objectives of the SOLLAGUA project: it makes the SFNs identified in the portfolio operational (WP1 task D1.1 "Portfolio") and helps to respond to the

identification of needs (WP2 task D2.1 "Stakeholder needs"), reflecting the work of this Interreg project. It was tested and co-constructed in Sollagua Water Oriented Living Labs (WP2-D 2.2), and by facilitating the implementation of concrete projects, it helps to remove barriers to large-scale adoption (WP3). By providing tools for more circular, resilient, and territorialized water management, it ultimately contributes to the construction of agricultural systems aligned with the principles of agroecology.

2.2 Fit-for-purpose approach and multiple barrier principle

The Choice Tree is fundamentally based on two inseparable and structuring conceptual pillars: the "fit-for-purpose" approach and the principle of multiple barriers. These two foundations ensure that the tool offers solutions that are not only compliant, but also robust, efficient, and adapted to the realities on the ground.

The "fit-for-purpose" principle is at the heart of the Choice Tree philosophy. It consists of adapting the level and type of treatment to the quality required for the intended end use, in this case agricultural irrigation. This approach contrasts with a single vision that would seek to produce standardized quality water, often over-treated and therefore economically and energetically inefficient.

The "fit-for-purpose" approach is translated into the Choice Tree in a concrete and operational way. It is first reflected in the modularity of the treatment chains: the tree is structured in distinct successive phases : primary, secondary, tertiary, and disinfection, allowing for great flexibility. This means that users are not systematically directed towards a complete and potentially costly process; on the contrary, they can stop at the end of the secondary phase if the matrix check indicates that regulatory compliance for their specific use has already been achieved. This modularity is underpinned by a focus on usage from the very first stages. The tool integrates the type of irrigation envisaged, whether for food crops consumed raw, fodder, or industrial crops, which determines the target quality class (A, B, C, or D according to European regulations) and influences the entire decision-making process. Finally, this approach eliminates over-treatment. By guiding users toward achieving the sufficient and necessary level of quality, rather than a standardized maximum quality, the Choice Tree promotes economically viable and energy-efficient REUSE of treated water, a decisive argument for its adoption by farmers concerned about the profitability of their investments.

At the same time, the Choice Tree is based on the principle of multiple barriers, a fundamental safety strategy that aims to put in place several successive lines of defense to control risks, particularly health risks. The central idea is that if one barrier fails, the next one or ones provide redundant protection. This principle, which underpins modern regulations such as Regulation (EU) 2020/741 imposing a risk management plan, is fully integrated into the tool's logic.

Its implementation in the Choice Tree is systemic. First, each treatment step is designed as a specific barrier. Primary, secondary, tertiary, and disinfection treatments form a series of successive and complementary barriers, each targeting the reduction or elimination of distinct categories of contaminants (TSS, BOD5, nutrients, pathogens). Second, simulation matrices serve as a tool for objectively verifying the effectiveness of these barriers. Secondary matrices, for example, make it possible to precisely quantify the effectiveness of the secondary treatment barrier and verify whether the quality of the water produced complies with regulations for the intended use. Any non-compliance detected automatically triggers the proposal of an additional barrier, such as tertiary treatment or disinfection. Finally, the tool embodies an integrated defensive logic: the tree's reasoning structure methodically guides the user towards the construction of a system that, as a whole, forms a robust and coherent system of barriers. This design goes far beyond simply meeting thresholds at the station outlet; it ensures the implementation of an intrinsic and safety water treatment chain, reinforcing confidence in the practice of REUSE of treated water.

The “fit-for-purpose” approach and the multiple barrier principle are not mutually exclusive; they reinforce each other in the Choice Tree. The former defines the objective to be achieved (the water quality for the targeted use), while the latter defines the method for achieving it safely (the stacking of barriers). The Choice Tree is therefore the operationalization of this synergy: it guides the user in designing a process that is both fit-for-purpose and safe (multiple barriers), avoiding both under-protection and waste of resources. This dual logic is essential for building the confidence of users and health authorities, which is a prerequisite for the deployment of REUSE of treated water.

2.3 Limitations identified upstream

From its initial design, the choice tree had several structural limitations that could compromise its suitability for real-world situations. The first concerned the accessibility of the regulatory framework. The tool was designed to directly incorporate the complexity of French, Spanish, and Portuguese regulatory texts, without any mechanism for translating this complexity for non-specialists. This approach implicitly assumed that users were already familiar with the distinctions between the different quality classes (A, B, C, D) and their implications, which was a risky assumption given the widespread lack of knowledge about REUSE of treated water observed during initial discussions with stakeholders.

Furthermore, the assumed universalism of the design represented a major pitfall. The initial tree had been developed according to a standardized technical and regulatory logic, without sufficient consideration of the heterogeneity of the contexts of use. However, the fundamental differences between the target countries (such as farmers' living arrangements or the nature of water stress) were not sufficiently integrated into the tool's architecture. Similarly, the variability of local constraints

(available land, investment capacity, skilled labor) was not systematically incorporated as a criterion for distinguishing between the proposed technical solutions.

Technical terminology bias was inherent in the expert-led design. The systematic use of specialized terms (BOD5, TSS, tertiary treatment) without an integrated popularization mechanism created an immediate barrier to entry for uninitiated users. The very structure of the tree, modeled on the technical process of water treatment, did not take into account the mental representations and technical literacy level of the target audiences, risking to render the tool unusable without systematic support from experts.

These three limitations : regulatory opacity, inappropriate universalism, and technical jargon, revealed a gap between the technical sophistication of the tool and the actual ability of its end users to grasp it, fully justifying the Living Lab approach and the successive iterations that followed.

These limitations were overcome thanks to a Living Lab methodology that placed the user at the heart of the improvement process. The regulatory approach was redesigned by creating simplified and automated compliance matrices, transforming complex texts into binary indicators (compliant/non-compliant) that could be used directly. The question of country and type of irrigation was integrated from the outset, enabling the tool to automatically select the applicable regulatory framework.

To solve the problem of universalism, the tree has evolved towards greater modularity. Local constraints (available surface area, budget, level of technical expertise) have been taken into account at each decision-making stage, allowing technical options to be filtered according to the user's specific context. Different versions have been designed to respond to the specific characteristics of each country and type of user.

Finally, the barrier of technical vocabulary was removed through a major effort to simplify the language: creating explanatory posters, rephrasing questions in accessible language, and developing a user guide. Automation via Python scripting ultimately made it possible to mask the technical complexity while retaining it in the calculation engine, thus offering a simple interface without sacrificing scientific rigor.

3. Design Methodology

3.1 Tools used

The Choice Tree was built using a systematic triangulation methodology, combining scientific, regulatory, and empirical sources to ensure both the technical robustness and operational usefulness of the tool.

To create this decision tree, several tools were used at each stage (Table 1):

Table 1. Tools used for the construction of this tool and their features.

Tool used	Tool function
Scientific gates	These are websites that compile verified scientific articles. Bibliographic research consists of identifying books and articles relevant to this tool and gathering information that allows to familiarize with choice algorithms (Fragnière, 2023). The main websites used during this research are: HAL Science, ResearchGate, ScienceDirect, MDPI, Cairn, etc.
Canva	An online design and publishing tool whose mission is to enable everyone to create. It is used to create slideshows, posters, and more. Application used for the aesthetic creation of the tree of choices.
Excel	Microsoft Excel is a spreadsheet program. Excel spreadsheets allow matrix creation and management of farmers appointments. It also allows to build and store tables of data and calculations. It is a workbook containing several spreadsheets. A tool for creating graphs.
Python	A computer language that allows you to write programs to automate various repetitive tasks. This process is called "scripting."

Logiciel R	R is a data processing software program that allows users to perform complex data treatment on large amounts of data and generate accurate graphical illustrations. It is an object-oriented programming language in which each piece of data is stored in an object that must be named.
Microsoft Word	It is word processing software published by Microsoft.
Scribbr	List of all sources used in my scientific research. This tool allows you to format your bibliography in order and includes: 1. the names of the authors 2. the titles of the works 3. the names and locations of the companies that published your copies of the sources 4. the publication dates of your copies

Table 2: Summary of the method used during the process of the Choice Tree

Steps	Methodology	Tool(s) used
Bibliography	-Review of scientific and technical literature on REUSE of Treated Water and water treatment. -Study of regulations in France, Spain, and Portugal. -Study of farmers' needs.	-Scientific portals (Researchgate, Sciences Direct, HAL sciences, etc.) -Scribbr (sources)
Data processing and modeling	-Development of a script to create the decision tree -Structuring of criteria (regulatory, technical, economic, environmental).	R, Python
Creation of primary matrices	Development of retention matrices by primary treatments. Bibliography then formatted into tables.	Excel
Creation Tree of Choices	Tree of choices already made by the previous intern and modifications according to bibliography	Canva

Field validation 1	Practical application/Testing of the tree with potential users in Couserans	In-person interviews
Final modifications Choice Tree	-Completion of the final "beta" version of the decision tree after feedback from interviews. -Creation of posters accompanying the decision tree	Canva
Field validation 2	Practical application/Testing of the tree with potential users in France	Phone interviews
Writing and formatting	Development of a user guide to facilitate its adoption	Word

To summarize the different steps of the Choice tree (Table 2) building were :

1. Bibliography

2. Data processing and modeling
3. Creation of the Choice Tree
4. Creation of primary matrices
5. Field validation through interviews with farmers
6. Modification of the Choice Tree
7. Creation of a Python script
8. Creation of an HTML script for digitization
9. Writing and formatting
10. Final presentation

3.2. Sources Used

3.2.1. Scientific and technical foundations

The Choice Tree was constructed based on a systematic review of scientific and technical literature, enabling the purification performance of different treatment technologies to be accurately quantified. This approach drew on several types of complementary sources:

Peer-reviewed scientific publications were the main reference for establishing retention rates. The work of Mainardis et al. (2021) on wastewater fertigation provided a conceptual framework for the agronomic integration of REUSE of treated water, while that of Capodaglio (2020b) formalized the "fit-for-purpose" approach as a structuring principle for the selection of treatments. For specific technical data, the study by Tarón-Dunoyer et al. (2017) was decisive in characterizing the performance of primary treatment, particularly coagulation-flocculation processes. Zarrouk's (2020) research provided a detailed comparative analysis of conventional processes, supplemented by contributions

from Belmihoub (2023) on biological treatments and Fernanda & Leonardo (2022) on disinfection technologies.

Technical documents and professional guides enriched the operational data. The Memento Degremont (2004) provided detailed information on membrane technologies, while reports from the French National Agency for Water and Aquatic Environments (ONEMA, 2015) provided feedback on the actual performance of French wastewater treatment plants.

The SOLLAGUA project research reports played a crucial role in the selection of treatments. The portfolio of techniques (SOLLAGUA D1.1, 2024), written by Antonina Torrens, presented a comparative analysis of 17 processes according to standardized performance and feasibility criteria, identifying the most promising treatment chains for rural contexts in southwestern Europe (Table 3, 4, 5, 6).

Table 3: Comparison of retention rates for primary treatments

Retention rates (in %)	BOD5	COD	Nitrogen	TSS	Grease and fats	Turbidity	E. Coli
Coagulation Flocculation and clarification (CFC)	56,70	58,20	98	88,63	95	90,70	-
Primary clarifier	33,00	30,00	-	55,00	-	-	-
Hydrocyclone	51,50	54,50	-	69,33	87,63	26,00	-
Septic tank	66,56	69,95	40,97	67,83	65,12	-	55,16
Imhoff tank	31,25	33,75	-	54,00	-	-	-
Grease trap	86,77	78,23	76,10	88,69	-	-	99,00

Table 4 : Comparison of retention rates for secondary treatments

Retention rates (in %)	TSS	BOD5	NT	Phosphorus	E. coli	Intestinal parasites	Heavy metals
Ponds	35.85	64.48	28	17	99.64	100	46
Free-flowing wetlands	49.63	39.4	50	60	95.05	100	77.3
Wetlands with underground drainage	67.5	78	35	65.69	99.98	98	77
Membrane bioreactor	86	90	28.3	38.75	94	100	70.83
Activated sludge	77.83	90.88	54	35.6	99.26	74.44	53.14

Table 5: Comparison of retention rates for tertiary treatments

Retention rates (in %)	Emerging contaminants	Heavy metals	Nutrients	Organic matter	Pathogenic microorganisms
Sand Biofilter	>95%	>90% at neutral pH	50-80%	89-99%	>90%
Reverse osmosis	between 55% and 99%	95-99%	99.9%	90-98%	97-99,8%
Ozonation	50-70%	99.9%	99.9%	99.9%	-
Nanofiltration	80-90%	99.9%	99.9%	99.9%	>90%
Activated Carbon	90-99%	99.9%	99.9%	99.9%	79 %

Table 6: Comparison of retention rates for disinfection treatments

Retention rates (in %)	Stability	Formation of by-products	Interaction with MO	Contact time	Bacteria	Virus	Protozoa
Chlore	Relatively unstable	21	OUI	HOURS	4 u.log	4 u.log	3 u.log
O3	Unstable	8	OUI	Minutes	3 u.log	4 u.log	4 u.log
UV	Na	None	NON	None	3 u.log	2 u.log	3 u.log

All of this data has been summarized in comprehensive comparative tables that list retention rates for each parameter (BOD5, COD, TSS, total nitrogen, total phosphorus, E. coli, heavy metals) and for each treatment family. These tables feed directly into the Choice Tree simulation matrices, ensuring that the tool's recommendations are based on validated and up-to-date technical data.

3.2.2. Regulatory framework in Spain, France and Portugal

The regulatory analysis was conducted using a multi-level approach, ensuring the tool's compliance with the entire legal framework applicable to WWTP effluent for each country of Sollagua project . This analysis was based on exhaustive documentation of official texts and interpretation guides.

Table 7: Regulation of WWTP effluent quality thresholds for agricultural irrigation in European Union, Eur-Lex, 2020

Tableau 2 — Exigences de qualité applicables à l'eau de récupération destinée à l'irrigation agricole

Classe de qualité de l'eau de récupération	Objectif technologique indicatif	Exigences de qualité				
		E. coli (nombre/100 ml)	DBO_5 (mg/l)	MES (mg/l)	Turbidité (NUT)	Autre
A	Traitement secondaire, filtration et désinfection	≤ 10	≤ 10	≤ 10	≤ 5	*Legionella* spp.: < 1 000 ufc/l lorsqu'il existe un risque de formation d'aérosols
B	Traitement secondaire et désinfection	≤ 100	Conformément à la directive 91/271/CEE (Annexe I, tableau 1)	Conformément à la directive 91/271/CEE (Annexe I, tableau 1)	–	Nématodes intestinaux (œufs d'helminthes): ≤ 1 œuf/l pour l'irrigation des pâturages ou des fourrages
C	Traitement secondaire et désinfection	≤ 1 000			–	
D	Traitement secondaire et désinfection	≤ 10 000			–	

At the European level, Regulation (EU) 2020/741 (Table 7) of the European Parliament and of the Council of May 25, 2020 served as the universal legal basis. This text, analyzed through its publication in the Official Journal of the European Union and commented on by the Adour-Garonne Water Agency (AEAG, 2021), established the architecture of the four quality classes (A to D) and defined the minimum requirements for microbiological (E. coli, intestinal nematodes) and physicochemical (BOD_5, TSS, turbidity). Its risk management approach directly influenced the structure of the Choice Tree.

At the national level, the analysis focused on the specific regulatory frameworks of each partner country:

3.2.2.1 French regulations

In France, REUSE of Treated Water is governed by several recent decrees, reflecting a political will to accelerate the deployment of alternative water uses:

- Decree No. 2023-835 of August 29, 2023: this decree sets out the conditions for the use of treated wastewater and rainwater for non-domestic purposes. It specifies the procedures for reviewing applications, the categories of use (agricultural, industrial, urban), and monitoring requirements.
- Decree No. 2024-33 of January 24, 2024: this extends the possibilities for REUSE of treated water to new sectors, particularly agri-food, by defining the safety and traceability conditions to be met in order to avoid any health risks (Cerema, 2024).
- Decree No. 2024-796 of July 12, 2024: specifies the conditions for using water unfit for human consumption in a domestic or agricultural setting, subject to treatment, and strengthens the responsibility of producers and facility managers (JCIndustries, 2024).

France also applies a prefectural authorization procedure, requiring a hazard study and an environmental impact assessment. This procedure is still considered complex and cumbersome by many stakeholders in the field, although it is essential for health safety consideration.

3.2.2.2 Spanish regulations

REUSE of treated water is governed by Royal Decree 1620/2007 of December 7, 2007, which is one of the most comprehensive frameworks in Europe. It defines:

- Authorized uses (agriculture, industry, urban use, leisure).
- Specific quality parameters for each use.
- Rigorous authorization procedures with analytical monitoring and risk management.

Table 8: Spanish regulations on water REUSE of Treated Water in agriculture, Royal Decree 1620/2007 of December 7, Esaragua, 2011

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES	*ESCHERICHIA COLI*	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
2. AGRICULTURAL USES[1]					
QUALITY 2.1[2] a) Crop irrigation using a system whereby reclaimed water comes into direct contact with edible parts of crops to be eaten raw.	1 egg/10 L	100 CFU/100 mL Based on a 3-class sampling plan[3] with the following values: n = 10 m = 100 CFU/100 mL M = 1,000 CFU/100 mL c = 3	20 mg/L	10 NTU	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. *Legionella spp.* 1,000 CFU/L (if there is a risk of aerosolization) It is compulsory to conduct detection tests for presence-absence of pathogen (*Salmonella*, etc.) when results repeatedly show that c=3 for M=1,000.

INTENDED USE OF WATER	MAXIMUM ACCEPTABLE VALUE (MAV)				
	INTESTINAL NEMATODES	*ESCHERICHIA COLI*	SUSPENDED SOLIDS	TURBIDITY	OTHER CRITERIA
QUALITY 2.2 a) Irrigation of crops for human consumption using application methods that do not prevent direct contact of reclaimed with edible parts of the plants, which are not eaten raw but after an industrial treatment process. b) Irrigation of pasture land for milk- or meat-producing animals. c) Aquaculture.	1 egg/10 L	1,000 CFU/100 mL Based on a 3-class sampling plan[1] with the following values: n = 10 m = 1,000 CFU/100 mL M = 10,000 CFU/100 mL c = 3	35 mg/L	No set limit	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. *Taenia saginata* and *Taenia solium:* 1 egg/L (when irrigating pasture land for milk- or meat-producing animals) It is compulsory to conduct detection tests for presence-absence of pathogen (*Salmonella*, etc.) when results repeatedly show c=3 for M=10,000.
QUALITY 2.3 a) Localized irrigation of tree crops whereby reclaimed water is not allowed to come into contact with fruit for human consumption. b) Irrigation of ornamental flowers, nurseries and greenhouses whereby reclaimed water does not come into contact with the crops. c) Irrigation of industrial non-food crops, nurseries, silo fodder, cereals and oilseeds.	1 egg/10 L	10,000 CFU/100 mL	35 mg/L	No set limit	OTHER CONTAMINANTS included in the treated effluent disposal permit: discharge of these contaminants to the environment must be limited. In the case of hazardous substances, use of reclaimed water must comply with environmental quality standards. *Legionella spp.* 100 CFU/L

This decree (Table 8) was reinforced in 2024 with Royal Decree 1085/2024 of October 23, 2024 (Table 9), which introduces new quality criteria in line with European Regulation 2020/741 and requires operators to develop systematic REUSE of Treated Water plans.

Table 9: Quality thresholds for the use of REUSE of Treated Water for agricultural purposes in Spain , Agencia Estatal Boletín Oficial del Estado, 2024

Table I-3. Maximum allowable value for agricultural use

Class	*E. coli* (CFU/100 mL)	Turbidity (UNT)	SS (mg/L)	DBO_5 (mg/L)	Intestinal nematodes (egg/L)	*Legionella spp.* (CFU/L)	*T. saginata and T. solium* (egg/L)	Contaminants
Quality A. A	10	5	10	10	1 for the watering of grasses or forage	< 1,000 when there is a risk of aerosolization	-	View observations
Quality A. B	100	-	According to DARU	According to DARU	1 for the watering of grasses or forage	< 1,000 when there is a risk of aerosolization	1 for meat-producing animal pastures	View observations
Quality A. C	1,000	-	According to DARU	According to DARU	1 for the watering of grasses or forage	< 1,000 when there is a risk of aerosolization	1 for meat-producing animal pastures	View observations
Quality A. D	10,000	-	According to DARU	According to DARU	1 for the watering of grasses or forage	< 1,000 when there is a risk of aerosolization	-	View observations

3.2.2.3 Portuguese regulations

The Portuguese framework is defined by Decree-Law No. 119/2019 of August 21, 2019, which establishes:

- An approach based on the concept of multiple barriers (Figure 1), i.e., the successive implementation of treatments and controls to ensure the safety of recycled water (Thomas, 2024).
- The need for authorization issued by APA (Agência Portuguesa do Ambiente), based on risk analysis and intended uses.
- A grid of requirements by use (agricultural, urban, industrial), with adapted parameters.

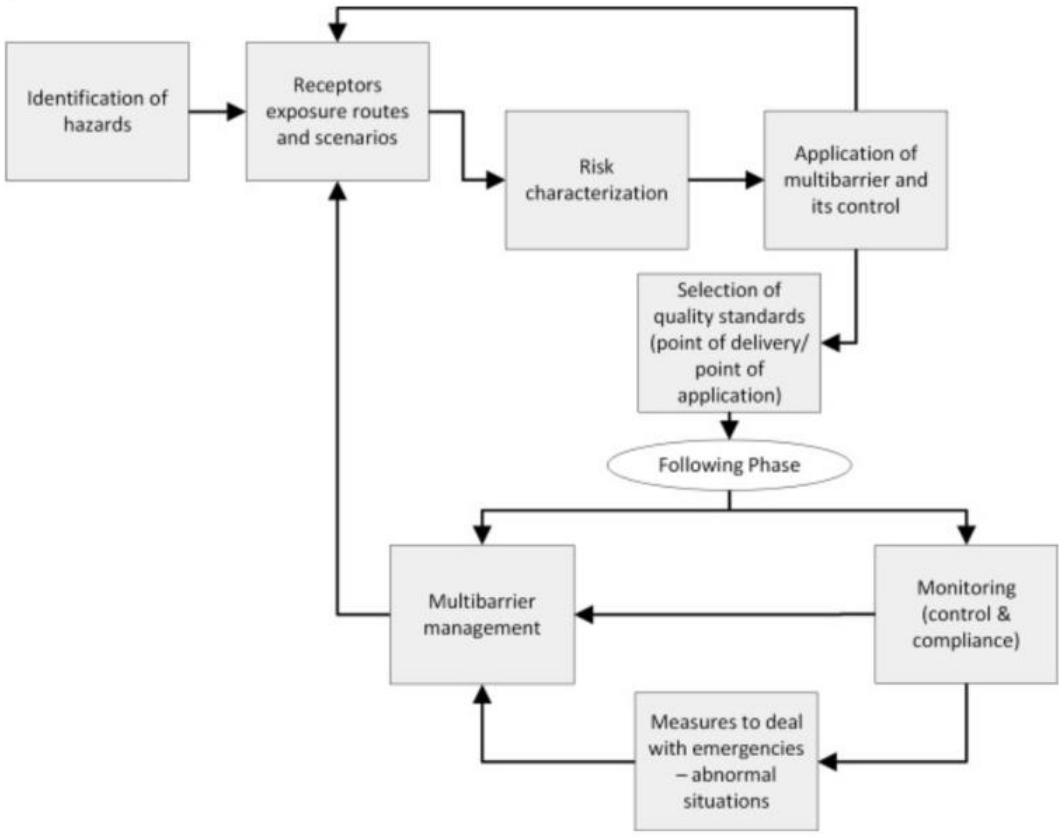

Figure 1. Risk assessment model under Portugal's new water REUSE of Treated Water policy, Rebelo et al. (2020)

The Portuguese decree stands out for its compatibility with European regulations and its proactive approach to promoting REUSE of treated water, particularly in the southern regions of the country that are highly exposed to water stress (Rebelo et al., 2020).

This comparative regulatory analysis has made it possible to construct country-specific compliance matrices (as illustrated in Appendices 35 and Tables 5 to 8 of this deliverable), which form the core of the Choice Tree verification system. The tool thus finely integrates the specific features of each legal framework, such as the French requirement to monitor *Clostridium perfringens* or the specificities of Spanish quality classes, while respecting fundamental European harmonization.

3.2.3 Field validation with interviews

The Living Lab method was implemented through two semi-structured interview campaigns:

- April 2025: Alpha version testing with farmers in Ariège (Foix and Savères markets), revealing difficulties in understanding technical vocabulary and practical concerns (seasonal storage, social acceptability)
- June 2025: Beta version testing extended to other French regions (Maine-et-Loire, Nord), confirming the need for automation and identifying specific needs depending on production contexts

This direct feedback, coupled with observations from the Couserans Living Labs, enabled the tool to be adjusted in critical areas: simplification of language, integration of practical criteria (available surface area, budget), and development of the Python interface for autonomous use.

This multidimensional approach ensures that the Choice Tree is neither a purely academic exercise nor a simple compilation of field feedback, but rather a hybrid tool that combines scientific expertise, regulatory constraints, and operational realities.

3.3. Construction process

The construction of the Choice Tree was orchestrated according to a rigorous methodology in three interdependent phases, transforming a complex knowledge base into an accessible operational tool. This process required the systematic formalization of decision-making parameters, the quantification of technical performance, and the integration of regulatory constraints into a coherent architecture.

3.3.1 Selection criteria

The definition of the fundamental selection criteria was the first decisive step to determine the process to adopt and the removal needed. Based on a cross-analysis of scientific literature and user feedback during Living Labs, five categories of parameters were identified and ranked to characterize the average quality of a "theoretical" source of waste water or rain water (Table 10, 11, 12 & 13). The type of agricultural use was differentiated according to the classification in EU Regulation 2020/741, distinguishing in particular between the irrigation of crops consumed raw, fodder, and industrial crops.

Table 10. Typical physicochemical parameters of wastewater from domestic uses

Type of wastewater/Physicochemical parameters	BOD5	TSS	Turbidity	Nitrogen	Phosphorus	Grease and fats	pH	Pathogens *(Viruses and Bacteria)*
Domestic Water	200-350	200-220 400	270	40	8-10.5	100	7.5-8	108 UFC/100 mL

Table 11. Typical physicochemical parameters of wastewater from industrial uses

Type of wastewater/Physicochemical parameters	BOD5	TSS	Turbidity	Nitrogen	Phosphorus	Grease and fats	pH	Pathogens *(Viruses and Bacteria)*
Industrial water	585	>250	>500	>232	<125	>100	9.17-9.7	106 UFC/100

Table 12. Average composition of rainwater (Aquavor, 2017)

Paramètres	Valeur Moyenne pour l'eau de pluie	Normes pour l'eau potable
pH	5,5 et 8	6,5 à 8,5
Conductivité (µS/cm)	90	< 2100
Nitrates (en mg/l de NO32-)	1,5	< 50
Ammonium (mg/l de NH4+)	0,022	< 0,1
Chlorures (en mg/l de Cl-)	6,5	< 250
Sulfates (mg/l de SO42-)	< 8	< 250
Magnésium (mg/l de Mg)	0,21	< 50
Zinc (mg/l de Zn)	466	< 5000
Fer (en mg/l de Fe)	< 50	< 200
Cadmium (µg/l de Cd)	< 10	< 5
Plomb (µg/l de Pb)	< 50	< 25

Table 13. Typical physicochemical parameters of wastewater from urban uses

Type of wastewater/Physicochemical parameters	BOD5	TSS	Turbidity	Nitrogen	Phosphorus	Grease and fats	pH	Pathogens *(Viruses and Bacteria)*
Urban Waters	350	300	<500	80	20	100	7.5-8.5	105-109 UFC/100 mL et 104 œufs/100

The required quality was calibrated to classes A to D of European regulations, while incorporating specific national requirements such as monitoring for *Clostridium perfringens* in France. The characterization of raw water types was based on standardized data for domestic, industrial, rainwater, and urban wastewater. The volumes to be treated were introduced as a criterion for distinguishing between individual and collective solutions, responding to farmers' practical concerns about the scalability of systems. Finally, local constraints : available space, budget, technical expertise, and social acceptability, were incorporated as essential filters, reflecting lessons learned from field interviews on the need to adapt solutions to the actual operating context.

3.3.2. Creation of matrices

The development of specialized treatment matrices was the most demanding technical quantification phase. For each stage of the purification process, detailed matrices were developed based on a meta-analysis of the performance documented in the scientific literature. Primary treatment was the subject of six comparative matrices evaluating the retention rates of primary settling tanks, hydrocyclones, septic tanks, and other processes. Secondary treatment was characterized using matrices specific to lagooning, constructed wetlands, and membrane bioreactors, incorporating their differentiated performance on TSS, BOD5, and nutrients. Tertiary treatment was organized according to a logic of specialization by type of residual pollutants (organic, microbiological, or emerging chemicals) with targeted technological options such as nanofiltration or granular activated carbon. Finally, disinfection was the subject of specific modeling focused on the logarithmic reduction of pathogens by UV, ozonation, or chlorination, which is crucial for meeting the sanitary requirements of the most sensitive agricultural uses.

The development of the Choice Tree matrices required the implementation of a specific modeling methodology, aimed at structuring technical and regulatory knowledge into a coherent and actionable system.

The architecture of the matrices was organized according to a logic of progressive specialization, where each level of treatment has its own representation modalities. For the primary matrices, a simplified structure was adopted, targeting fundamental parameters (TSS, BOD5, COD) with average retention rates from standardized studies. The secondary matrices introduced increased complexity, integrating specific parameters such as pathogen reduction and nutrients, with values differentiated according to the technologies. This stratification made it possible to strike a balance between comprehensiveness and usability, with each matrix being optimized for its particular decision-making context.

Modeling the interactions between parameters represented a major technical challenge. A weighting system was developed to take into account the synergistic or antagonistic effects between different treatment processes. For example, the effectiveness of UV disinfection was correlated with residual

turbidity levels, while the performance of biological processes was modulated according to BOD/COD ratios. These relationships were formalized through interaction coefficients validated by scientific literature, enabling a more realistic simulation of complete treatment chains.

The implementation of business rules was a crucial step in transforming data into decision-making intelligence. Specific algorithms were developed to handle special cases, such as incompatible treatments or mandatory sequences. The recommendation logic also incorporates operational constraints, such as the sensitivity of membranes to high TSS loads or the impact of seasonal variations on extensive processes. These rules ensure that the proposed solutions are technically consistent as a whole and not simply a juxtaposition of independent processes.

The uncertainty propagation mechanism has been integrated to reinforce the robustness of the recommendations. Each retention rate is associated with a confidence interval derived from the variability observed in the literature. The system thus calculates several possible scenarios and can identify the most resilient solutions in the face of fluctuations in inlet water quality or operational uncertainties. This approach makes it possible to assess the sensitivity of different treatment chains and to favor those with the best operational stability.

3.3.3. Selection of regulatory data

Integrated regulatory verification was the essential validation phase to ensure the compliance of the proposed solutions. A sophisticated automated verification system was implemented, based on three main components. Landscape compliance matrices were custom-developed for each national regulation, resulting in a corpus of 72 distinct matrices capable of handling the specificities of French, Spanish, and Portuguese regulations. An integrated calculation module enables systematic comparison between simulated treatment performance and applicable regulatory thresholds, transforming complex technical data into binary compliance indicators. A conditional decision-making logic has been designed to automatically trigger proposals for additional treatments in the event of detected non-compliance, thus embodying the principle of multiple barriers at the heart of modern REUSE of treated water regulations.

This systematic architecture enables Choice Tree to generate not a single, rigid solution, but a reasoned range of combinations that are technically viable, regulatory compliant, and adapted to the specific constraints of each project. It aims to embody as closely as possible the “fit-for-purpose” approach advocated by the SOLLAGUA project, while maintaining the health and safety requirements that underpin confidence in the practice of REUSE of treated water in agriculture.

3.3.4. Technical tools used:

The transformation of the Choice Tree into an operational tool was based on a chain of complementary technical tools, enabling the transition from a theoretical design to a concrete and scalable application.

The development of the Python script (choice_tree_python_script.py) materialized the algorithmic formalization of the decision-making logic. This module-structured code encapsulates the various critical functionalities: managing the user's journey through successive questions, querying treatment databases, and performing regulatory compliance calculations. The modular architecture adopted allows for easy maintenance and future developments, such as the addition of new countries or treatments. The implementation also incorporates robust error management mechanisms to ensure the stability of the tool in the face of atypical user input, and optimizes performance through data structures adapted to the processing of complex matrices.

The conversion to an interactive HTML interface was a decisive step towards adoption by end users. This transposition, developed in collaboration with Irea Touche (developer) from the Laboratoire du Génie Chimique (UMR5503 CNRS INP UT, France), transforms the tool into a web application accessible without any particular technical skills. This tool should be made available on the Sollagua interactive platform with access via the Interreg SUDOE web site of the project. The graphical interface is based on intuitive navigation that guides the user step by step, with contextualized input controls (adaptive drop-down lists, validated numeric fields) and immediate visual display of results. The strict separation between business logic (Python) and presentation (HTML/CSS) ensures both the sustainability of calculations and the flexibility of the user experience.

The integration of an external data management system guarantees long-term scalability. Regulatory parameters and technical processing characteristics are externalized in standardized configuration files (CSV, JSON), allowing them to be updated without modifying the source code. This approach also facilitates adaptation to other geographical or regulatory contexts and paves the way for collaborative maintenance by project partners.

4. Structure and functioning

4.1 General architecture

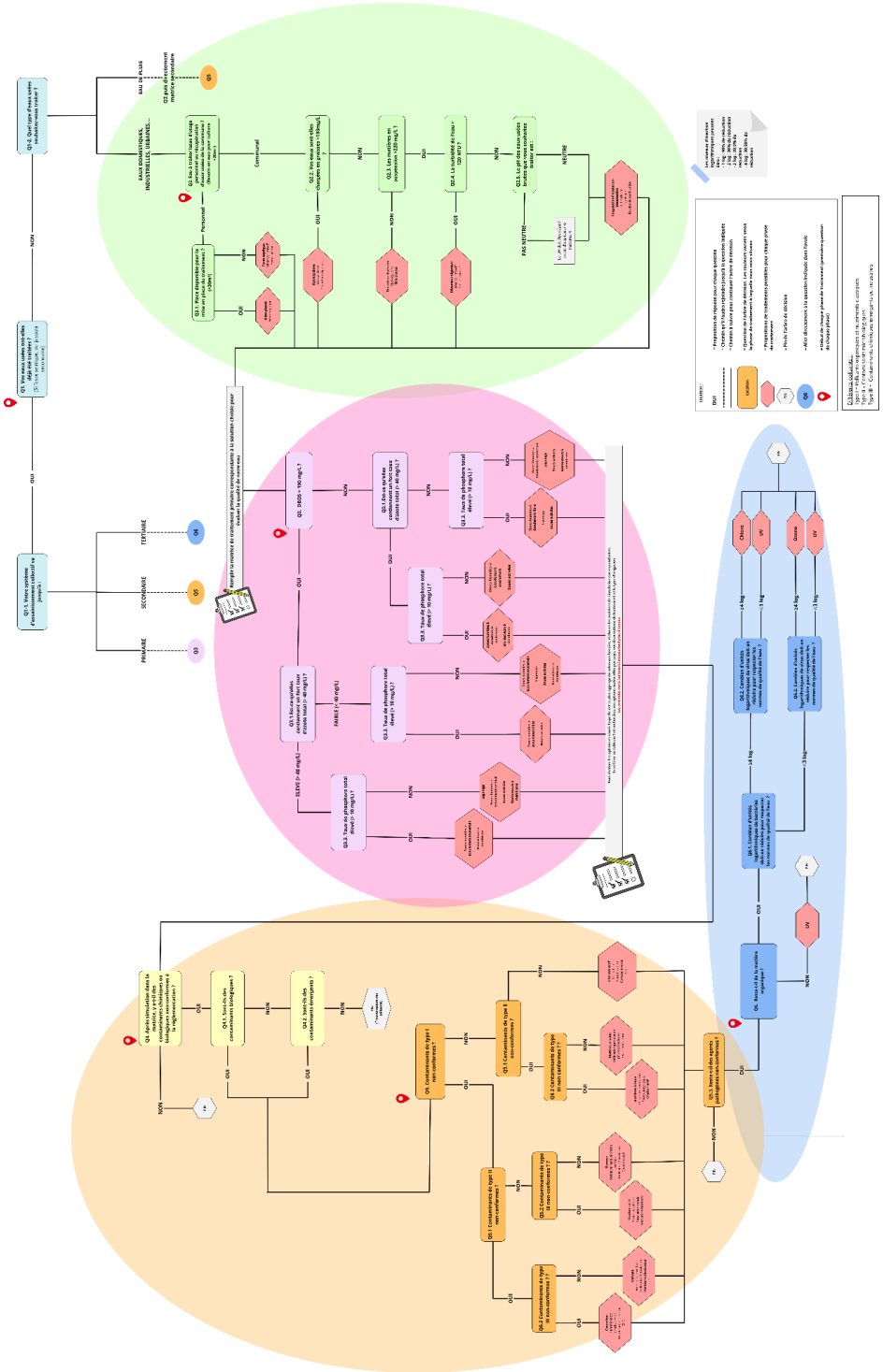

Figure 2: Overview of the choice tree structure

The choice tree was organized into successive modules corresponding to the major, classic phases of water treatment (pretreatment, primary, secondary, and tertiary treatment, and disinfection). For each module, a set of key questions was defined based on water quality parameters and the technology's capacity (Figure 2). This structure allowed for a modular approach for the end user, facilitating the gradual integration of new options and creating a clear link between diagnostics and technical solutions.

Once the logic was finalized, each decision path was coded in a binary format, with each row representing a given situation, each column a question ("yes/no"), and the last column indicating the recommended treatment. This table was then used as the basis for the computer modeling of the tree.

The construction of the choice tree took place in several successive phases. Initially, during 2024, an alpha version was developed based on the D1.1 Portfolio of the SOLLAGUA project, which presents a portfolio of wastewater treatment techniques. This initial version allowed for mapping all the technical solutions, both conventional and extensive, and associating them with usage contexts. This version was designed as a basis for reflection to structure possible treatment chains according to the quality of the incoming water and the intended end use. It was then transformed into a beta version, enriched by a literature review on the treatment efficiencies of different contaminants, a regulatory update including the new French decrees of 2024 concerning the possible uses of REUSE of Treated Water (LegiFrance, 2024), and field tests with farmers and local project developers.

The tree design process is based on the "fit-for-purpose" principle, meaning that the treatment is appropriate for the end-users. This requires prioritizing decision criteria around four main areas. First, the quality of the incoming water, based on indicator parameters such as BOD5, TSS, total nitrogen, phosphorus, and pathogens. The choice will also be guided by the type of end use (agricultural irrigation, green space, urban use, groundwater recharge, etc.), each with different quality requirements, as well as site constraints such as available space, estimated budget, and acceptable technical complexity. Finally, the regulatory and geographical context (France, Spain, Portugal) helps define the possible uses and applicable standards, which will allow for the selection of the most suitable treatments. These criteria are translated into questions, divided into several blocks according to the treatment phases. These questions help users understand the quality of the wastewater and the current state of wastewater recovery, making them understandable to end users (development agents, communities, agricultural advisors). They are organized in a tree structure to guide users toward a recommended treatment process (primary + secondary + tertiary + disinfection if needed).

The choice tree consists of a series of interconnected questions. The user should start with question Q1 (Choice Tree Design, SOLLAGUA Folder or Figure 2). The questions at this stage of the tree will

determine at which treatment stage the user begins to develop their treatment process. In some cases, the treatment process will begin with primary or secondary treatment, or supplement their existing wastewater treatment system with tertiary or disinfection treatment. If the user has no treatment facilities in the community, the treatment process will begin with primary treatment. At the end of the Q1 question series, the user will know where to go next.

Step Q2 focuses on the different treatment options available at the primary treatment stage. The questions center on the physicochemical parameters of the raw wastewater to be treated. At the end of this step, various green and grey options for primary treatment will be presented. It is important to note the treatment options presented at each stage throughout the choice tree, as the final options may differ depending on the tree's development. At the end of this stage of the choice tree, the user will be directed to question Q3. It is crucial to emphasize that if the water to be treated is rainwater, the user should proceed to question Q5. Reminders will be available as small notes outside the tree for the user's better understanding.

Step Q3 of the tree diagram consists of two parts. The first is a small branch of the tree, also focused on the physicochemical parameters of the raw wastewater to be treated. At the end of this branch, various possible green and grey solutions for secondary treatment will be proposed, which will be evaluated using a simulation matrix (see annexes document). All possible solutions must be evaluated using this simulation matrix, which constitutes the second part of Step 3. The simulation matrices are generated from precise information on the physicochemical parameters of the raw wastewater to be treated. To do this, the catalog of simulation matrices corresponding to the possible solutions proposed in the first part of Step Q4 must be consulted (see annexes document). Each matrix differs depending on the user's country, the type of irrigation planned for the wastewater, and the treatment options; hence the importance of selecting the correct categories.

The simulation matrices evaluate the contaminant removal capacity of each type of secondary treatment. Once the column for the physicochemical parameters of the raw wastewater to be treated is completed, the removal rate for each contaminant by the treatment must be calculated using the retention percentage indicated in the simulation matrix (percentages extracted from the compiled literature; see annexes document). The decision tree user has to choose the treatment process and to proceed to the calculation. This calculation will be used to verify the compliance by comparison with current regulations. If the regulations are met, the user will mark a 1; otherwise, they will mark a 0. This classification of compliance or non-compliance with regulations will be used to evaluate the best secondary treatment option and will form the basis for proceeding to the next step of the tree with the questions in step Q4. Once all the simulation matrices for possible solutions have been completed, the user can select the one(s) that comply with the regulations (in order to develop the next step of the tree).

Step Q4 of the choice tree serves as an interconnection between the simulation matrix and step Q5 (tertiary treatment). Here, the user decides whether or not to implement tertiary treatment to

complete their treatment process. Depending on the case, the user can determine whether their treatment process stops at secondary treatment or must be supplemented by tertiary treatment.

Step Q5 focuses on the different possible treatments at the tertiary treatment stage. Unlike the primary and secondary treatment stages, the questions here focus on the types of contaminants that do not comply with regulations and that must be removed. This requires considering the results obtained via the simulation matrix or the physicochemical parameters of the water at the outlet of the wastewater treatment plant (WWTP) that is to be supplemented with treatment. At the end of the tree, as at each step, various tertiary treatment alternatives, both grey and green, will be presented. Depending on the user's needs, they will be directed to step Q6, or the treatment process will be finalized at the tertiary treatment stage.

Step Q6 focuses on the different possible disinfection treatments. At the end of this step, the best possible treatment for reducing the number of pathogens in the wastewater will be proposed. The questions at this stage focus on the logarithmic units of viruses and bacteria to be reduced in the water. To do this, the user must consider the results obtained via the simulation matrix or the biological parameters of the wastewater treated by the wastewater treatment plant (WWTP) where disinfection treatment is to be implemented. Taking into account the quantity of each species of occurring pathogen, the user must estimate how many logarithmic units must be reduced to comply with regulations (according to their country and the type of irrigation planned).

4.2. Proposal for suitable processing chains

The suggested treatment chains embody the tool's philosophy of technological pluralism. The Choice Tree systematically provides a range of solutions balanced across three complementary categories. This approach goes beyond a simple technical compilation of the SOLLAGUA Portfolio (D1.1) by operationalizing its inventory through a logic of strategic combination. While D1.1 exhaustively listed 17 techniques according to their standardized performance, the Choice Tree introduces decisive added value by modeling their interactions and potential synergies. "Grey" or conventional treatment processes, such as membrane bioreactors or activated sludge, are valued for their compactness and stable treatment performance under controlled conditions. Their selection within the tree incorporates the Portfolio's technical specifications while contextualizing them: whereas D1.1 documented their average removal rates, the Choice Tree activates them only when spatial constraints or quality requirements absolutely justify it.

“Green” solutions, based on nature such as lagooning or constructed wetlands, are promoted for their low energy consumption and ecological co-benefits. Their integration goes beyond the scope of the initial technical catalog by quantifying their contribution to the resilience of rural areas – an identified but not operational dimension in the Portfolio. The tree thus allows for the technical legitimization of solutions sometimes perceived as secondary by demonstrating their suitability to specific contexts (mountainous areas, organic farms).

The true innovation lies in the "hybrid" systems that embody the Living Lab spirit of the project. The Choice Tree doesn't simply list juxtaposed options; it models optimized combinations where conventional treatment ensures basic abatement and the extensive solution guarantees robustness and tertiary purification. For example, combining physical pretreatment with a reed bed filter addresses both compactness requirements and agroecological needs. These combinations are calibrated to maximize complementarities: reduced operating costs for conventional systems through green pretreatment, or conversely, guaranteed performance of green systems through targeted technical support.

This avoids the pitfall of technological determinism that would limit options to either oversized conventional solutions or extensive solutions ill-suited to high loads. By systematizing the proposed combinations, the tool also educates users on a systemic view of processing, where optimization lies not in a single technology but in the orchestration of several processes. This approach directly reflects feedback from Living Labs, where flexibility and adaptability emerged as decisive criteria for the acceptability of REUSE of treated water projects.

4.3. Developed versions of the choice tree

4.3.1. Alpha version created in 2024

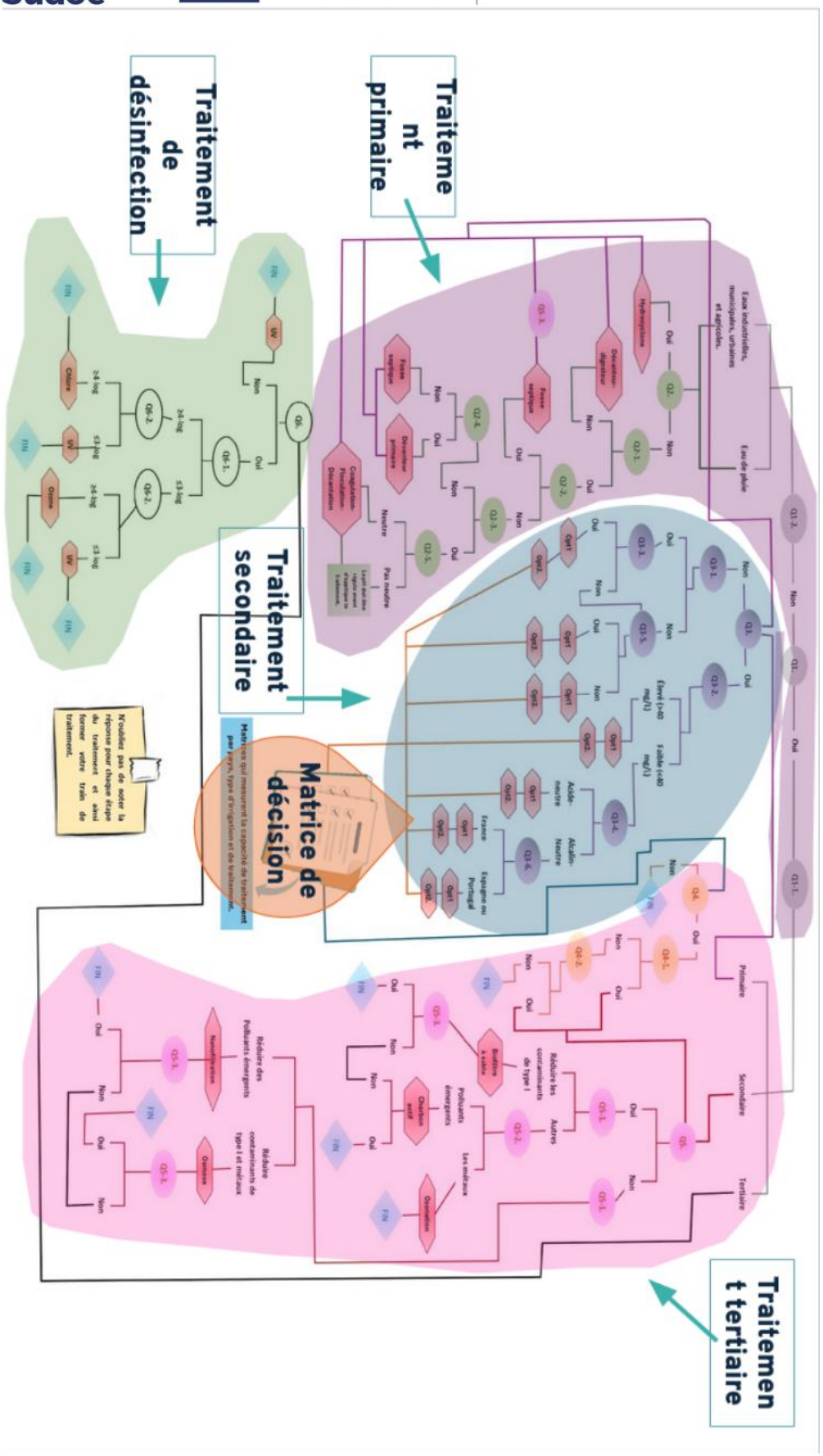

Figure 3: First version (V1) of the choice tree created in 2024

The alpha version of the choice tree, developed in 2024 by Mery Vasquez (Figure 3), was the first tangible manifestation of the decision-support tool concept for waste-to-energy (WTE) within the SOLLAGUA project. This preliminary work laid the essential foundations for subsequent development through three major contributions.

From a bibliographic perspective, this version established a solid knowledge base by compiling technical data on the performance of different treatment processes (pollutant removal rates, required surface areas, indicative costs). This comprehensive literature review, based on the treatment techniques portfolio (D1.1) and a systematic literature review, established the initial technical reference framework essential to the tool's scientific credibility.

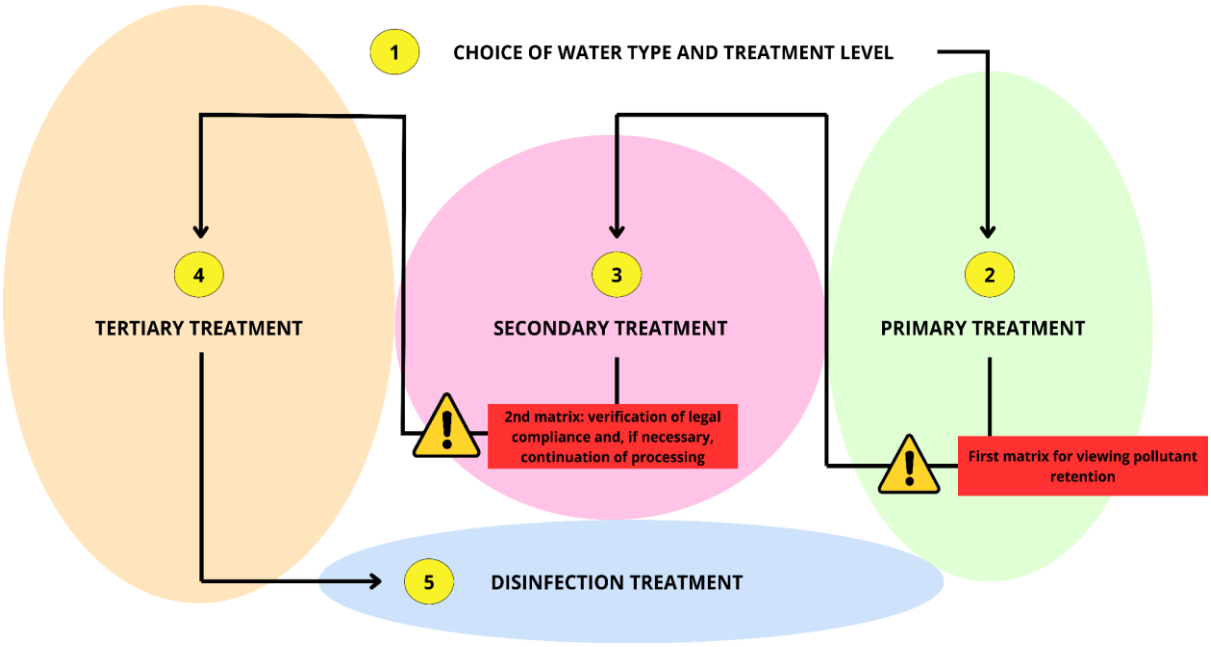

Figure 4: Diagram of the general functioning of the decision tree

From a structural perspective, the overall organization of the choice tree (Figure 4) into six sequences of questions (Q1 (choice of water type), Q2 (primary), Q3 (secondary), Q4 & Q5 (tertiary) to Q6 (disinfection)) defined the tool's fundamental architecture. This sequential structure, modeled on the conventional stages of wastewater treatment (pretreatment, primary, secondary, and tertiary treatment, and disinfection), established the progressive decision-making logic that characterizes the tool. The "fit-for-purpose" principle was integrated from this version, with treatments differentiated according to the water quality required for the intended agricultural use.

Finally, the introduction of the concept of decision matrices represented a significant methodological innovation. These matrices, which simulate treatment effectiveness and verify regulatory compliance, formed the operational core of the tool. Their initial design, while improvable, established the quantitative evaluation mechanism that already allowed for objective comparison of different treatment chains and validation of their suitability to the regulatory requirements of the three countries concerned.

Although not tested with end users, this alpha version provided the essential conceptual and technical framework for subsequent iterations. Its limitations, particularly regarding the complexity of the vocabulary and the cumbersome nature of the process, have precisely allowed us to identify the priority areas for improvement for subsequent versions, while preserving the fundamental architecture which has proven to be robust.

4.3.2. Intermediate (initial Python script).

```
213
214  def verifier_conformite():
215      print("\n=== Vérification de la conformité via annexe ===")
216
217      # Chargement des fichiers
218      tableau_annexe = pd.read_csv("annexeSecondaire.txt", sep="|", header=0)
219      tableau_contaminants = pd.read_csv("tableau2", sep="|", header=0)
220
221      # ===== BOUCLE PAYS (une seule fois) =====
222      pays_list = tableau_annexe['Pays'].dropna().unique()
223      while True:
224          print("\nDe quel pays êtes-vous ?")
225          for i, pays in enumerate(pays_list, 1):
226              print(f"{i} : {pays}")
227
228          try:
229              choix = int(input("\nChoisissez le numéro correspondant : "))
230              if 1 <= choix <= len(pays_list):
231                  pays_choisi = pays_list[choix - 1].strip()
232                  break
233              else:
234                  print(f"❌ Numéro invalide. Veuillez choisir entre 1 et {len(pays_list)}")

PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL  PORTS

De quel pays êtes-vous ?
1 : portugal
2 : france
3 : espagne

Choisissez le numéro correspondant : 2

Quel est le traitement utilisé ?
1 :  Zones humides à écoulement libre
2 :  Zones humides à écoulement souterrain
3 :  Boues activees
4 :  Bioreacteur à membrane
5 :  Lagunage

Choisissez le numéro correspondant : 4

Quel est l'usage prévu ?
1 :  Toutes les cultures vivrières consommées crues dont la partie comestible est en contact direct avec les eaux usées traitées et les tubercules consommés crus (1)
2 :  Les cultures vivrières consommées crues, dont la partie comestible est cultivée en surface et sans contact direct avec les eaux usées traitées, les cultures vivrières transformées et les cultures non alimentaires y compris celles destinées à l'alimentation des animaux producteurs de lait ou de viande,  cultures industrielles, cultures énergétiques et cultures de semences.
3 :  Cultures industrielles, cultures énergétiques et cultures de semences.

Choisissez le numéro correspondant : 2

✅ Annexe sélectionnée : 42
Quelle est la classe de votre eau selon la réglementation française ? (B/C) :
```

Figure 5 : Screenshot of part of the Python script and selection of corresponding matrices with appropriate questions.

The intermediate version, implemented as a Python script (Figure 5), marked a decisive step in the evolution of the decision support tool. This automation addressed two objectives: to strengthen the robustness of the decision-making process and to significantly accelerate the regulatory verification process.

From a technical standpoint, the script retained the sequential architecture of the alpha version, while adding conditional logic to accurately reproduce the decision-making sequences.

The modeling of the decision-making processes incorporates external data matrices via three reference files: a register of primary processing efficiency (tableau1.csv), a database mapping processes to efficiency numbers (annexePrimaire.txt), and a multinational regulatory corpus (tableau2.txt and annexeSecondaire.txt). The implementation of efficiency calculations follows the standard theoretical model: $Cs = Ce \times (1 - \eta/100)$, where Cs represents the outlet concentration, Ce the inlet concentration, and η the process-specific removal rate.

The compliance verification module operates using a nested multi-criteria selection algorithm: country → treatment technology → end use → quality class (for the specific case of French regulations). This verification includes the systematic integration of 72 simulation matrices, externalized in separate CSV files. This approach allows for a precise match between system performance and local regulatory requirements, with management of national specificities.

The primary treatment selection algorithms use decision functions based on critical thresholds: fat concentrations (>100 mg/L), suspended solids (>220 mg/L), turbidity (>120 NTU), and pH (6.5–8.5). For secondary treatment, the decision logic combines BOD5, total nitrogen, and total phosphorus parameters according to a Boolean matrix that determines the suitability of biological technologies.

Tertiary treatment follows a taxonomic approach based on the nature of residual contaminants, categorized into three classes: organic pollutants/nutrients (Type I), microbiological pollutants (Type II), and emerging chemical pollutants (Type III). Final disinfection uses an optimization model that selects the technology based on the logarithmic reduction levels required for bacteria and viruses.

Functionally, the script guided the user through a structured process, from raw water characterization to the selection of appropriate treatments for each phase. The automated regulatory verification module represented a significant improvement: it automatically calculated residual concentrations after treatment and compared them to country-specific regulatory thresholds (France, Spain, Portugal). This feature eliminated the risk of manual error and provided immediate compliance results.

By clearly separating technical data (processing performance, regulatory thresholds) from application logic, the script enabled rapid and targeted updates. This design facilitated adaptation to regulatory changes or the integration of new processing methods without requiring a complete code rewrite. This modular approach also provided a solid foundation for the future development of graphical interfaces, thus preparing the transition to a version more accessible to non-expert users.

The computerization of the reasoning process results in considerable time savings, a reduction in human error, and a seamless user experience. This makes the tool accessible to non-expert users while preserving the required technical complexity. It provides a usable basis for a future web

interface or mobile application. The script's interchangeable and scalable nature, thanks to its modular structure and external matrices, makes it a tool well-suited to changing contexts, particularly with regard to regulations governing the REUSE of treated water of waste. It is designed to be enriched (e.g., with new countries, treatments, or quality parameters) without requiring a complete rewrite of the program. Based on the Python script, continuing this automation, a developer, Mrs. Irea Touche from the Chemical Engineering Laboratory, is creating an HTML script, which will be hosted on a platform, to visualize the choice tree more graphically.

4.3.3. Beta (HTML interface tested and improved after interviews).

Figure 6 : Screenshot of the HTML script rendering used to create the choice tree

The beta version, embodied by an interactive HTML interface (Figure 6), represents the culmination of the SOLLAGUA decision support tool's evolution. This digital transformation marks a decisive step in the tool's accessibility and operationalization, while maintaining the algorithmic robustness of previous versions. Technically, the interface fully replicates the sequential architecture and decision-making logic of the intermediate Python script, but encapsulates them within a fluid and intuitive user experience. The HTML implementation enables dynamic management of diagnostic steps, from raw water characterization to the selection of appropriate treatments for each phase, with visual transitions that guide the user seamlessly. The qualitative feedback gathered from farmers and water managers during the two rounds of testing (April and June 2025) led to substantial functional and ergonomic improvements. From a functional standpoint, the questions have been simplified and reorganized to eliminate identified redundancies, such as the question about pH in the secondary phase, and new primary matrices have been created to more precisely quantify the effectiveness of pretreatments. The range of proposed treatments, particularly in the tertiary phase, has been significantly expanded to cover a more comprehensive spectrum of available technologies. From an ergonomic standpoint, a thorough redesign was carried out using Canva, resulting in a clearer and

better-structured visual interface with a step-by-step progression that reduces the cognitive load for the end user.

The regulatory verification module, a direct descendant of the Python script, operates according to the same nested multi-criteria selection algorithm : country → treatment technology → end use → quality class for French regulations, but now makes it accessible through an intuitive interface. The integration of external data matrices, including the 72 simulation matrices, is preserved and optimized for real-time calculations. The fundamental formula for treatment efficiency ($Cs = Ce \times (1 - \eta/100)$) remains at the heart of the system, but its application becomes transparent to the user, who benefits from immediate feedback on their project's compliance.

Alongside the interface development, educational materials, such as explanatory posters on wastewater REUSE of treated water and the tool's operation, have been designed to facilitate adoption by the target audiences. This interactive graphical interface, developed using a Python script by a team from the Chemical Engineering Laboratory, directly prepares the tool for hosting on the future Sollagua online platform, an essential condition for its long-term viability and widespread adoption.

By being hosted directly on the SOLLAGUA website, the tool will become accessible to a broad audience, farmers, local authority managers, and sanitation technicians, who will thus be able to easily and freely perform comprehensive wastewater treatment assessments. This web-based accessibility eliminates the barriers to entry previously posed by the need to master specialized software or programming languages, thus aligning the tool with its primary mission: to widely disseminate best practices for recycling water treatment chains building. Simultaneously, a dedicated mobile application is under consideration, which would further extend the tool's reach by offering offline access and an optimized user experience for field users, while maintaining the same technical rigor and structured decision-making approach as the web version. The beta version therefore shows the most advanced state of the tool, partially validated in real-world conditions and with a clear digitization roadmap that ensures its future operational viability.

A final version is expected to be finished before the 2026 year and a third part of the deliverable will be provided with the final HTLM code and a graphical interface.

5. Examples of choice tree usage

5.1 Presentation of 3 typical scenarios for using the Choice Tree

To illustrate the diversity of contexts for applying the choice tree within the SOLLAGUA project, three representative scenarios were modeled. They concretely demonstrate the tool's "fit-for-purpose" logic, which adapts the treatment process to the intended use, local constraints (technical, economic, and environmental), and the specific regulatory framework of each region. All proposed treatments are suggestions, not decisions made by the tree. The choice rests with the user.

5.1.1. Scenario 1 — France (Lot): Small, and isolated farm

This first scenario concerns an isolated farm of approximately 20 hectares, located in the Lot department. The farm specializes in sheep farming and forage crops and is not connected to the public sewage system. Its domestic and agricultural wastewater is treated autonomously, while irrigation and drinking water comes from a well whose flow rate becomes critical during the summer months. The location in a mid-mountain area, combined with a contrasting climate (harsh winters, dry summers), necessitates a robust, easy-to-maintain water REUSE of treated water solution that is completely independent of the mains water supply. The objective is therefore to secure the water supply while respecting the maintenance requirements and regulatory thresholds associated with Class D water use (irrigation of meadows and forage crops).

When navigating the tree view, the user first indicates the existing treatment level: the "primary" option here corresponds to the presence of a septic tank. This selection opens the Primary Treatment section in the interface, which presents the various options available in the corresponding appendix (all-water septic tank, settling tank, Imhoff tank, etc.). The calculation module (prim-eff) then applies the associated removal rates (from Table 1), allowing for the estimation of residual concentrations after this treatment. These values are used to determine whether a secondary or tertiary treatment stage is necessary. In a context of low flow rates and low-concentration domestic wastewater, a septic tank is a suitable system: robust, easy to maintain, and tolerant of load variations.

The next step in the process concerns the available surface area and the type of use (origin + available-space). The answers entered in the interface personal use and a surface area of approximately 30 m² guide the choice tree toward compact and low-tech solutions. The vertical flow reed bed filter is then proposed as a complementary unit, listed in the tool's appendices as a solution suitable for low flow rates. This process combines low operating costs, ecological co-benefits, and proven effectiveness in removing suspended solids (SS), BOD5, and microbial load. Its operation relies on a gravel bed with

decreasing grain size, planted with *Phragmites australis*, whose root system promotes substrate aeration and nitrification.

In the process flow diagram, selecting a 5 m³ septic tank with a pre-filter allows for the automatic calculation of the expected quality of the primary effluent. If the estimated concentrations are below the class D thresholds, the system is considered compliant; otherwise, the tool suggests adding a complementary planted filter. In this scenario, the combination of a septic tank and a reed bed filter is generally sufficient to meet class D requirements without the need for disinfection. The process flow diagram then verifies regulatory compliance and, upon detecting that the thresholds have been reached, halts the progression before the tertiary treatment and disinfection stages.

The final process selected for this case is therefore: septic tank → vertical flow reed bed filter → finishing basin (optional). This configuration offers complete autonomy, ease of management, and reduced operating costs. Should usage change (for example, towards irrigating a family vegetable garden), the tree would automatically reconfigure the treatment chain by incorporating a tertiary stage and appropriate disinfection (Figure 7).

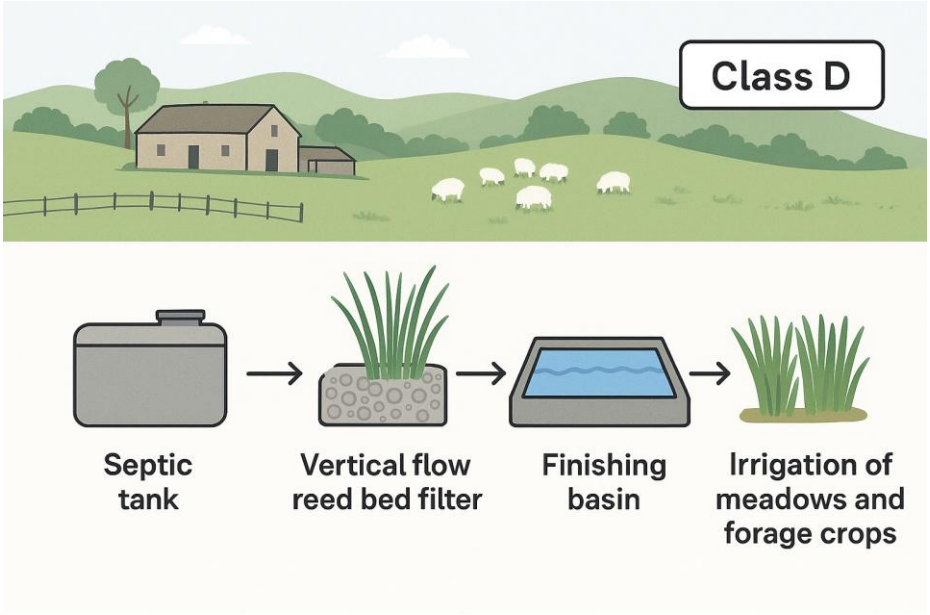

Figure 7: Visual representation of the treatments implemented in the scenario 1 (IA generated)

5.1.2. Scenario 2 — Spain (Almería): Post-wastewater treatment plant farm

The second scenario illustrates a larger-scale REUSE of treated water, typical of southern Spain. The 15-hectare farm, located in the province of Almería, produces tomatoes and peppers in greenhouses. It is situated in the immediate vicinity of a municipal wastewater treatment plant (WWTP) treating approximately 5000 m³/day. The available water is secondary effluent, requiring polishing to reach

the quality required for raw vegetables - classified as A according to European and Spanish regulations.

In the process flowchart, the user selects an existing "secondary" treatment level and a "common" source. The tool then loads the corresponding input values from the WWTP outlet (BOD5, TSS, turbidity, E. coli, and any micropollutants) and compares them to the regulatory thresholds from the national annexes. Since these concentrations generally exceed the Class A thresholds, the process tree triggers the recommendation of a complete tertiary treatment chain followed by disinfection.

A preliminary pretreatment is systematically recommended when turbidity or suspended solids (SS) parameters exceed the inlet thresholds of the tertiary units. The process tree proposes a combination of fine screening (3 mm) and rotary sieve, followed by an aerated equalization basin. This system stabilizes the hydraulic flow and protects the downstream filtration and adsorption units from fouling.

The next step is the tertiary treatment, parameterized in questions Q5/Q6 of the interface according to the types of pollutants targeted. In this scenario, types II (microbiological) and III (organic micropollutants) are activated, leading the Tree to recommend an optimized combination: rapid sand filtration (reduction of suspended solids and turbidity, UV protection), biological activated carbon (BAC) (adsorption and biodegradation of micropollutants), and medium-dose ozonation (advanced oxidation of recalcitrant compounds and enhanced disinfection). According to the performance matrices (Table 2), these treatments provide the best compromise between effectiveness and cost in this context.

Finally, the disinfection section automatically proposes a solution guaranteeing the required logarithmic reduction for bacteria and viruses. The Tree recommends a primary treatment using medium-pressure UV (~40 mJ/cm²), effective for microbial destruction without the addition of chemical reagents, supplemented by an injection of chlorine dioxide (ClO_2) to ensure residual disinfection in the irrigation system. The choice of these processes stems from the data collected on residual turbidity and organic load. The interface automatically combines the options that achieve compliance while taking into account the cost/efficiency ratio.

The final treatment process proposed for Almería is: pretreatment (screening + sieving + equalization basin) → rapid sand filtration → biologically activated carbon (BAC) ± ozonation → medium-pressure UV disinfection → ClO_2. This sequence addresses all the identified constraints: equipment protection, micropollutant removal, microbiological compliance, and maintenance of residual sanitary safety in the agricultural irrigation network (FIgure 8).

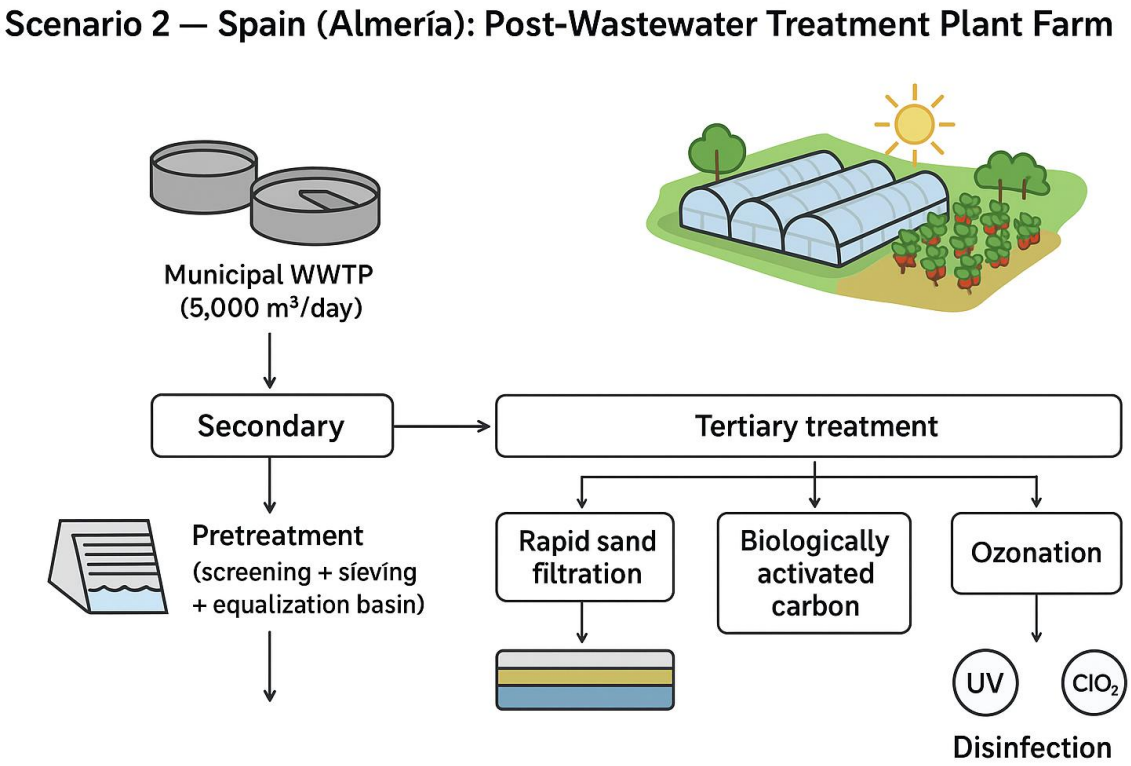

Figure 8: Visual representation of the treatments implemented in the scenario 2 (IA generated)

5.1.3. Scenario 3 — Portugal (Alentejo): Large-scale cereal farm

The third scenario involves a 500 hectares cereal farm in the Alentejo region, primarily cultivating durum wheat and sunflowers. This area experiences severe droughts and has limited surface water resources. The farm has the right to draw treated wastewater from an urban wastewater treatment plant serving approximately 20,000 inhabitants. The volumes involved are substantial, leading to the selection of extensive, low-cost solutions that comply with Portuguese regulations for irrigating large-scale crops not consumed raw.

In the tree diagram, the entered responses indicate an existing level of secondary treatment, a municipal origin, and a use for large-scale crops/forage, thus activating the specific Portuguese annexes (natural processes and nature-based solutions). The tool then directs users to lagooning or wetland systems, identified in the performance matrices as the most suitable for large volumes and local constraints.

The main proposed system is a natural lagooning system in series, composed of three successive basins: a deep anaerobic basin (sedimentation and hydrolysis), a shallow facultative basin (mixed aerobic-anaerobic microbial activity), and a maturation basin (oxygenation, solar exposure, and

pathogen reduction). These units, sized for a total retention time of approximately 30 days, ensure a significant reduction in BOD5, TSS, and nutrients with minimal energy consumption.

At the lagoon outlet, the tool recommends further polishing with a constructed wetland with subsurface flow, the substrate of which (sometimes enriched with zeolite) allows for efficient absorption of ammonium and phosphorus. This finishing treatment improves the physicochemical quality of the effluent and promotes local biodiversity. The tool identifies this combination as the most effective for ensuring regulatory compliance in class C or D while maximizing economic sustainability.

Regarding disinfection, the tree model suggests UV, ozone, or chlorine processes by default, but regulatory verification shows that the extensive lagoon + wetland system already meets the thresholds required for cereal irrigation. Chemical disinfection is therefore not essential. However, the tree model displays complementary management measures: buffer storage and floating cover, useful for limiting recontamination and evaporation in large treated water storage areas. In regions with high levels of sunshine, natural solar disinfection can be suggested as a local practice, although it is not yet modeled in the tool's performance matrices.

The final system selected for this scenario is: multi-basin lagooning (anaerobic → optional → maturation) → subsurface flow wetland → buffer storage. This combination maximizes robustness and resilience to droughts, while limiting operating costs and ensuring sufficient water quality for large-scale crops. It illustrates the tree's ability to identify nature-based solutions adapted to the specific territorial characteristics and economic realities of large Portuguese farms (Figure 9).

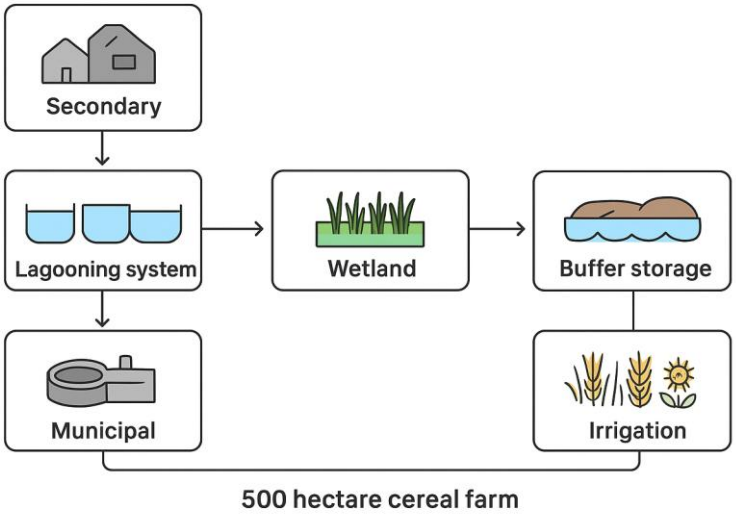

Figure 9 : Visual representation of the treatments implemented in the scenario 3 (IA generated)

5.1.4. Comparative analysis and conclusions drawn from the three scenarios

The three scenarios presented illustrate the wide diversity of contexts in which the choice tree can be applied, highlighting its adaptability to contrasted technical, regulatory, and territorial situations. The differences between the scenarios are primarily driven by the intended agricultural use, the scale of the project, and the national regulatory frameworks.

The first scenario, involving a small isolated farm in France, is characterized by low wastewater volumes, limited technical capacity, and low sanitary risk (Class D use). In this context, the choice tree prioritizes simple, robust, and low-maintenance nature-based solutions, avoiding unnecessary over-treatment and ensuring autonomy.

In contrast, the second scenario in Spain involves intensive greenhouse agriculture and high-value crops consumed raw, requiring class A water quality. Here, the choice tree identifies the need for advanced tertiary treatments and disinfection, combining several grey technologies to meet strict sanitary and regulatory requirements.

The third scenario, in Portugal, addresses large-scale agricultural REUSE of treated water under severe water scarcity conditions. The large volumes involved and the availability of land favor extensive systems such as lagooning and constructed wetlands, which offer robustness, low operating costs, and long-term resilience.

Overall, these scenarios demonstrate that there is no single optimal REUSE of treated water solution. The choice tree structures decision-making according to the fit-for-purpose and multiple-barrier principles, enabling context-specific treatment chains that balance regulatory compliance, technical feasibility, and territorial constraints.

5.2. Current Limitations of the choice tree

Despite the clear interest generated by the choice tree and the improvements already made through user testing, several limitations remain, both technical and functional. The sampling scope is a limitation in itself. Indeed, only French farmers were surveyed in a project involving three European countries. Furthermore, the Ariège region is not representative of the entire Île-de-France region. It is therefore reasonable to question the suggestions provided by the farmers. Would the same be true in another region? It is highly likely that this choice tree will need to be modified according to the needs and realities of each country.

Indeed, Spanish and Portuguese farmers, unlike French farmers, do not live on their farms. They live in cities and travel to rural areas for their work. Therefore, the issue of REUSE of treated water at the individual level (domestic/private rainwater) should not be presented as an option in the tool. Furthermore, the interviewed farmers were receptive to water REUSE of treated water. The sampling selection factor proved biased by the individuals who agreed to answer our questions and complete a tree diagram test, demonstrating a genuine desire to develop water REUSE of Treated Water, which may not be universally accepted within the agricultural sector.

Similarly, the choice tree was improved based on feedback from the farmers. While the tool was initially designed for agricultural irrigation, it is intended for water managers and technicians to advise

farmers. It is possible that limitations or additional needs exist, specific to the personnel for whom the tool is actually intended. The Python script automates the reasoning and simplifies many steps. However, its technical complexity means that it still requires a certain level of understanding of water treatment and related terminology. For users unfamiliar with concepts like BOD5, TSS, turbidity, or tertiary treatment, the tool can remain difficult to grasp without guidance. Support is essential for using the choice tree, and even for the solutions offered by SOLLAGUA, and is intended to guide decision-makers/farmers throughout the entire process. This currently limits its ease of use, particularly in the context of widespread distribution to farmers or local elected officials.

There is a lack of additional indicators that would further inform the available choices. Considering the distance between the water collection and REUSE of treated water points, the type of irrigated crop, and the frequency of use (daily or seasonal) are important factors not integrated into the choice tree, yet they are crucial considerations for decision-makers. This lack of input restricts the precision of the diagnosis and could, in some cases, skew the recommendations. The tool's current scalability is also considered a limitation. Even though the script was designed modularly, it still relies on source files (.txt, .csv) that must be properly manipulated and structured to add new countries, regulatory matrices, or processing methods. A more dynamic database structure (or one connected to a graphical interface) would be necessary to ensure simple and sustainable updates over time.

A major limitation is the lack of economic evaluation of the proposed solutions. Currently, the tool can indicate which processes are compliant from a technical and regulatory standpoint, but it does not allow users to sort or compare options based on their investment, operating, or maintenance costs. This aspect will be addressed in task 1.3 of the SOLLAGUA project, which aims specifically to establish techno-economic scenarios for waste REUSE of treated water.

This future step determines the full usefulness of the tool, particularly for informing and sharing with public decision-makers or agricultural operators subject to strong budgetary constraints.

6. Understanding the terrain and the players

6.1 Interview Methodology

As part of the testing phase of the decision support tool, a series of interviews was planned to gather qualitative feedback on the relevance, clarity, and feasibility of the choice tree. The target audience was primarily farmers, although they are not the direct target group for the choice tree tool, as it was created for their activities. The tool is intended for upstream use by technical intermediaries, but farmers are better positioned to identify the practical limitations of this choice tree.

Two interview formats were used:

- In-person interviews: conducted in the Couserans region of Ariège, on farms or with local authorities involved in resource REUSE of Treated Water projects. This format was preferred when logistical constraints allowed or as part of field visits integrated into other missions.
- Videoconference interviews were organized for the sake of collaboration and simplicity during the second wave of field tests, or to overcome constraints related to availability or geographical distance, as they took place throughout France.

The discussions were semi-structured, based on an interview guide that included an understanding of the decision-making process within the choice tree. The aim was to identify missing, redundant, or even unclear criteria. More broadly, the interview also assessed user adoption of the tool and identified any obstacles or opportunities that might arise.

The sample was designed to represent a diversity of territorial and technical situations. The objective was to interview at least five organizations per testing phase. Two rounds of testing were planned. The first series of interviews, referred to as alpha testing, was conducted with an initial panel of about twenty users to identify the initial limitations of the choice tree prototype (alpha version) and to formulate potential improvements. A second series of beta tests was conducted after adjustments, with a new panel of similar users, to verify the relevance of the modifications and validate the improved version of the tool.

The aim in selecting the sample was to primarily include farmers or organizations likely to REUSE their treated wastewater. Although the tool is primarily intended for technical stakeholders (local authorities, agricultural advisors, etc.), farmers are directly affected by the uses and constraints of the field. They are therefore able to identify the concrete limitations of the choice tree, particularly in terms of technical feasibility and understanding of the criteria.

In practice, the selection of respondents was also guided by criteria of availability and receptiveness: the panel was formed from organizations that responded favorably to the requests. Thus, the sample resulted from a compromise between intentional targeting (profiles relevant for REUSE of Treated

Water) and opportunity (positive responses to the interview request), which made it possible to guarantee a realistic implementation of the testing phase while ensuring the diversity of the contexts explored.

We contacted agricultural unions in the department by email, including the “Jeunes Agriculteurs”(JA), the National Federation of Farmers' Unions (FNSEA), the Confédération Paysanne, and the Coordination Rurale (CR). None of these unions responded to the emails, nor did the Ariège Chamber of Agriculture, which we contacted three times. It is likely that REUSE is not a priority for the agricultural unions, or perhaps they do not wish to focus on this topic at the moment. Many farms in Ariège were contacted individually, resulting in a higher response rate, both positive and negative. Additionally, an association that supports farmers in precarious situations, called "Solidarité Paysans Ariège," forwarded the email to one of its members, who then contacted us. Farmers sympathetic to the cause agreed to these interviews, but some explained their refusal to participate, whether due to time constraints, convictions, or beliefs about water REUSE. In total, the choice tree was tested with 15 farmers during the second phase with the beta version.

To test the choice tree, the focus was not so much on the farmers' motivations and opinions about water REUSE of Treated Water, but rather on an objective assessment of its feasibility and gathering practical feedback following the test.

Although the field testing and validation phase of the choice tree was conducted primarily in France, particularly in the Couserans region of Ariège, the tool was designed to meet the needs of the three partner countries in the project. This transnational dimension is essential because it allows for the integration of the regulatory, technical, and contextual specificities of each territory, while promoting the harmonization of practices across Southwestern Europe.

6.2. User Testing Results

6.2.1. First Series of Tests

6.2.1.1 Interviews and Profiles of Users Interviewed

During the initial testing phase, qualitative interviews were conducted in the field in Ariège in April 2025, with the aim of identifying the tree's initial limitations and discussing the vision of water REUSE with farmers. During an initial field trip in early April, including on-site meetings, three main types of profiles were encountered:

Active farmer (Montjoie-en-Couserans): committed to soil regeneration practices and highly aware of the issue of water REUSE of Treated Water. He already uses extensive techniques (lagooning, rainwater harvesting) and is interested in popularizing the topic. He tries to disseminate his ideas on

more holistic agriculture and the importance of water REUSE of Treated Water through media such as podcasts.

Retired farmer (Seix): an active member of a farmer support group. Although initially uninformed about water REUSE of Treated Water, he showed great interest in the collective potential of these solutions. He suggested raising public awareness at regional events.

Individual with an autonomous system (Boussenac): user of an individual wastewater treatment system for over 10 years, very attentive to the impact of his practices. Uses treated water to water his personal vegetable garden. Reports a lack of regulatory oversight of existing systems.

We returned to Ariège at the end of April to two markets: the Foix market and the night market in Savères. We met farmers with diverse profiles, ranging from a market gardener in a greenhouse to a farmer who had only recently started selling directly to consumers, as well as a flower grower and a fruit grower already using autonomous systems. Their geographical and technical contexts are diverse, as is their relationship with water. Some have easy access to the water table, while others collect rainwater or are considering reusing wash water. The situations encountered illustrate the disparities in challenges depending on whether the area is rural or mountainous, and on the level of self-sufficiency or investment possible.

In the first market, Foix, we interviewed nine farmers. One of them practiced fruit growing and also cultivated aquatic plants at home. She adopted rainwater reuse by filtering it with a planted filter system and expressed particular concern about social prejudices surrounding the use of recycled water. Another farmer, interested in water treatment, cited the cost of implementation as the main obstacle, more so than health risks. He also raised a key issue: seasonal storage, questioning the possibility of retaining treated water in basins for later use, particularly in the summer. Conversely, a market gardener cultivating 5 hectares of greenhouses felt he didn't need to change his practices: he draws water from the water table at a very low annual cost (around €300), making a change of system difficult to justify. Finally, a flower grower expressed serious concerns about the quality of wastewater, mentioning significant fears about crop contamination. Of the nine farmers interviewed, seven were worried about potential water scarcity during the summer months.

At the second market, the Savères night market, we interviewed two different profiles. A recently established farmer said she had enough water but was considering reusing the water from washing vegetables. However, she had heard that this type of REUSE of Treated Water was difficult to obtain authorization for, which, combined with her still precarious financial situation, was hindering any implementation. Finally, a farmer committed to organic farming said he was open to testing solutions such as lagooning or planted filters. However, benefiting from good access to resources in the Couserans region, he did not feel any urgency to modify his system at the moment.

6.2.1.2. Feedback from the alpha version of the tree

Feedback on the first version of the tool highlighted several obstacles. Generally, knowledge about wastewater treatment is limited, making the flowchart difficult to understand. The sequence of treatment phases (primary, secondary, tertiary) is not intuitive, especially when the vocabulary used is overly technical. Furthermore, the user journey is considered lengthy, sometimes repetitive, and therefore time-consuming. Some users expressed frustration: they felt that the water was systematically non-compliant after secondary treatment because the contribution of primary treatment (for example, a properly sized septic tank) was not being recognized. The tool's readability was also questioned: several people requested a larger printed version to be able to read it properly in the field.

Other feedback concerned the lack of precise guidance for selecting treatment systems. The distinction between applicable technologies is not always clear, especially in the absence of data on the volumes to be processed, the frequency of use (primary or secondary residence), or the types of household inputs used. These criteria are nevertheless crucial for sizing an appropriate system, particularly for small farms.

6.2.1.3. Suggested Areas for Improvement

The interviews identified several concrete areas for improving the choice tree. First, it would be useful to design simplified primary matrices to better characterize each user's initial situation. Second, several people suggested creating educational posters that explain in layman's terms what REUSE of waste water is, the processing steps, and the main operating principles of the tool. A more accessible version of the choice tree, based on simple questions and non-technical language, would also make it easier to reach non-specialist audiences. Furthermore, it seems essential to add certain variables to refine the approach: the quantity of water to be treated, the seasonal variation in needs, and the occurrence of an existing treatment system. This would allow for either a complete solution or a suitable tertiary component. Finally, several people emphasized the importance of designing the tool with a collective approach, adapting it to individual users as well as rural communities. This dimension will need to be better integrated into future versions of the tree.

6.2.2. Second Series of Tests

6.2.2.1. Interviews and Profiles of Users

In June 2025, a second round of tests was organized following the creation of new educational tools, including primary matrices to visualize the effect of upstream treatment, awareness posters on REUSE of Treated Water to simplify the techniques and clarify the terminology, and a user guide for the choice tree to facilitate navigation through the available options.

This series of tests was conducted in other French regions (Maine-et-Loire, Nord, etc.) by telephone and videoconference. These tests allowed the choice tree to be compared to other contexts, often characterized by more visible water stress during the summer months.

The first farmer, in Longué-Jumelles (49), cultivates 280 hectares of organic market gardens under the Demeter and Bio Cohérence labels. He would like to REUSE rainwater from his buildings and wash water, but his certifications and the distance between his plots (up to 10 km) complicate this possibility. He questions the distance between the water source and REUSE point and the potential costs involved. He is in favor of water REUSE via a treatment plant but fears his customers' perception, particularly regarding the safety of his canned goods. He finds the choice tree quite comprehensive but is puzzled by the absence of certain techniques.

The second farmer, in Nieppe (59), farms 100 hectares using mixed cropping. For 20 years, he has been reusing rainwater stored in two silos and treated by dilution with chemical solutions. He had considered a lagoon system for his domestic and wash water, but his project was rejected by the authorities. He finds the choice tree time-consuming to complete and regrets that his method is not listed. He suggests a simplified questionnaire that would directly indicate suitable solutions and their compliance. The third group, organic farmers in Saint-Étienne (42), cultivate 0.25 hectares of greenhouses and 1.5 hectares of open fields. They would like to REUSE rainwater through natural solutions such as lagooning, in line with their organic values. However, they fear contamination and customer mistrust, which hinders the adoption of rainwater REUSE of Treated Water. They consider the tree to be difficult for non-specialists to understand and suggest accompanying it with an explanatory poster about the SOLLAGUA project and how the tool works.

6.2.2.2. Feedback on the choice tree and suggested areas for improvement

Feedback from the farmers surveyed shows an overall positive reception of the choice tree, which was considered useful and relevant to its purpose. However, several areas for improvement were raised. The tool is perceived as time-consuming to complete and sometimes complex to understand, particularly for those unfamiliar with wastewater treatment. Some farmers were also surprised that certain REUSE techniques, already implemented on their farms, were not included, such as chemical treatment.

Suggestions emerged from this second round of tests aimed at improving the choice tree and making it more user-friendly. A simplified form, in the form of a questionnaire, that could be easily completed would be beneficial. Once completed, this form would automatically suggest possible treatment solutions and their associated regulatory requirements. Automation of the choice tree is also highly desirable to facilitate its use, save time, and reduce complexity for those unfamiliar with the process. Another idea that emerged was the creation of a poster presenting the SOLLAGUA project, explaining the context and operation of the tool. This would better prepare users for its use and facilitate their understanding.

6.2.3. Cross-sectional analysis of user tests

6.2.3.1. User profiles and factors influencing attitudes towards water REUSE of Treated Water

By cross-referencing the data from the two rounds of tests, several typical profiles and determining factors in farmers' attitudes emerged towards water REUSE .

Some users, often more environmentally conscious or already engaged in alternative approaches, expressed a strong desire for water autonomy. They were found both in Ariège (individuals with autonomous systems in Boussenac, farmers using lagoons) and in Saint-Étienne and Longué-Jumelles. These farmers are generally open to wastewater REUSE, but may be deterred by regulatory complexity or a lack of institutional recognition of the techniques used (e.g., chemical treatment or artisanal planted filters).

Another significant group consists of pragmatic farmers whose decisions are largely driven by cost (e.g., a greenhouse vegetable grower in Foix, a farmer in Longué-Jumelles). If access to water is inexpensive or relatively unconstrained, such as an easily accessible water table or sufficient rainfall, these farmers see little benefit in changing their systems. Conversely, when the cost or seasonal variability of water access becomes problematic, REUSE can once again become a viable solution, provided the return on investment is clear and guaranteed.

An important cross-cutting factor, even among the most motivated farmers, is the negative social perception of wastewater. Many farmers fear that their customers will associate REUSE with a decline in quality or a health risk. This cultural bias constitutes a major obstacle, even when technically and economically viable solutions exist. It is significant that this fear is expressed by both small producers in short supply chains (Ariège, Saint-Étienne) and larger farms (Longué-Jumelles).

6.2.3.2. Factors Influencing the Reception of the choice tree

A recurring criticism, expressed in both rounds of testing, concerns the complexity of the choice tree, both in terms of navigation and vocabulary. The use of technical terms or the unintuitive sequence of processing phases creates obstacles, particularly for non-expert users or those unfamiliar with the terminology of agricultural REUSE of Treated Water.

Several accounts reveal a gap between existing agricultural practices and the tool's recommendations. This gap is sometimes a source of frustration, especially when existing systems are not valued or recognized in the choice tree as sufficient steps. The lack of institutional recognition of certain empirical practices thus seems to reinforce a feeling of regulatory ambiguity and a disconnect between the field and the tool.

The study of the two rounds of tests highlights recurring dynamics between technical, cultural, and economic contexts. Water REUSE decisions are not solely based on water constraints, but also on the

social perception of water, the clarity of regulations, investment capacity, and access to relevant information.

Feedback on the choice tree illustrates both the relevance of the approach and the need for modularity: the tool must be adaptable to very different user profiles, incorporating a progressive approach, typical scenarios, and recognition of empirical practices. This reveals a tension between technical requirements and practical accessibility, which future versions of the tree will need to skillfully address.

6.3. Contribution to the social acceptability of REUSE of Treated Water: making the tool understandable and usable by farmers and unions.

Social acceptability is a major lever for the success of REUSE projects, particularly in rural areas where agricultural uses predominate. The perception of REUSE in France remains ambivalent. While interest in solutions to water scarcity is widely shared, concerns about food use and health still generate reluctance. This reluctance is primarily linked to a lack of trust in the quality control of treated wastewater. This reluctance is often explained by a lack of clear information, but also by deep-seated psychological barriers related to the idea of a "short loop" between waste and food. These perceptions also vary depending on the level of information, proximity to the agricultural sector, and trust in institutions. A key lever for acceptability lies in project transparency, water traceability, and user participation in the governance and survey of the systems.

Within the SOLLAGUA project, several local initiatives have highlighted the importance of participatory formats, such as territorial meetings or demonstration projects, to shift perceptions and create a collective dynamic around water resources for the REUSE . User testing of the choice tree revealed that awareness levels vary regarding resource REUSE . Some farmers, already committed to agroecological practices, immediately grasp the benefits of reusing a resource they consider underutilized. Others remain more hesitant, due to regulatory or health barriers that are still unclear, as well as a lack of overall understanding of what this actually entails on the ground. This confirms that the challenge is not simply technological, but rather territorial and social. It depends on the ability to structure clear information and create simple entry points for understanding, while also showcasing positive examples.

Feedback from farmers interviewed during field tests showed an overall positive reception of the choice tree, which was considered useful and relevant to its purpose. However, several areas for improvement were identified. The tool is perceived as time-consuming to complete and sometimes complex to understand, particularly for those unfamiliar with wastewater treatment. A recurring criticism, expressed in both rounds of tests, concerns the complexity of the tree, both in terms of navigation and vocabulary. The use of technical terms and the unintuitive sequence of treatment

phases create obstacles, especially for non-expert users or those unfamiliar with the terminology of REUSE.

To improve the tool's acceptability and usability, several suggestions emerged. It would be beneficial to design a simplified form, in the form of a questionnaire, that could be easily completed. Once completed, this form would automatically suggest possible treatment solutions and their associated regulatory compliance. Automation of the tree is also widely desired, to facilitate its use, save time, and reduce complexity for those unfamiliar with it. Another idea that emerged was the creation of a poster presenting the SOLLAGUA project, explaining the context and operation of the tool, which would better prepare users for its use and facilitate understanding.

An important cross-cutting factor, even among the most motivated, is the negative social perception of wastewater. Many farmers fear that their customers will associate wastewater REUSE with a decline in quality or a health risk. This cultural bias constitutes a major obstacle, even when technically and economically viable solutions are available. It is significant that this fear is expressed by both small producers in short supply chains and larger farms. To promote the adoption of REUSE, it is therefore essential to work on perception and information, by supporting farmers in understanding the health and regulatory safeguards, and by communicating transparently about the benefits and controlled risks. The choice tree, in its automated and simplified version, can thus serve as a support for this acceptance process. By offering a structured, readable, and adaptable framework, it helps to overcome some major obstacles identified in the literature and in the field: technical complexity, regulatory ambiguity, economic uncertainty, and lack of support. These are technical tools, but they also contribute to the major transformation of governance methods and the appropriation of issues related to sustainable water management.

7. Choice Tree Assessment

7.1 Relevance of the Tool Created

7.1.1. A Functional Decision Support Tool

From the alpha to the beta version, it was crucial to compare a version based on available scientific literature and resources with the realities faced by farmers on the ground. To create a tool tailored to their work, especially within a Living Lab framework, it is essential to consider the opinions and suggestions of all stakeholders. These discussions led to improvements and identified areas for further consideration in the SOLLAGUA project. Indeed, issues such as water retention, the distance between water collection and crop irrigation, and the variability of water reusability depending on the time of year (e.g., coastal cities) are all relevant to the decision-making process. Although these criteria were not included in the beta version of the choice tree, they provided useful recommendations for other aspects of the deliverable.

The field validation phase conducted with farmers and local authorities confirmed a strong, unmet demand for decision-making tools for REUSE Interviews in Ariège, Maine-et-Loire, and Nord revealed that local farmers are often overwhelmed by the technical, regulatory, and administrative complexities of wastewater treatment. For example, an organic farmer in Longué-Jumelles (49) highlighted the lack of accessible resources to assess the compatibility of REUSE water with the requirements of his certifications (Demeter, Bio Cohérence), while a farmer in Nieppe (59) pointed to the absence of turnkey solutions adapted to small farms. This gap is all the more significant given the increasing water stress: 78% (7/9) of farmers surveyed in Southwest France at a market expressed concern about water scarcity during the summer months. The choice tree thus fills a gap by offering a structured methodology, particularly appreciated in areas where REUSE projects are emerging (such as in Ariège) but struggle to materialize due to a lack of operational frameworks.

The tree's modular and sequential approach (primary → secondary → tertiary → disinfection) makes it possible to break down the complexity of technical choices and highlight the differentiating factors for separating options. Users appreciated the integrated "fit-for-purpose" logic, which systematically links the quality of the incoming water, local constraints, and the regulatory requirements of the end use. For example, during tests in the Couserans region, a farmer noted that the distinction between "green" (extensive) and "grey" (conventional) treatments allowed him to identify solutions compatible with his agroecological values. The automated compliance matrix (integrated into the Python script) enables simulation of the impact of each treatment on key parameters, significantly reducing the risk of misinterpreting regulatory thresholds. This step-by-step rigor is crucial in a context where only a small portion of the population claims to be familiar with European and national standards, according to feedback from the field.

7.1.2. Choice trees as a Decision Support Tool in Agriculture

The development and application of decision support systems, and more specifically Environmental Decision Support Systems (EDSS), are seen as significant levers for addressing the complex challenges of urban water management and wastewater treatment (Sànchez-Marrè, 2012). These tools help structure decision-making in contexts marked by high uncertainty, by mobilizing heterogeneous data, both quantitative and qualitative, from multiple domains (Comas et al., 2004).

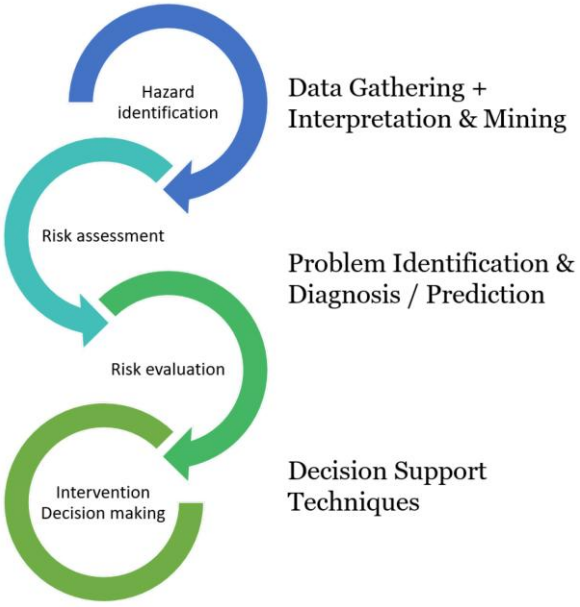

Figure 10 : Environmental Decision Support Systems for Monitoring Small Scale Oil (MDPI)

EDSS are designed to integrate this diversity of information into a coherent operational framework (Figure 10) (Alemany et al., 2005) and aim to improve the transparency, robustness, and traceability of technical choices. They play a strategic role in optimizing the design, sizing, selection, and management of treatment systems, taking into account technical, economic, environmental, and social criteria (Comas et al., 2004). By partially replicating expert reasoning and facilitating the comparison of scenarios, these tools provide decisive added value, particularly for small communities or areas with limited engineering resources.

An example of the Fluvia River in Catalonia (Spain) highlights the importance of considering specific local conditions, such as population distribution, seasonal variations, and the ecological sensitivity of receiving environments, when choosing appropriate treatment methods. It also demonstrates how EDSS (Environmental and Social Development Strategy) can manage the inherent complexity of these decisions by integrating a multidisciplinary approach, thereby improving the coherence and quality of the proposed solutions compared to traditional methods (Alemany et al., 2005). The SOLLAGUA project exemplifies this dynamic, employing tools such as the choice tree, developed within WP1, which aims to simplify treatment processes, disseminate technical options, and harmonize practices. The objective is to make often scattered or complex knowledge accessible in order to promote the

adoption of sustainable solutions such as wastewater REUSE of Treated Water for irrigation. By providing a structured, clear, and adaptable framework, these tools help overcome some major obstacles identified in the literature and in the field: technical complexity, regulatory ambiguity, economic uncertainty, and a lack of support. These tools are not only technical resources, but they also contribute to a major transformation in governance and ownership of issues related to sustainable water management.

This approach is reminiscent of the dynamics at play in the agricultural sector, where decision support tools (DSTs) have become key levers for supporting farmers in the increasing complexity of their technical choices (SMAG, 2024). Whether for irrigation management, fertilization control, or the planning of plant protection treatments, these tools rely on agronomic, meteorological, regulatory, or economic data to provide personalized, contextualized recommendations, often in real time (ISAGRI, 2024).

As in water treatment, agricultural DSTs aim to reduce uncertainties, ensure the safety of practices, and optimize results at different scales. In waterREUSEprojects, agricultural DSTs have established themselves as mediators between technical complexity and field realities, making innovation accessible to farms of very diverse sizes (Closset & Gourdain, 2025).

Whether designed for agriculture or water management, decision support tools (DSTs) share common goals: to make expertise readily available, to structure complex decisions in uncertain contexts, and to empower users. The SOLLAGUA project's choice tree can thus be seen as an environmental DST, similar to the tools used in precision agriculture, because it formalizes expertise to make it understandable, operational, and adaptable at the local level.

7.2. Current Limitations of the Tool

Despite the clear interest generated by the choice tree and the improvements already made through user testing, several limitations remain, both technical and functional.

The sampling scope is a limitation in itself. Indeed, only French farmers were surveyed in a project involving three European countries. Furthermore, Ariège is not representative of the entire France territory. It is therefore reasonable to question the suggestions provided by the farmers. Would the same be true in another region? It is highly likely that this choice tree will need to be modified according to the needs and realities of each country. Indeed, Spanish and Portuguese farmers, unlike French farmers, do not live on their farms. They live in cities and travel to rural areas for their work. Therefore, the issue of REUSE of Treated Water at the individual level (domestic/private rainwater) should not be presented as an option in the tool. Furthermore, the farmers interviewed were receptive to water REUSE of Treated Water. The sampling selection factor proved biased by the individuals who agreed to answer our questions and complete a tree diagram test, demonstrating a

genuine desire to develop water REUSE of Treated Water, which may not be universally accepted within the agricultural sector.

Similarly, the choice tree was improved based on feedback from the farmers. While the tool was initially designed for agricultural irrigation, it is intended for water managers and technicians to advise farmers. It is possible that limitations or additional needs exist, specific to the personnel for whom the tool is actually intended.

The Python script automates the reasoning and simplifies many steps. However, its technical complexity means that it still requires a certain level of understanding of water treatment and related terminology. For users unfamiliar with concepts like BOD5, TSS, turbidity, or tertiary treatment, the tool can remain difficult to grasp without guidance. Support is essential for using the choice tree, and even for the solutions offered by SOLLAGUA, and is intended to guide decision-makers/farmers throughout the entire process. This currently limits its ease of use, particularly in the context of widespread distribution to farmers or local elected officials.

There is a lack of additional indicators that would further guide the available choices. Considering the distance between the water collection and REUSE of treated water points, the type of irrigated crop, and the frequency of use (daily or seasonal) are important factors not integrated into the choice tree, yet they are crucial elements for decision-makers to consider. This limits the precision of the diagnosis and could, in some cases, skew the recommendations provided. The tool's current scalability is also considered a limitation. Even though the script was designed modularly, it still relies on source files (.txt, .csv) that must be properly manipulated and structured to add new countries, regulatory matrices, or processing methods. A more dynamic database structure (or one connected to a graphical interface) would be necessary to ensure simple and sustainable updates over time.

A major limitation is the lack of economic evaluation of the proposed solutions. Currently, the tool can indicate which processes are compliant from a technical and regulatory standpoint, but it does not allow users to sort or compare options based on their investment, operating, or maintenance costs. This aspect will be addressed in task and deliverable 1.3 of the SOLLAGUA project, which aims specifically to establish techno-economic scenarios for waste water REUSE. This future step determines the full usefulness of the tool, particularly for informing and sharing with public decision-makers or agricultural operators subject to strong budgetary constraints.

7.3. Supporting Farmers by Adopting Water REUSE

Faced with increasing water tensions, water use is now presented as a way to adapt to freshwater resources, particularly in agricultural irrigation. However, for it to become a concrete and relevant solution in local areas, it must be considered beyond the purely technical framework. The key issue is its ability to be understood, accepted, and adopted by a diverse range of stakeholders in often very different local contexts.

Interviews conducted revealed that awareness levels regarding water use vary. Some farmers, already committed to agroecological practices, immediately see the benefit of reusing a resource they consider underutilized. Others remain more hesitant, due to regulatory or health-related obstacles that are still unclear, as well as a lack of overall understanding of what it actually entails on the ground. This confirms that the issue is not simply technological, but rather territorial and social. It depends on the ability to structure clear information and create simple entry points to understanding, while highlighting positive examples (Figure 11).

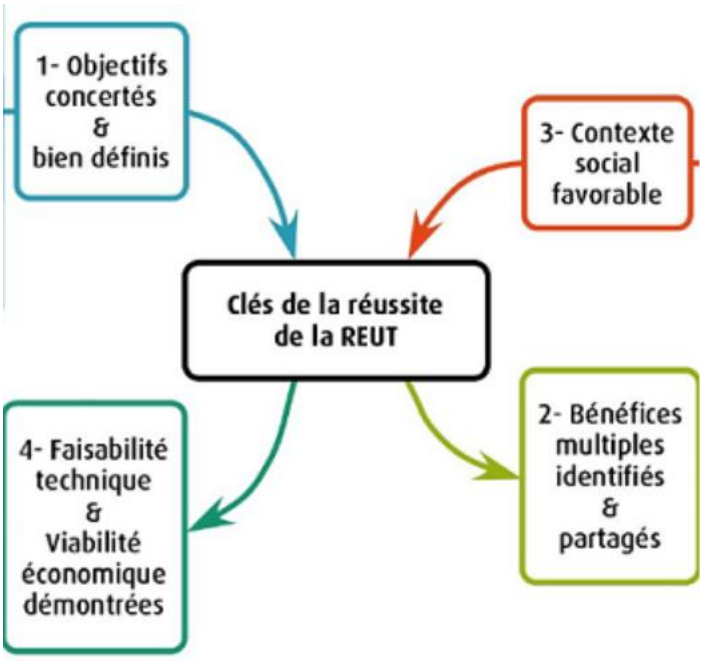

Figure 11. Diagram of possible keys for the implementation of REUSE of Treated Water (CEREMA, 2020)

It is in this context that the developed choice tree can serve as a structuring support, provided its scope is correctly defined, currently for agricultural irrigation and used by technicians with knowledge of wastewater treatment. It does not replace a complete technical study or in-depth economic analysis, but it allows for the establishment of a logical framework, guides initial thinking, and, above all, makes complex reasoning more accessible. It thus comes into play during the orientation phase and can be used at several points in the project: from the initial expression of the need, during the selection of processes, or in verifying regulatory compliance.

The question that then arises is: "How can we support farmers throughout this innovation process?" SOLLAGUA, through its tools and demonstrators, is implementing a strategy aimed precisely at providing comprehensive support to those who decide to implement wastewater REUSE of Treated Water. This involves mobilizing local partners such as chambers of agriculture, agricultural cooperatives, and local authorities. This also includes the implementation of demonstration projects and the creation of spaces for collective discussion.

Within this framework, the choice tree, developed in its automated version, made it possible to include the desired dimensions while laying the groundwork for the future integration of economic criteria. User testing highlighted the importance of a progressive, visual, and evolving approach, aligned with the users' capacity for appropriation on the ground. Furthermore, highlighting their perspectives underscores that the tree is not merely a technical tool; it serves as a catalyst for change management. In this sense, it does not aim to prescribe a single solution, but rather to equip stakeholders to develop responses tailored to their local constraints. Its continued development in digital form, its modularity, and its openness to other uses of REUSE of treated water allow for the possibility of genuine sustainability and widespread adoption across territories. If the tool continues to be enriched by feedback and project developments, it could become a key component of decision-support systems for more sustainable and resilient water management in agriculture. Water REUSE has a vital role to play in future agricultural systems, but its implementation will necessarily require a clear decision-making structure, efforts to break down existing social barriers, effective popularization of concepts such as our choice tree, and co-creation with end users.

The choice tree is therefore not an end in itself, but a lever to trigger a transition dynamic, provided it is grounded in local realities and conceived as an evolving tool, complementary to other decision-support mechanisms.

7.4. Conclusion

The Choice Tree is a practical and concrete tool, born out of the need to help farmers and managers to choose water REUSE solutions tailored to their specific conditions. Designed as part of the SOLLAGUA project, it combines technical data, regulatory rules, and user feedback to offer realistic and compliant treatment chains.

Its strength lies in its modularity: it does not provide a single answer, but several options, depending on the constraints of the land, available surface area, budget, type of crops, local regulations. Tested with farmers in France, it has evolved to become clearer and easier to use, while remaining technically rigorous.

The evolution trajectory : from the alpha version to the interactive HTML interface, it illustrates the Living Lab dynamic that drives the project: a constant back-and-forth between design and field feedbacks, between modeling and simplification, between scientific rigor and accessibility. The delivered scenarios (from Lot to Alentejo) demonstrate the tool's ability to generate both extensive and intensive processing chains, depending on local needs and regulations, while maintaining a clear focus on health safety, economic viability, and social acceptance.

By making complex information accessible, the Choice Tree helps to lower doubts and facilitate decision-making. It is a tool designed to be useful in the field, providing practical support for the

transition to more circular and resilient water management, in partnership with those who implement it.

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→ The bibliography used for the data tables is included in the SOLLAGUA Choice Tree annexes folder.

Interreg Sudoe

Co-funded by the European Union

SOLLAGUA

DOCUMENT INFORMATION

Project title

Nature-based solutions (NBS) and living labs for rural water reuse.

Start - end date

01/01/2024 - 31/12/2026 (36 months)

Programme

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Project type

Priority 1: Preserving natural capital and strengthening climate adaptation in the SUDOE area.

Specific objective 2.5: Promoting access to water and sustainable water

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Coordinator

Université de Toulouse

Project overview

SOLLAGUA, funded by the Interreg SUDOE Programme, is a three-year project that aims to promote nature-based solutions (NBS) for water reuse across the SUDOE region, which faces major challenges linked to water scarcity due to its semi-arid climate, the impacts of climate change and a growing population. The initiative seeks to address these shared challenges by implementing sustainable water-management strategies in three rural communities in France, Portugal, and Spain.

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