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

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Deliverable 4.3.1

Policy document for upscaling and out-scaling NCW at Mediterranean scale

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Abstract	The present report is produced as deliverable for the task 4.3 of AG-WaMED, Policy out-scaling at Mediterranean scale. It responds to sub-task 4.3.1 “Policy document for upscaling and out-scaling NCW at the Mediterranean scale.” This document analyzes the enabling conditions for adopting non-conventional water (NCW) solutions in five Mediterranean countries. Based on empirical evidence from local case studies, it identifies key drivers and highlights barriers including regulatory gaps and limited funding. The analysis points to strategic opportunities to strengthen NCW implementation through better institutional coordination, targeted incentives, and capacity building. By drawing cross-country insights, the document offers policy recommendations to enhance water resilience in the Mediterranean, positioning NCW as a crucial component of sustainable water management under increasing climate and resource pressures.		
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Introduction

This document is intended for the development of Deliverable 4.3.1, “Policy document for upscaling and out-scaling NCW at the Mediterranean scale (M20-34)”.The main inputs for the elaboration of this document are the results of Deliverable 4.2.2, "National Policy Document for Upscaling NCW.

In the face of increasing global water scarcity driven by the combined effects of climate change and water appropriation regimes, transitioning to more sustainable water governance and usage has become a critical issue for our societies (Brudge 2005, 2007). Based on the National Policy Documents for NCW Upscaling developed for Italy, Spain, Egypt, Tunisia, Algeria, this document aims to analyze the main barriers and drivers for promoting NCW at the Mediterranean scale.

In a narrower sense, the 'scaling out' process can be defined as the expansion of innovations to a larger group of actors, 'scaling up' as the implementation of political and legal changes, and 'scaling deep' as the enactment of profound cultural and institutional changes (Breaught et al. 2021).

These processes involve water transition, a new key concept in water governance. While several countries around the world claim to be engaging in water transitions, often framed by governments as a promise of success for moving towards water sustainability, the conditions necessary to achieve these objectives need to be better identified. Indeed, local administrations and organisations face obstacles or barriers of various kinds that can prevent, hinder, or slow the implementation of these transitions (Heiberg, Truffer, and Binz 2022; Sixt, Klerkx, and Griffin 2018).

In the field of research, the concept of water transition has been used by several scholars (Sullivan et al. 2017; Hartman et al. 2017; Travassos and Momm 2022). It has become an operational framework for analysing the transformation of water governance, as it implicitly incorporates the idea of a rupture towards more sustainable water uses (Eggimann et al. 2018; Novalia, Rogers, and Bos 2021). Much of this research falls within Sustainability Transition Studies. In the water domain, transition refers to the success of social or technological innovation that leads to the creation and implementation of institutional and technological changes to improve the sustainability of the water system (Hartman et al. 2017).

Although the notion of water transition is increasingly employed in scientific research and public policies, it has not been critically examined from the perspective of water governance research. We have not found any articles within this field that propose defining the contours of this concept. No research has yet undertaken a synthesis of the main empirical barriers and drivers of water transition implemented worldwide. We aimed to fill this gap by defining the boundaries of this concept through a systematic meta-analytical approach (Van Houtven 2007) in the literature on water transitions. By conducting a comprehensive analysis of this phenomenon, we identified the barriers that hinder water transitions globally, as well as the drivers that facilitate their deployment.

This paper is structured in three sections. First, we explain our methodology, that in this case, follows the same approach as that used in the Deliverable 4.2.2 documents. Based on a process of literature review, we then present a conceptual framework that we developed by identifying the barriers and drivers of water transitions. Finally, we present the results of applying this framework to a case study of a living lab. This application helps to understand the upscaling processes of NCW at the national level.

Methods

Based on a literature review on "water transitions", we have identified the main barriers and drivers to water transitions. We develop a conceptual framework of these barriers and drivers to then identify them in each living lab for understanding the up-scaling process of NCW.

Literature review

This research relied on a systematic meta-analytical approach (Van Houtven, 2007). This method uses empirical evidence to identify common points and causal mechanisms that contribute to the construction of notions or theories (Oberlack and Eisenack 2014, Wolfram and Kienesberger, 2023). Meta-analytical approaches are increasingly used to address global and regional patterns of socio-environmental change (Author et al. 2017). By capturing these processes, it bridges the gap between global assessments, which often lack detailed case studies.

Our research is based on systematic case selection and theory-grounded coding. First, the text corpus was constructed by consulting articles published between 2014 and 2024 from two databases: Social Sciences and Humanities Proceedings (ISI WOS) and Scopus "Social Sciences." The search was conducted by combining several keywords (see Table 1).

Table 1. Keywords used for article research. Source: Authors, 2024.

WOS Social Science		
Search string	**Hits**	**Date**
"sustainab* system" AND Water	14	08-dic
(sustainab* AND socio*techn*) AND Water	46	08-dic
"sustainability transition*" AND Water	140	08-dic

(sustainab* AND transition*) AND Water	1006	08-dic
(sustainab* AND [niche* OR regime*]) AND Water	458	08-dic
(sustainab* AND pathway*) AND Water	535	08-dic
(“system transition*” OR “system transformation*”) AND Water	41	08-dic
(system* AND [transformation* OR transition*]) AND Water	1615	08-dic
(system* AND [niche* OR regime*]) AND Water	653	08-dic
(system* AND [niche* OR regime*] AND [transformation* OR transition*]) AND Water	145	08-dic
(system* AND pathway*) AND Water	770	08-dic
(system* AND pathway* AND [transformation* OR transition*]) AND Water	142	08-dic
([transformation* OR transition*] AND socio*techn*) AND Water	50	08-dic
([transition* OR transformation*] AND pathway*) AND Water	235	08-dic
(“transition stud*” OR “transition theor*” OR “transition approach*”) AND Water	31	08-dic
([niche* OR regime*] AND socio*techn*) AND Water	28	08-dic
(pathway* AND socio*techn*) AND Water	7	08-dic
SCOPUS Social science		
Search String	**Hits**	**Date**
“sustainab* system” AND Water	56	08-dic
(sustainab* AND socio*techn*) AND Water	31	08-dic

“sustainability transition*” AND Water	64	08-dic
(sustainab* AND transition*) AND Water	731	08-dic
(sustainab* AND [niche* OR regime*]) AND Water	522	08-dic
(sustainab* AND pathway*) AND Water	375	08-dic
(“system transition*” OR “system transformation*”) AND Water	30	08-dic
(system* AND [transformation* OR transition*]) AND Water	2066	08-dic
(system* AND [niche* OR regime*]) AND Water	1372	08-dic
(system* AND [niche* OR regime*] AND [transformation* OR transition*]) AND Water	147	08-dic
(system* AND pathway*) AND Water	642	08-dic
(system* AND pathway* AND [transformation* OR transition*]) AND Water	86	08-dic
([transformation* OR transition*] AND socio*techn*) AND Water	26	08-dic
([transition* OR transformation*] AND pathway*) AND Water	184	08-dic
(“transition stud*” OR “transition theor*” OR “transition approach*”) AND Water	34	08-dic
([niche* OR regime*] AND socio*techn*) AND Water	10	08-dic
(pathway* AND socio*techn*) AND Water	4	08-dic

After removing duplicates, we reviewed the titles of the results (n = 2184) to check whether they were concerned about water resources or drinking water. During this first screening, a large number of publications had to be excluded due to terminological overlaps but lacking relevant content (e.g. ocean, fish in rivers, and maritime transport). Second, the abstracts of the remaining articles (n = 350) were examined according to two criteria: first, whether the article mentioned governance issues, and second, whether the issue of change or transition reflected in the title was substantiated. Third, for the selected articles (n = 74), we reviewed the full text by reading the introduction, methodology, and results to verify that the article’s

analysis focused on a case study of water transition, even if the author did not necessarily use this term. This resulted in a corpus of 52 publications. We then coded the articles on Atlas-TI to describe these studies by identifying the theoretical framework, object of analysis (innovation, regime, or other), and use of hydrological data. Next, we sought to outline the contours of water transitions according to their application domains and geographical characteristics (country, space, and scale). Finally, we identified textual elements referring to barriers or drivers of transition.

Theoretical framework proposal

In this section, we present the barriers and drivers identified from the literature review. For each of them, we provide a definition.

Barriers of water transitions

The analysis of the corpus identified eight types of barriers to water transition in 26 articles (Table 2).

Table 2. Presentation of eight barriers to water transition. Source: Authors, 2024.

	Barriers	**Definition**	**References**
1	Intersectoral barrier	Lack of relationships between actors at different levels, absence of individuals, collective, and technical synergies, and/or emergence of conflicts around an innovation.	(9) Ward and Butler 2016; Hess 2018; Liu and Jensen 2018; van Welie et al. 2018; Savini and Giezen 2020; Novalia, Rogers, and Bos 2021; Heiberg, Truffer, and Binz 2022 ; Nilsson and Blomkvist 2021; Travassos y Momm 2022
2	Political barrier	Lack of clear political support for local initiatives, absence of participation and consideration of local needs, and international orientation by funders towards policies and projects unsuitable for Southern regions.	(7) Acheampong, Swilling, and Urama 2016; Ward and Butler 2016; Silvestri et al. 2018; Sixt, Klerkx, y Griffin 2018; Yasmin, Farrelly, and Rogers 2018; Afghani, Hamhaber, and Frijns 2022; Travassos y Momm 2022
3	Institutional barrier	Institutional fragmentation and internal coordination problems, strong institutionalization of the existing sociotechnical regime	(6) Herslund et al. 2018; Kundu et al. 2018 ; Sixt, Klerkx, y Griffin 2018; Suleiman 2021 ; Helgegren et al. 2021 ; Pakizer et al. 2023

		entrenched in daily institutional practices and logics.	
4	Economical barrier	Lack of visualization of the benefits and economic viability of the innovation compared to established regimes, or costs too high relative to demand uncertainty.	(6) Domènech et al. 2015; Xu et al. 2016; Ward y Butler 2016; Kundu et al. 2018; Silvestri et al. 2018; Sixt, Klerkx, y Griffin 2018
5	Normative barrier	Regulatory obstacles produced by legal frameworks or poor definition of laws leading to interpretation issues.	(5) Baigorrotegui, Parker, y Estenssoro 2014; Domènech et al. 2015; Ward y Butler 2016; Liu y Jensen 2018; Afghani, Hamhaber, y Frijns 2022
6	Technical barrier	Inadequate infrastructure, difficulties in use or malfunction of the innovation.	(4) Domènech et al. 2015 ; Kundu et al. 2018 ; Eggimann et al. 2018 ; Nilsson y Blomkvist 2021
7	Cognitive barrier	Lack of knowledge to use or maintain new technologies.	(4) McConville et al. 2017; Liu y Jensen 2018; Suleiman 2021; Afghani, Hamhaber, y Frijns 2022
8	Behavioral barrier	Failure to consider contexts (practices, habits, beliefs) in developing innovation and the economic, social, and environmental benefits it can provide.	(3) Kundu et al. 2018; Silvestri et al. 2018; Afghani, Hamhaber, y Frijns 2022

The most recurrent type of barrier-to-water transition is the intersectoral barrier. This refers to situations where there are no relationships between actors (social, institutional, political, and economic) at different levels, or there is a lack of synergies and alignments to support innovation. It also refers to the presence of resistance or conflict regarding innovation. The second type is political barriers. In this case, the lack of political support for local initiatives, failure to consider the needs of local populations, and implementation of ill-suited projects by international donors and organisations hinder water transitions. The third type is institutional barriers, which are linked to institutional fragmentation and coordination problems among institutional actors or excessive institutionalisation of the existing sociotechnical regime, generating path dependence situations.

The fourth type is economic barriers. The lack of visibility of benefits and economic viability of innovation, compared to established regimes, as well as high costs relative to demand uncertainty and market existence, can hinder water transitions. The fifth barrier is normative barriers, referring to the obstacles produced by the current legal and regulatory frameworks. A lack of clarity in law definitions can also create difficulties in local interpretation and hinder water transition. The sixth is technical barriers related to difficulties in using innovation due to poor design or malfunction. Dependence on centralised infrastructure which is unsuitable for local practices, can also hinder transition. The seventh type is cognitive barriers: a lack of knowledge to use or maintain new technologies can slow water transitions. Finally, behavioural barriers to water transitions are linked to disregard for contexts (practices, habits, and beliefs) in which innovation can be adopted, as well as economic, social, and environmental benefits.

Drivers of water transitions

The analysis of the corpus identified eight types of water transition drivers in 28 articles (Table 3).

Table 3. Presentation of eight drivers of water transition. Source: Authors, 2024.

	Drivers	**Definition**	**References**
1	Shared vision driver	The existence of a common vision that shifts collective perception towards a new regime or widespread adoption of innovation.	(7) Fam et al. 2014; van der Voorn and Quist 2018; White et al. 2019; Lennartsson et al. 2019; Criqui, 2020; Miörner et al. 2022; Mguni et al. 2022
2	Cognitive driver	The creation and assimilation of knowledge to enhance policy orientation; the presence of professional knowledge to support innovation; individual and social learning to change practices.	(7) Hoolohan et al. 2019; Criqui, 2020; Herrfahrdt-Pähle et al. 2020; McConville et al. 2022; Mguni et al. 2022; Binz et al. 2016 ; Blomkvist et al. 2020
3	Institutional driver	The existence of formal and informal institutions to drive experimentation, a coherent and flexible framework, and multiple institutional mechanisms to facilitate regime change and support this transition.	(6) Werbeloff et al. 2017; Wutich et al. 2020; Herrfahrdt-Pähle et al. 2020 ; Ampe et al. 2021; Pollachi et al. 2023; Nastar 2014
4	Individual driver	The presence of a promoter who uses their influential power to support the transition, particularly from the beginning of the process	(6) Werbeloff et al. 2017; Wutich et al. 2020; Ampe et al. 2021; Pollachi et al. 2023; Travassos and Momm 2022; Nastar 2014

		and to steer towards regulatory framework change.	
5	Networks drivers	The existence of networks with actors located at other scales to support innovations, their diffusion, or scaling up.	(5) Lieberherr and Truffer 2015; Mguni et al. 2022; da Conceição et al 2023; Dobre et al. 2018; Nastar 2014
6	Political driver	Political support from state actors and coherence of public policy instruments to support the transition.	(5) Sullivan et al. 2017; García Soler et al. 2018; Hoolohan et al. 2019; Karimi et al. 2021; Suleiman et al. 2020
7	Normative driver	Legal support through the presence of clear and strict regulatory measures, and assistance to stakeholders for their proper implementation.	(3) Werbeloff et al. 2017; Hartman et al. 2017; Suleiman et al. 2020
8	Economic driver	The existence of financial support from various stakeholders and demand or market to support the innovation.	(3) McConville et al. 2022; Binz et al. 2016 ; Suleiman et al. 2020

The most common driver of water transition is sharing a common vision among different actors. This refers to the existence of a collective vision built in collaboration among stakeholders that generates a change in perception, favouring a new sociotechnical regime. User support (both public and consumer) is also a key element in adopting innovation and supporting transitions. The second type is cognitive drivers. In this case, the creation and assimilation of knowledge improves policy orientation, and decision-making accelerates water transitions. Additionally, improving professional knowledge (2) and individual learning to integrate the use of innovation are key elements in their development.

The third type of driver, institutional, is linked to the existence of formal and informal institutions that can drive experimentation, a coherent and flexible framework, and several institutional mechanisms that can provide a solid foundation for water transitions. The fourth category refers to individual drivers. The presence of promoters, leaders with particular skills, and creative minds who use their influence to support the transition is key. This role is particularly important if engaged early in the transition process towards changing regulatory frameworks.

The fifth driver is associated with the existence of networks. The presence of contact and relationships with actors at other scales supports innovation, diffusion, and scaling up. Political drivers refer to the importance of political support from state actors as well as the integration and coherence among different public policy instruments to support the water transition. The

seventh type of driver is legal: legal support for innovations and regime changes through strict and clear regulatory measures and the training of officials and managers for their proper application strengthens the success of transitions. Finally, economic drivers are linked to the financial assistance required for innovation development, as well as the formation of demand by users, and thus, a market for further development.

Barriers and drivers at the Mediterranean level

From the perspective of the theoretical framework adopted in this report, this section analyses the main barriers and drivers shaping the transition towards non-conventional water (NCW) use in the Mediterranean region. The aim is to identify the institutional, regulatory, economic, cognitive, and socio-cultural conditions that either hinder or enable the scaling-up of NCW solutions across diverse national contexts. The analysis is based on the key findings emerging from the national policy documents developed for Spain, Italy, Egypt, Tunisia, and Algeria. By comparing these country-specific insights, the section seeks to highlight common patterns and critical differences, contributing to a shared understanding of the opportunities and constraints for advancing integrated and sustainable water governance in the Mediterranean.

1. Main barriers at the Mediterranean level

1.1 Inter-sectoral barrier: Fragmented governance and misaligned sectoral agendas

The ability of Mediterranean countries to scale up non-conventional water (NCW) solutions is significantly constrained by the fragmentation of governance frameworks and the weakness of cross-sectoral coordination mechanisms. In all five national contexts analyzed, water management responsibilities are distributed across multiple administrative levels—national, regional, and local—and among sectors with distinct and often divergent operational logics, such as urban water supply, agriculture, and environmental protection. Rather than producing an effective polycentric governance model, this institutional complexity frequently results in overlapping competencies, regulatory ambiguities, and decision-making processes marked by delays and uncertainty.

Although chronic water scarcity has led to the emergence of ad hoc collaborations among actors—particularly in regions under significant hydrological stress—such efforts remain limited in scope and duration. In general, they fail to consolidate into formalized institutional arrangements or integrated planning strategies. As a result, initiatives involving NCW technologies, including desalination, wastewater reuse, and aquifer recharge, tend to rely on short-term funding opportunities and isolated political momentum rather than coordinated, long-term, cross-sectoral agendas. Additionally, underlying distributional tensions persist. While urban utilities can often pass the costs of NCW solutions on to consumers, farmers must compete in open markets where the price of desalinated or treated water can place them at a

significant disadvantage. This cost asymmetry undermines broad-based social support for shared infrastructure and generates obstacles to collective investment .

This overarching pattern is manifested in distinct ways across the five countries studied. In Spain, stakeholders in the Segura Basin and Campo de Cartagena report relatively strong institutional relationships and a history of collaboration in managing water scarcity. However, misalignments between national and subnational policies persist. While desalination projects are promoted at the national level, the associated distribution infrastructure is often the responsibility of regional and local governments—or even private agricultural actors—leading to delays due to budget constraints. Moreover, farmers face challenges incorporating desalinated water into their irrigation systems, both due to cost and quality issues, which are not adequately addressed by current policy frameworks. Despite frequent cooperation among institutions, water policy remains fragmented, as hydrological planning and spatial land-use management continue to operate in parallel silos.

In Italy, the governance of water remains highly fragmented. In regions like Val d'Orcia, there are no public irrigation systems, and farmers manage their own reservoirs with minimal institutional support. Multiple institutions operate across different levels of government, subject to complex and sometimes conflicting regulations, which makes the approval of new water infrastructure both time-consuming and uncertain. Tensions also arise between environmental and agricultural interests, especially regarding the impact of reservoirs on ecosystems. Stakeholders have noted that while some local governments and consortia have shown support for reservoir construction, such as in the case of the San Piero in Campo dam, these projects often stall due to lack of funding and the absence of clear governance mechanisms. Coordination at the basin level remains weak despite attempts to strengthen it through the work of River Basin District Authorities.

In Egypt, efforts to promote cross-sectoral coordination have focused on participatory water management models. The creation of irrigators' associations, supported by international donors, sought to enhance local engagement in the maintenance of irrigation systems and infrastructure. However, in the absence of a robust legal framework, these associations remain institutionally weak and financially unsustainable. While collaboration does occur between government agencies, private actors, and international organizations, these partnerships are often project-based and contingent upon external funding. As a result, sustained institutional coordination is difficult to achieve, especially at the local level.

In Tunisia, institutional fragmentation is compounded by the limited capacity of technical agencies and the absence of structured coordination platforms. Government departments and specialized services tend to operate reactively, focusing on emergency responses rather than long-term planning or proactive stakeholder engagement. Interactions among users, researchers, public administrations, and civil society actors are often sporadic and informal. For example, the governance of wastewater reuse involves multiple actors—such as the CRDA, GDA, and ONAS—yet their coordination remains restricted to data exchanges and limited maintenance activities. Concerns over water quality, aquifer contamination, and health risks further complicate the implementation of NCW projects. Although some coordination efforts occur through quarterly meetings at the governorate level, these spaces are insufficient to drive coherent long-term strategies.

In Algeria, inter-sectoral barriers are shaped by weak communication among stakeholders, fragmented institutional responsibilities, and limited government support for user associations. These organizations, which are meant to maintain irrigation systems and water infrastructure, often lack both resources and technical capacity. Consequently, infrastructure degradation and water losses—due to infiltration, inefficient irrigation techniques, or leakage—remain widespread. Farmers frequently resort to modifying traditional irrigation systems individually or in small groups, which has led to uneven access to water and further governance fragmentation. An additional concern is the lack of bilateral cooperation between Algeria and Tunisia for the management of shared aquifers. In contrast to other North African countries that have engaged in cross-border water agreements, Algeria and Tunisia have yet to formalize joint strategies, leaving transboundary groundwater resources vulnerable to overexploitation and degradation.

In sum, while the specific configurations of inter-sectoral barriers differ among the countries studied, a shared pattern of institutional fragmentation, regulatory inconsistency, and weak cross-sector engagement clearly emerges. Without robust mechanisms for horizontal and vertical coordination—capable of reconciling divergent sectoral objectives—NCW policies will continue to face implementation challenges. Strengthening these mechanisms is thus a fundamental prerequisite for advancing integrated, equitable, and sustainable water governance in the Mediterranean.

1.2 Political barrier: Uneven commitment and top-down decision-making

Across the Mediterranean, official discourse consistently endorses non-conventional water (NCW) solutions, yet the day-to-day politics of financing, regulation and coordination expose three structural weaknesses. First, political backing is cyclical: support rises when water scarcity peaks or when particular parties gain office, then wanes, interrupting long-term programmes. Second, decision-making is centralised in every country analysed; ministries or national agencies set priorities, whereas sub-national actors—those who finance, build and operate NCW infrastructure—participate late or only in a consultative capacity. Third, several national reports point to a mismatch between international funding rules or supra-national regulations and local agronomic or climatic realities. These three factors combine to delay project execution and limit the territorial reach of NCW investments.

In Spain, desalination enjoys formal support, yet its uptake is constrained by the high price of desalinated water and by conflicts between national policies that limit agricultural expansion and local governments that defend intensive farming. Alignment (or lack thereof) between parties in office at national, regional and municipal levels determines whether local needs are incorporated into water planning. Stakeholders also criticise European trade rules that impose strict environmental requirements on EU producers while allowing imports produced under more lenient standards.

Italy presents broad rhetorical agreement on the need to expand storage capacity, but fragmented authority and occasional objections from environmental committees lengthen approval times. Participatory opportunities—an online comment tool and three workshops during preparation of the Tuscan Water Protection Plan—have proved insufficient to integrate specific local concerns. In parallel, new EU rules discouraging irrigation expansion in formerly

rain-fed areas clash with regional strategies that see irrigation as critical for high-value crops such as wine and olive oil.

In Egypt, national strategies (e.g., Water Plan 2037, Water Resources Strategy 2050) and international donors (FAO, UNDP, WB, WFP) explicitly support NCW infrastructure, but investment is concentrated in the Nile Basin. Basin-scale planning in other regions is limited, ministries work in silos, and financial constraints impede maintenance of cisterns and embankments. Cultural norms also restrict the participation of women in decision-making, reducing community influence over project choices.

Tunisia illustrates the implications of a strongly centralised model: the Ministry of Agriculture controls allocation and infrastructure, regional services merely implement directives, and water-user associations are kept outside policy discussions. Allocation rules are not fully public, and the current Water Code offers no legal basis for stakeholder participation, although a draft reform seeks to address this gap.

In Algeria, governmental commitment to NCW—particularly aquifer recharge—is limited, and decisions are made mainly at the central level, leaving local actors without a formal voice. Donor projects sometimes adopt generic frameworks that overlook Algeria's arid conditions, while modern large-scale schemes have accelerated aquifer depletion and marginalised traditional low-cost techniques such as *tabias* and *jessour*.

Without steady political support, inclusive decision-making forums and funding instruments adapted to local contexts, NCW initiatives will continue to advance unevenly across the Mediterranean. Strengthening multi-level coordination and aligning external financing with on-the-ground water realities emerge as essential next steps.

1.3 Institutional barrier: Fragmented governance and bureaucratic inertia

Across the Mediterranean, non-conventional water (NCW) initiatives advance within institutional landscapes marked by overlapping mandates, centralised decision-making and slow, procedure-heavy administrations. Responsibilities are dispersed among numerous ministries, agencies and tiers of government without a single coordinating framework, so every new desalination pipeline, reservoir or reuse scheme triggers a multi-layer approval chain. Bureaucratic caution—fuelled by legal liability and rigid hierarchies—further lengthens authorisations, while departments with conflicting priorities issue contradictory instructions. In several countries, strict regulatory standards or funding rules are poorly integrated with operational realities, and budget constraints limit the capacity of agencies to translate plans into works on the ground. The resulting institutional fragmentation raises transaction costs for applicants, discourages smaller producers and embeds territorial inequalities in access to NCW services.

In Spain, desalination plants can be built relatively quickly, yet the storage and distribution networks required for agriculture depend on multiple administrative bodies whose coordination has proved difficult. Because desalination facilities must run continuously, managers struggle to balance fluctuating demand, while farmers linked to these plants face water prices far above

those paid by peers with historical surface-water rights. Conflicting provisions in the Segura and Tagus River Basin Plans add further uncertainty.

Italy exhibits severe institutional fragmentation. The shift from River Basin Authorities to District Authorities was intended to streamline planning, but the new bodies lack clear mandates and funding. River-basin and flood-risk plans are produced with different methodologies, regional departments issue diverging incentives or restrictions, and every permit entails multiple reviews under the Environmental Consolidated Act. Large farms with ample capital sometimes navigate the process, yet smaller operators deem the two-year approval cycle prohibitive.

In Egypt, hierarchical structures and overlapping laws produce lengthy, opaque procedures. Ministries prioritise projects that secure immediate external finance, leaving reservoir construction and maintenance underfunded outside the Nile Basin. Coordination gaps mean remote communities still rely on rainwater harvesting or costly tanker deliveries, and decentralised wastewater schemes envisaged in Decrees 135/1999 and 334/2002 have progressed slowly.

Tunisia faces tight public budgets and stringent regulations that require socio-environmental impact assessments, adherence to NT106.02 and NT106.03 standards, and detailed “cahiers des charges” before any treated-wastewater project can proceed. These safeguards, while essential for health and environmental protection, extend timelines and paperwork. Limited integration of research findings into policy and low farmer acceptance of wastewater reuse reinforce the bottlenecks.

In Algeria, responsibilities for aquifer recharge and other NCW options are scattered among agencies working within conventional management paradigms. Decision-makers are reluctant to endorse unfamiliar techniques, collaboration between research institutions and government is minimal, and regulatory overlaps generate project delays. The absence of a unified governance framework leaves even technically feasible schemes without a clear path to approval.

These challenges point to the need for more flexible and better-coordinated institutional arrangements. Strengthening inter-agency collaboration, clarifying mandates, and streamlining procedures could significantly enhance the capacity of public institutions to support NCW expansion in an inclusive and efficient manner.

1.4 Economic barrier: High implementation costs and uneven cost-recovery

Across the Mediterranean, non-conventional water (NCW) projects face two interrelated economic challenges. First, implementation costs are consistently high, while demand for NCW remains uncertain and fluctuating. Infrastructure such as desalination plants, reservoirs and recharge systems must operate continuously to ensure efficiency and financial viability, yet user demand—particularly in agriculture—is highly sensitive to the relative price of conventional water sources. Second, the burden of cost recovery is often unevenly distributed. Farmers or local communities with limited financial capacity are frequently expected to absorb the full cost of infrastructure and operation, while others benefit from access to cheaper,

subsidised or historically guaranteed water sources. This imbalance limits uptake and undermines the economic sustainability of NCW interventions.

In Spain, desalinated water is reported as the most expensive resource available. When groundwater or inter-basin transfers are accessible at lower cost, desalinated water remains unused, compromising plant amortisation. During drought, however, demand and willingness to pay increase significantly. Farmers dependent on desalinated water face particularly high costs, as they are required to finance infrastructure amortisation, while those with access to traditional water rights benefit from cheaper supplies. This disparity creates competitive distortions within the agricultural sector. In response to this, stakeholders have suggested implementing price stabilisation mechanisms—comparable to those used in the electricity sector—and expanding the use of renewable energy to reduce production costs.

In Italy, economic barriers are centred on high up-front costs and unclear long-term financial returns. While some winemakers, operating with higher profit margins, have managed to self-finance reservoirs, smaller farms growing olives or cereals often lack the capital and perceive the investment as unjustifiable. Stakeholders also highlight the absence of standardised metrics for comparing the cost of reservoir-stored water with conventional sources, making it difficult to assess economic feasibility. This uncertainty is particularly problematic for small and medium-sized producers who also face limited access to external funding.

Egypt presents a case in which the benefits of NCW infrastructure—particularly in terms of job creation, land preservation and improved living conditions—are widely recognised. However, the costs associated with implementation, especially for cistern construction, remain prohibitive. For Bedouin communities in the northwest, the investment required for an average cistern is unaffordable without financial support. Despite alignment with broader development goals, these projects remain largely inaccessible without targeted subsidies or external funding.

In Tunisia, aquifer recharge is acknowledged as an essential strategy for long-term water sustainability, yet it is not currently integrated into national economic planning. Its benefits are neither quantified nor valued within agricultural value chains, making it difficult to justify investment. Farmers, facing high establishment and maintenance costs, are reluctant to adopt recharge or wastewater reuse technologies due to uncertainty about their efficiency and return on investment. This challenge is compounded by demographic shifts, including rural out-migration, which reduce the human capital available to maintain traditional water management systems.

In Algeria, artificial recharge faces similar difficulties. The perception of high costs and uncertain long-term viability discourages both public and private investment. Large-scale modern irrigation projects, while boosting yields, have contributed to aquifer depletion and the abandonment of traditional collective systems such as *tabias* and *jessour*. The deterioration of these historically effective and low-cost techniques, combined with the lack of maintenance funding, has further reduced the availability of affordable alternatives.

Overall, stakeholders across the region point to the need for economic instruments that can address cost disparities, reduce financial risk and ensure more equitable access to NCW infrastructure. The development of cost-sharing schemes, targeted subsidies, and

mechanisms for long-term financial viability appear as central demands to enable broader adoption of non-conventional water practices.

1.5 Normative barrier: Regulatory complexity, legal fragmentation, and evolving frameworks

Across the Mediterranean the legal environment for non-conventional water (NCW) is marked by a mix of highly detailed provisions and regulatory gaps, generating uncertainty for proponents of desalination, reservoirs, aquifer recharge or treated-wastewater reuse. In several countries the approval of NCW works requires navigating multiple sectoral laws—water, environment, cultural heritage, coastal management—whose scope and hierarchy are not always well aligned. Where rules are explicit, they can be so stringent (e.g., on water pricing or sediment disposal) that projects become financially onerous; where rules are missing or outdated, authorities proceed case-by-case, lengthening timelines and discouraging investment.

In Spain no statute forbids desalination itself, yet the Water Law and the public–private distinction it establishes create indirect hurdles. Seawater belongs to the maritime public domain, whereas the product of desalination is private; once blended with public supplies it may fall back under concession rules, obliging users to secure additional permits. Because desalination plants are mostly public, their tariffs must recover full costs, making the water too expensive for many farmers and limiting agricultural uptake.

Italy illustrates the opposite problem: an abundance of overlapping and restrictive norms. New reservoirs must comply with stringent environmental safeguards and, where relevant, landscape-heritage regulations. Sediments excavated during construction are classified as waste unless extensive analyses prove otherwise; even then they can normally be reused only on the originating farm, raising costs and curbing cooperative solutions. Frequent changes in jurisdiction and uneven interpretation among officials add to delays despite recent attempts at simplification.

In Egypt every private intervention affecting water resources requires a licence from the Ministry of Water Resources and Irrigation, and land-use controls prohibit cultivation on unlicensed plots. Sectoral statutes—such as Law 147/2021 on irrigation systems and the coastal-zone regulations under Law 4/1994—impose further layers of assessment. Stakeholders report that limited familiarity with these instruments inside the administration prolongs procedures and, in some cases, restricts land availability for reservoirs.

Tunisia’s Water Code expressly allows the reuse of treated effluent, so legal ambiguity is minimal; nonetheless, implementation remains modest because economic, technical and social constraints are not matched by strong normative incentives or enforcement mechanisms. The regulatory clarity, por sí sola, has proved insufficient to drive widespread adoption.

Algeria faces the challenge of legal obsolescence: key statutes pre-date current NCW practices, and updates proceed slowly. In the absence of specific provisions for artificial recharge, each proposal encounters ad-hoc scrutiny, which adds uncertainty even when no explicit conflicts with existing law are identified.

Stakeholders in the region emphasise that clearer, better-coordinated regulations—together with consistent interpretative guidance—would reduce approval times and facilitate the integration of NCW into mainstream water management.

1.6. Cognitive and Behavioral Barrier: Knowledge Gaps, Cultural Practices, and the Social Acceptance of NCW

Across the Mediterranean region, cognitive and behavioral barriers significantly shape the adoption and sustainability of non-conventional water (NCW) solutions. These obstacles often stem less from a total lack of technical knowledge than from uneven access to specialized training, limited institutional support, and the persistence of social perceptions or cultural practices that hinder the uptake of new technologies. In particular, behavioral resistance to certain NCW practices—such as wastewater reuse—remains a critical issue in some contexts, while in others, local traditions serve both as assets and limitations in the implementation process. Furthermore, the absence of structured capacity-building programs and the weak integration of local actors into decision-making processes compromise the long-term effectiveness of NCW strategies.

In Spain and Italy, the technical knowledge among farmers is generally solid, especially in sectors with high technological adoption, such as irrigation in the Campo de Cartagena or vineyard management in Tuscany. However, the challenges lie in the limited diffusion of best practices and the need to broaden adoption beyond pioneering actors. In Italy, gaps in land and water conservation practices, especially related to erosion control and sediment management, hinder reservoir maintenance. While advisory services and demonstration-based learning have gained traction, financial and institutional support remains necessary to facilitate broader implementation. Similarly, in Spain, although farmers are well prepared to manage desalinated water, there is room to expand training programs aimed at mitigating long-term risks such as soil degradation.

In contrast, Tunisia, Egypt, and Algeria face more acute deficits in technical training and structured support systems. In Tunisia, while stakeholders possess general water management knowledge, they lack specialized capacities in aquifer modeling, integrated resource management, and socio-ecological systems. The absence of socio-professional structures in rural areas further undermines knowledge transfer. In Egypt and Algeria, cognitive barriers are more severe: local actors, particularly in Bedouin or smallholder contexts, often lack access to the training needed to maintain and optimize NCW infrastructure. In Algeria, the lack of specialized knowledge in aquifer recharge and groundwater modeling constrains implementation, despite the existence of traditional hydraulic know-how. In Egypt, the success of cistern installations depends heavily on traditional observation techniques, which, while valuable, are rarely complemented by modern tools such as GIS or remote sensing.

Behavioral dimensions further complicate the picture. In Spain, although farmers generally support desalination due to historical water scarcity, the high cost and environmental critiques—particularly concerning brine disposal and energy consumption—generate ambivalence. In Italy, behavioral barriers arise from tensions between agricultural and environmental priorities, with conflicts over reservoir construction and river maintenance reflecting broader debates on landscape protection versus production needs. In Tunisia, social resistance to wastewater reuse is the most significant behavioral challenge. Despite legal

authorization, distrust among both farmers and consumers hinders its expansion. Awareness campaigns and pilot projects have attempted to change perceptions, but with limited success. Similarly, in Algeria, local practices and beliefs strongly influence the reception of NCW initiatives. Traditional systems of collective water management are being eroded, and new technologies often fail to engage with community norms, leading to skepticism and low adoption.

In sum, cognitive and behavioral barriers to NCW adoption in the Mediterranean are deeply intertwined. Technical knowledge alone is insufficient to ensure successful implementation unless accompanied by appropriate social engagement, cultural sensitivity, and inclusive institutional support. Addressing these challenges will require not only training programs and technical support but also mechanisms that incorporate local knowledge, build trust in new technologies, and bridge the gap between traditional practices and contemporary water management strategies.

Table 4. Barriers of water transition in the Mediterranean. Source: Authors, 2025.

Barriers to water transitions at the Mediterranean-level	
Technical Barrier	Technical barriers relate to infrastructural limitations, uneven access to technology, and the complexity of integrating NCW systems into existing water networks. While some countries show advanced implementation, most face challenges in ensuring operational efficiency, storage, and connectivity.
Environmental Barrier	Environmental barriers include pollution risks, inadequate monitoring, and ecosystem impacts. These are particularly pronounced in wastewater reuse and desalination, where salinity, contaminants, and discharge management raise sustainability concerns.
Institutional Barrier	Institutional barriers stem from governance fragmentation, overlapping mandates, and slow bureaucratic processes. Coordination among agencies is weak across the region, hindering efficient planning and implementation of NCW solutions.
Economic Barrier	Economic barriers include high investment and operational costs, uncertain long-term profitability, and lack of financial incentives. Small and medium farms are particularly affected due to limited access to funding and credit mechanisms.
Normative Barrier	Normative barriers involve outdated, fragmented, or overly complex regulations. Even when legal frameworks permit NCW use, implementation is slowed by unclear procedures, rigid classifications, and inconsistencies in regulatory interpretation.

1.6. Cognitive and Behavioral Barrier	Cognitive and behavioral barriers combine knowledge gaps, insufficient training, and resistance to change. While traditional knowledge is strong in some areas, it is rarely complemented by structured technical education or inclusive engagement strategies. Social perceptions, especially around wastewater reuse, remain a major challenge.

2. Main Drivers at the Mediterranean level

2.1 Shared vision: heterogeneous levels of collective commitment to non-conventional water across the Mediterranean

A shared vision—defined as the alignment of strategic priorities among public authorities, water users, and other stakeholders regarding the role of non-conventional water (NCW)—emerges as a relevant but variably developed driver across the Mediterranean countries analyzed. While some national contexts, such as Spain and Egypt, reveal relatively clear and operative visions that have supported the deployment of NCW solutions, others, like Italy and Tunisia, exhibit only partial alignment between policy frameworks and the practical engagement of local actors. In Algeria, by contrast, the absence of an articulated and widely endorsed strategy has limited the scale and coherence of NCW implementation. Rather than a binary presence or absence, the shared vision should be understood along a spectrum: from active mobilisation and institutional coordination, to rhetorical consensus without operational translation, to fragmented or locally grounded practices in the absence of national guidance. This variation affects the capacity to sustain long-term investment, coordinate stakeholders, and legitimize the role of NCW in national water strategies.

In Spain, there is a broadly shared understanding among stakeholders—especially within the Campo de Cartagena Irrigation District—of the importance of desalinated water as a response to persistent water scarcity. Farmers generally support its use and actively apply for annual concessions from multiple desalination plants, including Valdelentisco, Torrevieja, Escombreras, and Mojón. While this reflects a consolidated demand, the implementation of desalination continues to face significant challenges due to high costs and the lack of coordination between hydrological and territorial planning frameworks, which hinders the full integration of desalinated water into long-term strategies.

In Egypt, the expansion of cisterns is identified as a common priority among various stakeholders. The documents point to a consistent vision shared by communities—especially Bedouins—who demand more infrastructure to improve rainwater harvesting and reduce vulnerability to drought. This demand has prompted government action, such as securing international funding and implementing the Matrouh Resource Management Project (MRMP) in the 1990s. These initiatives show alignment between local needs and institutional responses, as reported in the national documents.

In Italy, stakeholders generally agree on the need to increase water storage capacity, particularly in response to summer droughts intensified by climate change. There is broad recognition of the importance of reservoirs, including both the construction of new

infrastructure and the restoration of existing ones. However, in regions like Val d'Orcia, reservoirs are considered a conventional solution rather than an innovation. The documentation notes that recent mobilisation efforts have been limited, with no significant collective initiatives reported in the last decades, although past efforts linked to the Common Agricultural Policy are acknowledged.

In Tunisia, NCW strategies—particularly aquifer recharge—are incorporated into national water and soil conservation plans. However, these initiatives are primarily driven by the public sector, and there is no clearly established shared vision that includes all stakeholders. Farmers contribute to indirect recharge but are not systematically involved in structured programs. Although workshops and pilot experiences are mentioned as potential means to promote collaboration, the documents suggest that engagement mechanisms are still limited and fragmented.

In Algeria, the documentation indicates the absence of a shared and coordinated vision around NCW, particularly aquifer recharge. No structured collaboration is reported, and the perception of NCW varies among actors. Some localised experiences—such as circular water management practices in oasis regions—are mentioned, but these remain isolated responses rather than expressions of an integrated national strategy. The lack of a common approach is identified as a factor that limits stakeholder mobilisation.

2.2 Cognitive Driver: Knowledge creation, assimilation and learning processes for NCW adoption

Across the Mediterranean, cognitive drivers refer to the generation, dissemination and assimilation of knowledge that supports the development and implementation of non-conventional water (NCW) solutions. These include formal training programs, scientific research, pilot projects, and traditional or community-based knowledge systems. The extent and structure of these learning processes vary significantly across the region. In some countries, such as Spain and Egypt, knowledge creation and technical training are more systematically integrated into NCW strategies. In others, like Tunisia and Algeria, knowledge production exists but remains weakly institutionalised, while in Italy awareness is widespread but structured learning initiatives are largely absent. These differences shape the capacity of each country to consolidate NCW approaches and ensure their long-term sustainability.

In Spain, the Region of Murcia—particularly the Campo de Cartagena—offers a notable case of integrated knowledge systems in desalination policy. Public–private partnerships between desalination plants, irrigation entities, and research institutions have generated pilot experiences on reverse osmosis optimisation, boron removal and water blending. The Water Observatory provides up-to-date information for professionals, facilitating data-driven planning. These mechanisms enable continuous adaptation and learning, aligning technical innovation with agricultural demands and environmental sustainability.

In Italy, although the benefits of small reservoirs are widely acknowledged—especially in the context of increasing climate-related water stress—no significant structured initiatives were identified to support professional training or encourage changes in land and water management practices. While some conservation techniques are implemented at farm level, the role of institutionalised learning in the diffusion of NCW remains limited. As such, learning

is present mainly in informal or individualised forms, and its articulation within broader water strategies is weak.

In Egypt, water management is a national priority, which has led to the implementation of training programs and technical support for NCW infrastructure, particularly in rainwater harvesting. These initiatives aim to enhance local capacity for maintaining and improving cistern systems. Traditional knowledge, especially within Bedouin communities, plays a complementary role in the localisation and maintenance of these systems, supporting learning through embedded social practices.

In Tunisia, knowledge production is driven mainly by technical studies that evaluate the feasibility and performance of aquifer recharge. These studies have informed national strategies but have not translated into widespread training initiatives. Efforts to promote learning rely on awareness campaigns and pilot projects rather than formal educational programmes. The division of roles between public institutions (in charge of infrastructure) and farmers (responsible for indirect recharge) has limited opportunities for knowledge exchange and joint capacity building.

In Algeria, knowledge creation regarding artificial aquifer recharge occurs through local projects, research collaborations and awareness initiatives. However, these efforts have not yet led to integrated policies or structured professional training. Informal learning and social transmission of water management practices—especially in oasis regions—support community-based adoption of NCW practices, but without institutional reinforcement, such learning remains fragmented and lacks long-term sustainability.

In sum, the cognitive driver emerges as a critical but unevenly developed factor across the Mediterranean. Countries with formalised learning systems and knowledge-sharing platforms are better positioned to expand and maintain NCW infrastructure. Strengthening institutional support for training, fostering collaboration between actors, and integrating scientific and traditional knowledge can significantly enhance the impact and scalability of NCW solutions in the region.

2.3. Institutional Driver: Uneven coordination and limited integration between research, policy and implementation

The institutional driver refers to the configuration of formal organisations—ministries, research centres, basin agencies and funding programmes—that enable experimentation, knowledge transfer and policy coordination for non-conventional water (NCW) solutions. Across the five countries reviewed, these institutions range from well-articulated research-policy networks that actively guide NCW deployment to more fragmentary arrangements focused on pilot projects or ad-hoc funding windows. The degree to which institutional arrangements provide sustained technical support, facilitate multi-actor coordination and align national and local planning frameworks largely determines the pace and scope of NCW adoption.

In Spain, the Region of Murcia exhibits a dense institutional ecosystem. Research bodies such as CEBAS-CSIC, the Universidad Politécnica de Cartagena and IMIDA generate applied studies on desalinated water quality, soil interactions and crop management. Regular coordination meetings between plant operators, researchers and farmers, together with real-

time monitoring networks (SAIH, SAICA), translate this knowledge into operational adjustments. Nevertheless, inconsistencies between the Segura and Tagus river-basin plans, combined with the absence of a coherent national action framework, continue to create uncertainty for long-term investment.

In Italy, institutional support is present but limited. The Rural Development Programme of the Tuscany Region offers funding for improved water management, and consultants disseminate good agricultural practices; however, these initiatives do not specifically target new reservoir construction. Stakeholders consider available resources insufficient for widespread NCW uptake, and no dedicated experimentation platforms were identified for reservoir innovation.

In Egypt, research centres under the Ministry of Agriculture and the Ministry of Water Resources and Irrigation, together with universities such as Alexandria and Matrouh, develop methodologies that inform policies for financing cisterns and dikes. Training programmes aimed at Bedouin communities build technical capacity for rainwater harvesting and infrastructure maintenance. The challenge lies in scaling these efforts and ensuring stronger linkage between research outputs, funding streams and field implementation.

In Tunisia, the Ministry of Agriculture and the Ministry of Environment provide the regulatory and technical framework for artificial recharge, while the Hydrographic Basin Agency (ABH) supplies technical and financial backing for project development. Although these institutions are pivotal, the national documents do not report structured coordination mechanisms that fully integrate local actors with ministerial initiatives, which limits the consolidation of recharge practices.

In Algeria, the Hydrographic Basin Agency also plays a central role, coordinating pilot projects on artificial aquifer recharge and supporting experimental innovations. Beyond these pilots, however, no additional mechanisms are documented that would promote large-scale NCW deployment. The institutional framework therefore remains at an exploratory stage, and its expansion is identified as a prerequisite for broader diffusion of recharge technologies.

Overall, institutional capacity emerges as a differentiated yet decisive driver: where research, policy and user networks are closely intertwined, NCW projects gain traction and adaptive management becomes feasible; where such linkages are weak or confined to isolated pilots, the transition beyond demonstration remains uncertain.

2.4. Individual and Network Drivers: Leadership gaps and uneven collaboration across contexts

Leadership exercised by individuals or traditional authorities, together with the density of stakeholder networks that connect users, technology suppliers and public institutions, constitutes a combined driver that can accelerate—or, when absent, slow—the diffusion of non-conventional water (NCW) solutions. Examination of Spain, Italy, Egypt, Tunisia and Algeria reveals a broad spectrum: from settings where pioneering leaders operate inside well-articulated multilevel networks that sustain desalination or cistern programmes, to contexts where neither champions nor stable coalitions are in place, leaving NCW initiatives fragmented and small-scale.

In Spain, desalination benefitted first from early public investment under the AGUA Plan and from pioneers in the Canary Islands; later, farmer cooperatives in Murcia's Campo de Cartagena demonstrated its practicality for high-value horticulture, helping to normalise its use. Leadership figures such as José Manuel Claver Valderas provided political advocacy, while a dense network links technology firms (Aqualia, Acciona, Sacyr Water), irrigation communities, SCRATS, and regional and national administrations. Workshops, extension services and EU funding complete an ecosystem that couples advocacy with continuous technical support.

In Italy, reservoirs are accepted as conventional infrastructure, and farmers' associations occasionally lobby, together with reclamation consortia, for new storage. However, no prominent individuals champion reservoir expansion, and the networks that do exist have so far failed to obtain policy changes or significant funding. Recent droughts have raised awareness, but without sustained leadership or multilevel coalitions progress remains incremental.

In Egypt, leadership is rooted in traditional governance: Bedouin councils allocate cisterns by tribal need, and village heads (omdas) mobilise resources and negotiate with ministries. The Wadi Garawla Agricultural Cooperative bridges local communities with the Ministry of Agriculture and the Ministry of Water Resources and Irrigation, ensuring technical coordination and equitable distribution. This alignment of community leadership with a functioning cooperative structure has underpinned projects such as the Matrouh Resource Management Project and continues to support cistern expansion.

In Tunisia, documentation points to an absence of domestic champions for aquifer recharge and limited local networking. International platforms—IAH, CSIRO, IGRAC and others—provide research exchange and training opportunities, but national coordination mechanisms capable of translating this knowledge into field implementation are weak. Without recognised leaders to connect farmers, public agencies and international expertise, recharge initiatives remain dispersed.

In Algeria, neither influential promoters nor structured stakeholder networks are reported. Local adaptations of traditional water-harvesting methods in oasis regions proceed independently, but lack of coordinated advocacy means artificial recharge receives little regulatory or financial support. The diffusion of best practice and access to technical assistance thus depend on isolated pilot efforts rather than on organised coalitions.

Overall, Mediterranean experience suggests that NCW adoption is quickest where individual leadership and multilevel networks reinforce one another—linking demonstration, political negotiation and technical advice. Where either element is missing, the driver weakens, and NCW projects advance slowly or remain confined to local experiments.

2.5. Political Driver: divergent state priorities and multi-level dynamics in NCW governance

Political commitment—expressed through laws, investment programmes and inter-governmental coordination—sets the pace at which non-conventional water (NCW) solutions move from project status to established practice. Across the Mediterranean, national approaches range from more consolidated strategies that incorporate NCW into water-security

agendas to more tentative or fragmented frameworks in which regulatory gaps and uneven implementation persist. Spain and Egypt illustrate relatively proactive efforts, albeit with ongoing challenges. Italy and Tunisia present intermediate profiles, where supportive instruments exist but remain partially operational or locally constrained. Algeria shows limited national-level articulation, although some local initiatives offer relevant precedents. These contrasts reflect how multi-level politics—between ministries and regions, and between domestic institutions and international donors—either reinforce or undermine the momentum toward NCW adoption.

In Spain, national administrations have progressively incorporated desalination as a central component of water policy for the southeast. The 2004 AGUA Plan marked a shift from large-scale water transfers to alternative supply strategies, and more recent investments reflect a sustained commitment to expand desalination and reuse. However, this national push has encountered reservations at the regional level, particularly in Murcia, where authorities and agricultural actors often continue to favour water transfers on economic grounds. Tensions between the cost of desalinated water, environmental concerns, and institutional coordination pose ongoing challenges. Despite this, the integration of desalination into broader policy instruments—such as the DSEAR Plan—and experiments with brine valorisation suggest a dynamic and evolving governance landscape.

In Italy, the political framework supporting NCW is present but not fully consolidated. National planning documents like the Piano Invasi and PNISI provide some direction, and regional initiatives such as the Water Management Plan in Tuscany propose innovative models (e.g. shared public reservoirs). Yet stakeholders point to regulatory ambiguities, slow implementation, and insufficient financing as obstacles to broader adoption. While these limitations do not preclude future progress, they suggest that political support remains uneven and that greater alignment between levels of government would be needed to scale up NCW initiatives.

In Egypt, there is a comparatively strong alignment between political commitment, legislation, and international financing mechanisms. Legal frameworks such as the 2021 Water Resources Law provide a foundation for NCW development, and initiatives like the Matrouh Resource Management Project demonstrate the capacity of the state to coordinate with external donors and respond to local needs. While challenges related to funding continuity and technical adaptation persist, the case of Egypt illustrates how policy, law and funding can converge to support NCW expansion—particularly in vulnerable rural areas.

Tunisia exhibits a combination of traditional and modern approaches to water management. State-led investment in dams, recharge structures and the reuse of treated wastewater indicates a degree of political engagement, and conservation programmes such as CES promote local techniques rooted in historical practices. However, the integration of these diverse measures into a cohesive NCW strategy remains partial. Limited stakeholder engagement at the local level and the need for better alignment between traditional systems and infrastructure-intensive projects suggest that further coordination would be necessary to strengthen the political driver.

In Algeria, political support for NCW remains limited, particularly at the national level. While some local experiences—such as those led by the Hydrographic Basin Agency—demonstrate

technical potential for artificial recharge, the absence of a dedicated national strategy and regulatory framework restricts broader development. Government investments tend to prioritise other water infrastructure (desalination, wastewater treatment), and support for smaller-scale recharge systems is relatively marginal. These conditions highlight the importance of political leadership in enabling coordinated action, especially in contexts where local experimentation lacks formal institutional backing.

In sum, while all five countries show some level of engagement with NCW strategies, the degree of political support varies considerably in scope, coherence and institutional articulation. Where political will is matched by regulatory clarity and intergovernmental coordination, NCW initiatives appear more robust; where such alignment is lacking, implementation tends to remain fragmented or experimental.

2.6. Economic Driver: Asymmetric financial capacities and incentives shaping NCW implementation across the Mediterranean

The economic dimension of non-conventional water (NCW) adoption reveals a markedly uneven landscape across the Mediterranean region. While some countries benefit from robust public investment, international aid, and established market demand, others face persistent financial constraints, low institutional support, and limited economic incentives. The presence or absence of sustained funding, cost-reduction mechanisms, and user-targeted subsidies critically conditions the feasibility and scalability of NCW solutions.

In Spain, desalination in the region of Murcia benefits from a diversified and relatively stable financial architecture. National subsidies, EU cohesion and climate funds, and electricity price support mechanisms—combined with strategic public–private partnerships—enable the operation and maintenance of desalination plants despite their high energy and capital costs. Targeted subsidies have made desalinated water more accessible for farmers, especially since water tariffs were lowered in 2023. Nonetheless, the economic sustainability of this model remains sensitive to energy prices and to the relative costs of alternative sources, such as inter-basin transfers.

In Italy, although there is some degree of financial support from regional, national, and European levels, it is limited in scale and often insufficient to meet the high investment requirements of new reservoirs. The complexity of fund access and the fragmented nature of funding schemes constrain implementation. Despite the clear market demand driven by seasonal water scarcity in agriculture, the current economic support structure does not yet provide a strong enabling environment for the expansion of NCW infrastructure.

In Egypt, international aid constitutes the primary financial driver of NCW implementation. Organizations such as the World Food Program (WFP) have played a central role in funding cisterns, dikes, and rainwater harvesting structures, particularly in marginalized areas where local financing is virtually absent. Although demand among Bedouin communities is high—given the direct link between water availability, agricultural productivity, and income generation—the continuity of NCW implementation remains heavily dependent on external financial flows.

In Tunisia, public authorities provide key financial support mechanisms, including direct project funding and user subsidies, particularly for the reuse of treated wastewater (EUT). However, market dynamics are less predictable: in some instances, supply exceeds farmers' uptake, suggesting a need for improved alignment between provision and demand. While the subsidy system offers strong economic incentives, the long-term sustainability of NCW adoption would benefit from more diversified funding channels and greater user engagement.

In Algeria, the economic driver is the weakest among the cases examined. There is no substantial public or private financial support structure for artificial recharge models, nor is there a clearly articulated market demand to incentivize adoption. Sporadic initiatives supported by the National Agricultural Development Fund (FNRDA) have not been sufficient to establish a scalable or sustainable practice. Without the development of coherent economic instruments and a more favorable policy environment, NCW solutions remain marginal within Algeria's broader water management strategies.

In sum, economic drivers play a pivotal but highly uneven role in shaping the uptake and consolidation of NCW strategies in the Mediterranean. The presence of subsidies, external aid, and stable demand can compensate for high costs and technical complexity, while their absence often translates into fragmented, small-scale efforts with limited replicability. Addressing this asymmetry remains a critical challenge for the regional scaling of sustainable water solutions.

Table 5. Drivers of water transition in the Mediterranean. Source: Authors, 2025.

Driver at the Mediterranean Level	
Cognitive	Uneven awareness and technical understanding of NCW; diffusion strongest where desalination or reuse has longer track records.
Institutional	Fragmented coordination across governance tiers; research, policy and implementation often operate in silos.
Individual	Leadership gaps shape uptake: clear champions in Spain and Egypt, limited promotion elsewhere.
Network	Collaboration networks facilitate diffusion in Spain and Egypt; weak or absent structures in Algeria and parts of Italy and Tunisia.

Political	Political commitment varies: proactive plans in Spain and Egypt; more tentative or fragmented support in Italy, Tunisia and Algeria.
Normative	Legal environments range from enabling (Spain, Tunisia) to unclear or obstructive (Italy, Algeria), affecting implementation legitimacy.
Economic	Financial asymmetries: sustained subsidies and external aid in Spain and Egypt; significant funding gaps in Italy and Algeria.

Strengthening Enabling Conditions for the Adoption of NCW in the Mediterranean: Insights and Guidelines for Regional Action

The analysis of drivers and barriers across Mediterranean countries highlights a set of shared dynamics that can inform the development of regional strategies to promote the adoption of non-conventional water (NCW) solutions. Despite diverse institutional contexts, the comparison reveals converging challenges and opportunities that underscore the need for coordinated policy efforts.

First, several types of barriers persist across the region, including unclear or outdated legal frameworks, fragmented governance, limited financial mechanisms, and insufficient coordination between scientific knowledge, policymaking, and implementation. These obstacles are particularly evident in the case of artificial recharge, which lacks consistent regulatory and institutional support in most countries. Moreover, the absence of key promoters or champions at the individual and political level slows progress and limits the potential for innovation and stakeholder engagement.

On the other hand, the comparative analysis also reveals key drivers that represent valuable entry points for policy development. These include:

- The emergence of shared visions and narratives that frame NCW as a strategic response to climate change and water scarcity.
- A growing knowledge base and technical capacity, supported by scientific institutions, international cooperation, and living labs that demonstrate the feasibility of NCW.
- The presence of local leadership, particularly in cases such as Spain and Egypt, where pioneering actors or traditional authorities have played a central role in fostering innovation and uptake.

- Experiences of networked collaboration, linking users, technical actors, and policy institutions across levels of government.

- Institutional mechanisms that enable public investment and economic incentives, including EU funding, national subsidy schemes, and cost-sharing arrangements.

These findings suggest that regional policies should aim to create enabling environments that (i) reduce legal and institutional uncertainty, (ii) build coalitions of actors across sectors and scales, (iii) strengthen public investment and international cooperation, and (iv) support knowledge diffusion and the development of shared strategic narratives. Rather than prescribing uniform solutions, such policies should foster experimentation, recognize contextual specificities, and promote flexible frameworks that support the scaling up of successful NCW models.

In this sense, a Mediterranean strategy should not only address existing barriers but also amplify the drivers already in place, promoting synergies among them and mobilizing the region's potential to innovate in the face of water insecurity.