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

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National policy document for NCW upscaling - Egypt

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Task Leader	Maria Cristina Rulli mariacristina.rulli@polimi.it		
Main Author	Dr. Chloe Artero & Dr. Melina Tobias		
Contributors			
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Abstract	The present report is produced as deliverable for the task 4.2 of AG-WaMED,Integrated Watershed Management Plans and NCW out-scaling. The document contributes to the development of national policy frameworks for upscaling non-conventional water (NCW) uses in selected Mediterranean countries. It addresses the emerging concept of water transition, understood as a shift towards more sustainable governance and use of water resources. Through a systematic literature review, the study develops a conceptual framework that identifies the key barriers and drivers of water transitions. It applies this framework to a case study of a living lab (Egypt) to analyze upscaling processes at the national level. The findings inform future policy recommendations and contribute to broader Mediterranean-scale strategies for NCW deployment.		
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Introduction

This document is intended for the development of Deliverable 4.2.2.5, "National policy documents for NCW upscaling (Italy, Spain, Egypt, Tunisia, Algeria, D34)." Subsequently, the results will also contribute to sub-task 4.3.1, “Policy document for upscaling and out-scaling NCW at the Mediterranean scale (M20-34).”

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). The objective of this document is to collect data to compare the upscaling processes of NCW at the national level. 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, which involves literature review. We then present the 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.

Theorical 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 entrenched in daily institutional practices and logics.	(6) Herslund et al. 2018; Kundu et al. 2018 ; Sixt, Klerkx, y Griffin 2018; Suleiman 2021 ; Helgegren et al. 2021 ; Pakizer et al. 2023

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 and to steer towards regulatory framework change.	(6) Werbeloff et al. 2017; Wutich et al. 2020; Ampe et al. 2021; Pollachi et al. 2023; Travassos and Momm 2022; Nastar 2014

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 in Egypt

In this section, we aim to analyze the barriers and drivers identified for the case of Egypt. These were derived from two main sources: the responses to the guidelines provided to the countries (a methodology specific to this deliverable) and the inputs from Deliverable 4.1.1, Integrated Governance and Policy Analysis Report.

Barriers

Intersectoral Barrier: Coordination and Institutional Participation Challenges

Water management in Egypt involves multiple actors, with government support playing a key role in facilitating collaboration (Living Lab responses). The utilization of cisterns and dikes is based on agreements among users, ensuring that these small-scale water infrastructures are effectively managed. Larger reservoirs, on the other hand, are collectively managed, reflecting a cooperative approach among water users.

Technical and collective collaboration for implementing NCW solutions is largely dependent on funding availability. While no fixed timelines exist for joint efforts, there are ongoing partnerships involving government agencies, international organizations, private companies, and research institutions, working together to develop new water management models.

However, challenges persist at the local level. Reports indicate that irrigator associations were introduced with support from international donors and development banks to enhance local participation in irrigation management. The goal was to foster a sense of ownership among stakeholders, ensuring their active involvement in maintaining irrigation systems. Despite these efforts, participation in these organizations remains low, partly due to the absence of a legal mandate, which has hindered their financial operations. The lack of strong institutional engagement affects both infrastructure maintenance and overall water management quality.

Political Barrier: Support for NCW but Unequal Investment and Participation Challenges

There is political support for the installation of new unconventional water use (NCW) infrastructure in Egypt, as these projects are seen as key to combating climate change and addressing drought conditions (Living Lab responses). Additionally, the international orientation of funders such as FAO, UNDP, WB, and WFP is generally aligned with the region’s needs, as they provide targeted funding for water infrastructure projects, particularly in the Northwest Coast.

Despite this support, several obstacles limit the participation of local communities. Key challenges include a lack of financial resources to implement projects that directly address local needs, a shortage of skilled personnel, and traditional cultural norms that sometimes hinder participation, particularly for women, who may be excluded from decision-making processes.

Reports indicate that while efforts are being made to expand unconventional water sources and water-saving methods, these developments are not effectively integrated with broader water reallocation strategies. In practice, water savings from irrigation or domestic network improvements tend to be reinvested within the same sector, rather than being redistributed to areas with the greatest need.

In regions such as the Wadi Naghamish Basin, investment in water infrastructure remains insufficient, with poor maintenance of embankments and cisterns. The cost of maintaining these structures falls primarily on low-income local communities, who express dissatisfaction with the level of financial support from the state and local authorities. Reports also highlight that while Egypt's National Water Plan 2037 and National Water Resources Strategy 2050 commit to water security and sustainable management, in practice, water investments have been concentrated in the Nile Basin, often neglecting northwestern regions. This territorial disparity in water access reflects a broader issue: the absence of basin-scale water management planning. As a result, challenges in coordinating different ministries and addressing administrative centralization contribute to inequalities in water distribution, particularly between northern and southern regions. While the government's Vision 2030 strategy commits to integrated water resource management, reports suggest that the lack of basin-scale coordination could exacerbate existing inequalities between agricultural and domestic water users and among different tribal groups.

Institutional Barrier: Bureaucratic Complexity and Fragmented Governance

The installation of unconventional water use (NCW) infrastructure in Egypt faces significant institutional challenges, particularly due to bureaucratic inefficiencies, fragmented governance, and lack of financial resources (Living Lab responses). The involvement of multiple governmental bodies often results in prolonged approval processes, with overlapping responsibilities and unclear legal frameworks leading to delays and confusion. Additionally, many departments lack knowledge of specific laws and decrees, further complicating coordination.

Institutions in Egypt operate under hierarchical structures, which slow down decision-making and create rigid bureaucratic procedures. The prioritization of projects that secure immediate funding often takes precedence over long-term sustainability initiatives, leading to underinvestment in reservoir construction and maintenance. Moreover, profitability concerns may conflict with social and environmental responsibilities, limiting the scope of NCW development.

Reports indicate that water governance in Egypt is highly centralized and lacks transparency, with diffuse and conflicting responsibilities among government agencies. The multiplicity of laws and regulations, despite the 2021 Irrigation Law, has led to gaps in accountability and inefficiencies in decision-making. While Egypt's National Water Plan 2037 and National Water Resources Development and Management Strategy 2050 commit to sustainable water management, investment has been heavily concentrated in the Nile Basin, neglecting northwestern regions where water access remains a critical issue.

In some areas, particularly in Wadi Naghamish Basin, poor institutional coordination has exacerbated water access disparities. Residents in remote areas rely on rainwater collection or costly trucked water deliveries, while agricultural activities struggle due to drought and inadequate infrastructure maintenance. Additionally, sewer system connections are lacking, forcing communities to depend on basic septic tanks, which pose sanitation risks. The implementation of Decrees 135/1999 and 334/2002, which aim to establish decentralized wastewater treatment systems, has been limited due to institutional and financial constraints.

Overall, the combination of administrative centralization, lack of coordination between ministries, and difficulties in securing international funding presents a major institutional barrier to the expansion of NCW infrastructure in Egypt.

Economic Barrier: High Implementation Costs and Socioeconomic Benefits

The economic benefits of installing new reservoirs in Egypt are widely acknowledged, as they create job opportunities, leverage existing infrastructure, and contribute to financial viability (Living Lab responses). The main economic advantages are tied to broader socioeconomic goals, including increased water availability, land preservation, and improved living conditions for local communities. These improvements are expected to enhance agricultural productivity, leading to higher incomes for individual beneficiaries.

Despite these benefits, the high implementation cost of new cisterns remains a major challenge, particularly for Bedouin communities, who cannot afford the required investment. The cost of digging 1 m^3 of cistern storage is approximately 400 Egyptian pounds, and with an average cistern capacity of 75 m^3, the total cost per unit reaches 30,000 Egyptian pounds, making it financially inaccessible for many residents. These financial constraints highlight the need for external funding and financial support mechanisms to ensure equitable access to NCW infrastructure in Egypt.

Normative Barrier: Complex Regulatory Framework and Licensing Restrictions

The implementation of NCW infrastructure in Egypt faces significant regulatory challenges due to the involvement of multiple governmental bodies, which leads to prolonged approval processes and bureaucratic hurdles (Living Lab responses). Additionally, there is a lack of knowledge among different departments regarding specific laws and decrees, further complicating project approvals.

One of the key regulatory barriers is that any private work or modification related to water resources, including reservoirs, requires a license from the Ministry of Water Resources and Irrigation. Moreover, land use is strictly regulated, with cultivation or any other use without a license being prohibited, which can restrict land availability for reservoir development. Since the Ministry has centralized control over water distribution, this can cause conflicts or delays in project implementation.

Two important regulations governing NCW projects include Law No. 147 of 2021, which aims to establish efficient water management, irrigation, and drainage systems, and the Integrated Coastal Zone Management (ICZM) strategy, which is framed within Law No. 4/1994 for environmental protection. The ICZM strategy emphasizes sustainable water use and protection of coastal areas, including reservoirs, and considers both environmental and social impacts. These regulatory constraints highlight the need for clearer legal guidelines and streamlined approval processes to facilitate the development of NCW infrastructure in Egypt.

Technical Barrier: Insufficient Infrastructure and Adaptation Challenges

The current infrastructure for rainwater harvesting in Egypt is insufficient to support NCW solutions, particularly considering prolonged drought periods. Continuous investment and maintenance are required to ensure the efficiency and sustainability of these systems.

Several technical challenges hinder the implementation of new technologies in NCW development. The use of Geographic Information Systems (GIS), Remote Sensing (RS), and modeling tools to optimize cistern placement and maximize rainwater collection remains limited. These technologies require continuous adaptation and expertise to ensure their effectiveness in Egypt's climate conditions.

Reports indicate that a significant portion of cisterns in the region are no longer functional, despite growing water scarcity needs. Approximately 79% of the cisterns are operational, but drought conditions prevent recharge, and the lack of rainfall leads to cracks in the cement lining, further damaging storage capacity. To improve NCW implementation, upgrading infrastructure, investing in modern technology, and ensuring regular maintenance are necessary to enhance water harvesting efficiency and long-term sustainability.

Cognitive Barrier: Limited Knowledge and Training Needs

There is insufficient knowledge and training among actors regarding the use and maintenance of reservoirs in Egypt. This lack of expertise affects the long-term sustainability and efficiency of NCW infrastructure. To successfully implement NCW solutions, training programs should focus on new and innovative water harvesting methods and proper cistern maintenance. Strengthening technical knowledge in rainwater collection, storage management, and infrastructure upkeep would improve the effectiveness and longevity of these systems.

Behavioral Barrier: Reliance on Indigenous Knowledge Over Technology

Indigenous knowledge plays a crucial role in the successful installation of new reservoirs in Egypt. Bedouin communities rely on traditional water flow observations to determine optimal cistern locations, rather than using modern technologies such as GIS, Remote Sensing (RS), and Modeling. These traditional practices are fully integrated into the development of NCW solutions, as Bedouins do not depend on advanced technological tools for site selection. This reliance on local expertise is essential for NCW expansion but may also limit the adoption of new, more precise methodologies for water harvesting optimization.

Table 4. Main Barriers to water transition in Egypt

	Barriers	**Definition**	**Description**
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.	Government support facilitates NCW implementation, and water infrastructures like cisterns and dikes are managed through user agreements. However, collaboration across entities depends on funding availability, and local irrigator associations face low participation and weak institutional support due to the absence of a legal mandate
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.	Political support exists for NCW projects, especially in combating climate change, but financial and human resource limitations hinder local participation. Cultural norms restrict decision-making roles for women, and while international donors align with regional needs, investments often favor the Nile Basin over northwestern regions, exacerbating territorial disparities
3	Institutional barrier	Institutional fragmentation and internal coordination problems, strong institutionalization of the existing sociotechnical regime entrenched in daily institutional practices and logics.	Highly centralized governance and bureaucratic delays slow down project approvals. Overlapping responsibilities between ministries, lack of coordination, and prioritization of profitable projects over sustainable solutions further hinder NCW expansion. Low transparency and fragmented policies make decision-making inefficient, particularly in remote areas like Wadi Naghamish Basin, where water access remains precarious
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.	NCW solutions contribute to job creation and land preservation, improving living conditions and financial viability. However, high costs prevent local Bedouins from installing new cisterns, with a single unit costing 30,000 Egyptian

			pounds, making external funding essential
5	Normative barrier	Regulatory obstacles produced by legal frameworks or poor definition of laws leading to interpretation issues.	Complex regulations and licensing requirements slow down NCW implementation. Private water projects require authorization from the Ministry of Water Resources and Irrigation, and land use restrictions complicate reservoir development. Lack of legal clarity and centralized control over water distribution lead to delays and conflicts
6	Technical barrier	Inadequate infrastructure, difficulties in use or malfunction of the innovation.	Rainwater harvesting infrastructure is insufficient and requires continuous investment and maintenance. The adoption of GIS, Remote Sensing, and Modeling for site selection is limited, making cistern placement less optimized. Many existing cisterns are damaged or non-functional due to drought-induced structural deterioration
7	Cognitive barrier	Lack of knowledge to use or maintain new technologies.	Lack of technical knowledge and training affects the use and maintenance of reservoirs. Capacity-building programs are needed to introduce new water harvesting techniques and cistern maintenance strategies to ensure sustainability
8	Behavioral barrier	Failure to consider contexts (practices, habits, beliefs) in developing innovation and the economic, social, and environmental benefits it can provide.	Bedouins rely on indigenous knowledge to determine cistern locations based on water flow observations, rather than using modern technologies like GIS or Remote Sensing. While this ensures cultural integration, it may limit the adoption of more advanced water harvesting methods

Drivers

Shared Vision Driver: Common Priority on Expanding Cistern Infrastructure

In Egypt, there is a shared vision that prioritizes increasing the number of cisterns as a key strategy to combat drought and enhance rainwater harvesting. This collective understanding has directly influenced the perception and adoption of non-conventional water (NCW) solutions, as communities recognize the necessity of expanding water storage infrastructure.

A clear example of how this vision has mobilized stakeholders is the response to climate change-induced drought periods. The growing demand from Bedouin communities for more cisterns led to governmental action, with the Ministry of Agriculture and Land Reclamation securing international funding to support the expansion of water storage infrastructure. A notable initiative in this regard was the Matrouh Resource Management Project (MRMP) in the 1990s, which facilitated the construction of dikes and the excavation of new cisterns to enhance local water availability.

Cognitive Driver: Prioritization of Water Management and Training Initiatives

In Egypt, water management is a national priority due to the country's limited and insufficient water resources. This recognition has influenced knowledge creation and assimilation efforts, particularly in financing non-conventional water (NCW) solutions.

To support professional learning and encourage the adoption of new practices, specific training programs have been implemented. These efforts aim to enhance technical capacities and promote more efficient water management strategies.

At the local level, individual and social learning processes play a significant role in facilitating the adoption and maintenance of NCW solutions. Rainwater harvesting is widely accepted and integrated into traditional water management practices, while other models, such as seawater desalination, exist but remain limited in use due to high costs associated with desalinated water. This indicates that while knowledge on NCW solutions exists, economic constraints impact the feasibility of certain technologies.

Institutional Driver: Research and Capacity Building for NCW Implementation

In Egypt, several formal institutions play a role in facilitating experimentation and innovation in water management. Research centers affiliated with the Ministry of Agriculture and Land Reclamation and the Ministry of Water Resources and Irrigation, along with universities such as Alexandria University and Matrouh University, are actively developing research methodologies. These institutions aim to promote and enhance policy direction for financing new cisterns and dikes, which are critical for rainwater harvesting.

Institutional mechanisms supporting NCW installation include training programs that focus on knowledge transfer and skill development. Specifically, Bedouin communities receive training on new water harvesting techniques and the maintenance of cisterns and dikes. These efforts help improve local capacity for sustainable water management and ensure the long-term functionality of NCW infrastructure.

Despite these initiatives, the scalability and effectiveness of institutional support remain key challenges, particularly regarding the alignment of research outputs with on-the-ground implementation and funding mechanisms.

Individual Driver: Traditional Leadership and Community-Based Promotion of NCW

In Egypt, the local Bedouins council serves as the primary promoter of NCW implementation, particularly for the installation of new cisterns. The allocation of cisterns among tribes is determined by the council based on tribal size and specific water needs, ensuring a fair distribution of water resources within each watershed.

This community-driven leadership model has a direct influence on regulatory and financial frameworks, as the distribution of new cisterns depends on fund availability and the decision-making process within the council. The head of the village, or Omda, plays a critical leadership role in overcoming initial barriers by negotiating resources, mobilizing support, and ensuring the smooth implementation of water management projects.

The influence of these traditional leadership structures highlights the importance of locally embedded governance models in NCW implementation. However, the effectiveness of these mechanisms relies on sustained external funding and strong coordination with governmental and international agencies.

Networks Driver: Role of Agricultural Cooperatives in Facilitating NCW Implementation

In Egypt, Wadi Garawla Agricultural Cooperative serves as the main network supporting the diffusion and scaling of NCW, particularly through the installation of new cisterns and dikes. This cooperative plays a critical role in bridging local Bedouin communities with governmental institutions, such as the Ministry of Agriculture and Land Reclamation and the Ministry of Water Resources and Irrigation.

The cooperative acts as a regulatory intermediary, ensuring fair distribution of cisterns and facilitating stakeholder coordination, thereby contributing to the successful implementation and expansion of these water management solutions.

Collaboration across local, regional, and national levels is essential to sustaining NCW projects.

- Local level: Implements the action plan by working directly with Bedouin communities.

- Regional level: Acts as a liaison, with the deputy ministries of agriculture and water resources ensuring coordination between local and national authorities.
- National level: Develops the strategic framework for water resource allocation among different sectors.

This multi-scalar collaboration strengthens policy implementation, resource allocation, and project sustainability, making agricultural cooperatives a key institutional mechanism for enhancing the adoption and effectiveness of NCW technologies.

Political Driver: Government Support and International Funding for NCW

In Egypt, state actors actively support the installation of new cisterns and dikes by securing international funding from organizations such as the Food and Agriculture Organization (FAO), the World Bank (WB), the United Nations Environment Program (UNEP), and the World Food Program (WFP). These financial resources have been essential in facilitating NCW initiatives, particularly in water-scarce regions.

To align public policy with NCW implementation, the government has issued laws and ministerial decrees that regulate water resource management and environmental protection. Key legal frameworks include:

- Law No. 147 of 2021 – Focuses on water resource administration, distribution, irrigation, and drainage systems.
- Law No. 4 of 1994 – Aims to protect the environment, ensuring sustainable water use and conservation.

The European Union (EU) and other international donors align their funding with Egypt’s water management needs, providing financial support for infrastructure development.

One of the most instrumental policy actions in promoting NCW solutions was the Matrouh Resource Management Project (MRMP) in the 1990s, led by the Ministry of Agriculture and Land Reclamation. This internationally funded initiative was specifically designed to increase the number of cisterns and dikes, enhancing rainwater harvesting capacity in arid regions.

These political efforts demonstrate government commitment to NCW implementation through legislative, financial, and policy measures, supporting long-term water security and resilience against climate change.

Normative Driver: Legal Framework and International Aid for NCW Implementation

In Egypt, there is clear legal support for the installation of new NCW, primarily through two key laws:

- Law No. 147 of 2021 – Focuses on water resources and irrigation, establishing regulations for water administration, distribution, irrigation, and drainage systems.
- Law No. 4 of 1994 – Aims to protect the environment, ensuring that water management strategies align with sustainability and conservation principles.

In practice, the Living Lab (LL) region is a remote area that relies entirely on rainfall for agriculture, as Nile water does not reach this region. Given these conditions, the Ministry of Agriculture and the Ministry of Water Resources play a key role in securing international funding for the installation of cisterns and dikes, which are crucial for rainwater harvesting and water security.

The regulatory framework assists stakeholders in correctly applying NCW solutions by facilitating access to international financial aid. This external support has been fundamental in enabling infrastructure development, addressing water scarcity challenges, and enhancing local resilience against climate variability.

Economic Driver: International Aid and Economic Incentives for NCW Implementation

In Egypt, the installation of new NCW, particularly cisterns, dikes, and weirs, relies entirely on international financial support. Key stakeholders providing aid include the World Food Program (WFP), which has funded multiple projects to help Bedouins construct new water harvesting infrastructure.

Despite the clear economic benefits, local financing is insufficient to cover the high implementation costs. Bedouin communities cannot afford to build cisterns independently, as the cost of digging 1m³ is approximately 400 Egyptian pounds, meaning a cistern with a 75m³ capacity costs around 30,000 Egyptian pounds.

However, demand for NCW solutions remains strong because more cisterns mean greater rainwater harvesting, which helps mitigate drought impacts, increase fig and olive production, and ultimately boost economic returns for local communities.

The main economic incentive for Bedouins to adopt NCW solutions is the potential income generation from improved water availability for agriculture and livestock. Nonetheless, without continued international funding, large-scale implementation remains a challenge.

Table 5. Main Drivers to water transition in Egypt

	Drivers	**Definition**	**Description**
1	Shared vision driver	The existence of a common vision that shifts collective perception towards a new regime or widespread adoption of innovation.	A common vision exists prioritizing increased cistern construction to combat drought and enhance rainwater harvesting.
2	Cognitive driver	The creation and assimilation of knowledge to enhance policy orientation; the presence of professional knowledge to support	Knowledge creation is encouraged through research and training, but desalination remains limited due to high costs.

		innovation; individual and social learning to change practices.	
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.	Research centers and universities support policy direction and Bedouin training in water harvesting techniques.
4	Individual driver	The presence of a promoter who uses their influential power to support the transition, particularly from the beginning of the process and to steer towards regulatory framework change.	The Bedouin council and village leaders (Omda) play key roles in promoting and distributing NCW solutions.
5	Networks drivers	The existence of networks with actors located at other scales to support innovations, their diffusion, or scaling up.	Agricultural cooperatives act as intermediaries between Bedouins and government ministries to facilitate implementation.
6	Political driver	Political support from state actors and coherence of public policy instruments to support the transition.	The government secures international funding (FAO, WB, UNEP, WFP) and implements relevant laws and decrees.
7	Normative driver	Legal support through the presence of clear and strict regulatory measures, and assistance to stakeholders for their proper implementation.	Laws (e.g., Law No. 147/2021, Law No. 4/1994) provide regulatory support, but implementation depends on external funding.
8	Economic driver	The existence of financial support from various stakeholders and demand or market to support the innovation.	NCW projects rely on international aid; economic benefits encourage adoption, but local financing is insufficient

Conclusions: Barriers and Drivers for the Development of NCW in Egypt

The analysis of Egypt's experience with Non-Conventional Water (NCW) solutions reveals a complex landscape marked by both structural challenges and emerging opportunities. On the one hand, significant barriers hinder the widespread implementation of these strategies—particularly those based on rainwater harvesting through cisterns and dikes, which are especially relevant in arid and semi-arid regions. On the other hand, a combination of institutional commitment, local engagement, and economic incentives provides a foundation upon which future efforts can build.

Barriers: Fragmentation, Limited Resources, and Technical Gaps

Among the main barriers identified, institutional and political fragmentation stands out. While there is clear political will—especially in securing international financing—NCW strategies are not yet fully integrated into Egypt's long-term water management planning. Centralized decision-making limits the involvement of local stakeholders and weakens the adaptive potential of policies on the ground. This is closely linked to economic constraints: implementation relies heavily on international aid, and the high costs involved make self-financing unviable for local populations, particularly Bedouin communities. Furthermore, regulatory frameworks, though in place, are primarily operationalized through top-down government projects, offering limited space for autonomous or community-led initiatives.

Technical and behavioral challenges further complicate the scenario. Capacity gaps in advanced water management techniques—such as aquifer recharge modeling—limit the scalability of NCW solutions. Training programs exist but are still insufficient. Meanwhile, although there is broad acceptance of cisterns, other technologies like desalination face resistance due to perceptions of high cost and complexity.

Drivers: Shared Vision, Institutional Support, and Local Engagement

Despite these obstacles, several drivers act as enablers for NCW development in Egypt. A widely shared vision among both government actors and local communities—especially regarding the role of cisterns and dikes in addressing water scarcity—has proven essential to mobilize resources and political will. Ministries such as those of Agriculture and Water Resources play an active role in seeking funding and promoting infrastructure, while local institutions like tribal councils are key in coordinating implementation efforts. Agricultural cooperatives, such as the Wadi Garawla Cooperative, serve as critical bridges between state actors and rural communities, facilitating knowledge transfer and ensuring project sustainability.

In addition, although self-financing remains a barrier, the economic benefits of increased water availability—such as higher agricultural yields—create powerful incentives for adoption when external support is present. While implementation is still heavily dependent on project-based funding, the existence of a legal framework offers a platform for alignment with national policies and future scaling.

In sum, Egypt's approach to NCW is marked by strong political interest and community-level engagement, particularly in rainwater harvesting. Yet, the persistence of centralized planning, insufficient technical capacities, and funding dependency limit its transformative potential. Addressing these barriers will require a more coherent national strategy that embeds NCW solutions into broader water governance frameworks, strengthens financial and technical mechanisms, and expands the role of local actors—especially cooperatives and tribal councils—in shaping and sustaining long-term change.

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