The advent of EU water reuse regulation in the Mediterranean region: policy and legislative adaptation to address non-conventional water resources utilization in agriculture

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Abstract

The provision of safe, sustainable and accepted ways of water supply for the Mediterranean basin by using non-conventional water resources is key to reducing the gap between agricultural water demand and supply. The gap will only increase due to population growth and climate change. To guarantee the proper exploitation of non-conventional water resources, a unified EU regulatory framework is essential to harmonize diverging approaches among EU member states. The article offers a review of the current policy and legislative frameworks addressing non-conventional water resources treatment and application in agriculture in selected Mediterranean countries, including non-EU countries. A particular focus is put on the new EU Water Reuse Regulation of 2020. By combining literature review and stakeholders' consultation under different techniques i.e., sentiment analysis, interviews with written follow-ups and surveys, this work offers different visions from EU countries and non-EU countries around the Mediterranean which might be affected by the regulation.

Keywords: water reuse; water scarcity; non-conventional water resources; agriculture; regulation; the Mediterranean.

Introduction

Global food production and demand are increasing (European Commission, 2019), as well as worldwide water consumption, and they are all closely linked with the agricultural sector, the larger water user globally. Water demand in the future is expected to even increase due to population growth and climate change patterns (Lavrnić et al., 2017). The Mediterranean region, together with its agricultural sector, has always been characterised by limited and irregular availability of water resources. It is expected that the region will become even more vulnerable in the near future due to climate change - e.g. drought events (Bucak et al., 2017; WWAP, 2017)

In the case where the water available is not enough to satisfy water demand, non-conventional water resources (e.g. treated wastewater) can be considered as a solution and a source to overcome this gap. Different studies (Alcalde Sanza and Gawlik, 2017, 2014; Barbagallo et al., 2012; Lopez et al., 2006; Mancuso et al., 2020) have shown how domestic wastewater reuse in agriculture could support addressing water scarcity. Moreover, using non-conventional water sources for irrigation purposes could also ensure that enough water of good quality is reserved for drinking purposes.

However, apart from some technical aspects, the possibility to resort to this solution at a large scale is currently hindered by obstacles mainly belonging to the *social* and *legal* spheres. In terms of the legal ones, the lack of a unified legislative framework at the EU level was often brought to the fore. This divergence among applicable frameworks is also evident across Mediterranean countries. Among the countries in this region, Israel and Italy are often framed as two extreme examples. Israel considered the leader in wastewater reuse in the Mediterranean basin, requires around 10 parameters to be met for reusing wastewater, while in Italy, a country where a small proportion of its treated wastewater is reused, around 50 parameters have to be respected (Lavrnić et al., 2017). At a social level, the aversion of some stakeholders to legal and technical innovations, in part also caused by these diverse attitudes, represents an extensive burden factor encouraging the application of larger water reuse.

In order to overcome the legal and practical impasse generated by diverging frameworks across the European Union (EU), the EU has adopted the new Regulation on minimum requirements for water reuse for agricultural irrigation, applicable for all EU Member States from 26 June 2023 (REGULATION (EU) 2020/741). This aspect is included in the new Circular Economy Action Plan (CEAP). The CEAP was implemented in 2020 by the EC and involves a series of regulations to advance the circular economy in Europe. While this regulation intervenes at an EU level, has several spill over effects on non-EU countries in the Mediterranean, as discussed in this study.

This research focuses on the legal and policy framework for non-conventional water use in agriculture in the seven countries that can be considered illustrative of the Mediterranean region. Namely, they are Italy, Spain, France, Greece, Tunisia, Israel and Turkey. Even though closely connected, these countries have different legislations that regulate the field of wastewater reuse, and several of them do not have single reference legislation but actually, their framework is built on *an aggregation of legislations*. The countries selected in this study belong to the consortium FIT4REUSE[1], a European Research project funded under PRIMA - Partnership for Research and Innovation in the Mediterranean Area.

The analysis of challenges and opportunities of water reuse in different geographical areas are ample in the grey and academic literature, such as – respectively – the Innovation Deals project (2018a, 2018b) and the SUWANU Europe project (2019) Kamizoulis et al. (2003), Kellis et

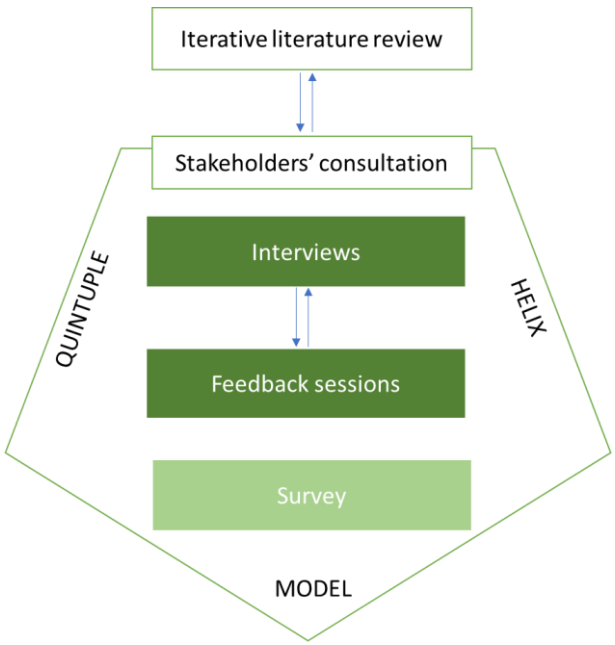
[1] FIT4REUSE website: https://fit4reuse.org/

al. (2013), and Berti Suman and Toscano (2021). Besides the listed studies, the original contribution of this to the scientific and academic debate is to provide an overview of the current legislative and policy scene for non-conventional water resources treatment and usage in the indicated Mediterranean countries, and an original discussion of socio-legal aspects connected with the current status quo and progresses. Therefore, the objective of this research is to identify and compare policy and legislative gaps, constant trends, and breakpoints, together with key stakeholders aiming at co-developing alternative water reuse scenarios across the Mediterranean region.

Material and methods

This work adopted a socio-legal lens of analysis as the aim of the study is the identification and comparison of legislation and policy legislation of non-conventional water use in agriculture, and the perception thereof by relevant stakeholders. As this study inspects a series of legal innovations ongoing in the field, an empirical legal studies approach is adopted. This approach involved the combination of literature review with collection and analysis of primary data elicited from stakeholders' consultation as indicated in Figure 1 embracing the quintuple helix model which engages diverse stakeholders. This work builds on an earlier study performed within the framework of the FIT4REUSE project (Berti Suman et al., 2020). The present article updates the reflection two years after the study was carried out, in particular taking stock of the most recent (albeit not abundant) legal developments and of the attitude of the actors involved. From a methodological level, the manuscript reflects the analysis of data collected on the occasion of selected events, such as Water Reuse Events described below that occurred during these two years, outcomes in the literature from 2022-2023, and from the deployment of a survey, which provides key novelties to this work.

Figure 1. Methodological representation.



Iterative literature review

An in-depth literature review was conducted following an iterative approach. Bibliographic databases disclosing scientific articles and grey literature – i.e., research reports, conference

proceedings, and different studies from reliable sources – were consulted using keywords and search under this theme and through a 'snow-balling' technique.

The legal review included textual analysis of EU and national legislation and regulations, available in national archives and databases and selected based on existing studies identifying them, such as Alcalde-Sanz and Gawlik (2017) and IMPEL (2018).

Stakeholders' consultation

Stakeholders' identification followed the quintuple helix model proposed by Carayannis et al. (2012). This paradigm grasps university-industry-government-public-environment interactions), the role of academia, industry, political system, media (including culture), and the environment (natural and societal) as a subsystem of knowledge creation and innovation.

Identified stakeholders were engaged within different momenta under the following techniques:

- Sentiment analysis of primary data, comprising the response by interested and concerned actors to the consultations launched by the European Commission (EC) under the release of the EU Proposal for a Regulation on water reuse (European Commission, 2018) adopting a socio-legal lens of review on the responses made publicly available on the EC's webpage.
- Several interviews (**10**) with experts were performed to cover all countries represented in this study. The access to them was thanks to the FIT4REUSE project, as they were already part of the project or suggested by a project member. Interviews helped to contrast findings from the literature review while gathering new information. Interviews were conducted online with each participant, were recorded, and lasted for around 1 hour. The interview formatting was semi-structured, mixing general questions asked to each participant and country-specific questions, leaving also space for spontaneous insights emerging from the interviewed person. Detailed questions can be found in Supplementary Materials (SSMM).
- Feedback sessions (in virtual and physical focus groups settings) were organised with actors within the network of the FIT4REUSE project under the umbrella of the Water Reuse Forums and with external actors on occasion of the Water Reuse Day 2020 (during 'Ecomondo') which aimed to corroborate the results of this work. Also, interviewers participated in these sessions to ensure information was well captured.
- An online survey was published to clarify some results from the interview in June 2022. The survey was allocated in an online platform called Multi-stakeholder Water Reuse Platform, where several stakeholders covering the quintuple helix structure were invited to take part in it (**47 responses** were collected from all countries represented in this study). Questions can be found in SSMM.

Thanks to the combination of literature review and the described participatory approach, it was possible to define current legislative and policy scenarios and foresight on how they will look after implementing the EU Water Reuse Regulation. In particular, the legislative scenarios documented were systematized in a table working as a 'live inventory' of the status quo for the selected countries of interest. For each legal instrument identified, it was reported the Name, Country/Region, Type of instrument, Issuing body, Date of issuing Status, Updates/Notes, Targeting agriculture need (y/n), Targeting aquifer recharge (y/n), Targeting other uses (y/n + entry), Implementation, Usage, Social perception. Details are available in SSMM.

Results and discussion

Insights into each country

This section combines the result of a country-specific legal review with inputs from the interviews. Quotation marks and italics signal quotes taken verbatim from the interviewees' statements. Therefore, the quotes aim to reflect experts' opinions on the matter.

Italy

The Ministerial Decree n. 185/2003 is the cornerstone legislation on technical norms for wastewater reuse. There is available a summary of the Italian legislative framework, including selected regional legislation which was realized for the Innovation Deal project (2018a and 2018b). In April 2023, Italy launched the Decree-Law n. 39/2023 (Decreto-Legge n. 39/2023 in Italian), to be aligned with the Regulation (EU) 2020/741 of the Parliament European Union and the Council of 25 May 2020, as described in Article 7 of the Italian Decree-Law, referring to the reuse of purified wastewater for irrigation use. This Decree-Law was released due to the water scarcity faced by this country.

The interviewed expert mentioned as a benchmark the Ministerial Decree n. 185/2003, and highlighted ISPRA's work as part of the afore-cited IMPEL project (2018) as relevant for an integrated review of water reuse legislation across Europe, while the survey has also reported the Proposal for a Regulation of the European Parliament and of the Council on minimum requirements for water reuse (COM/2018/337).

When evaluating the implementation of such legislation, it resulted that some regions are regulating the field with their legislating measures (e.g., regional decrees), for example, the region Puglia, regardless of the overarching national regulation. Regions can have their own regulations depending on their needs, as in the example of Puglia due to water scarcity problems, they have their own water reuse promoting measures, as indicated in their Regulation (named in Italian as *Regolamento Regionale, n. 8 Norme e misure per il riutilizzo delle acque reflue depurate D.Lgs. n.152/2006).* Experts also highlighted as a barrier, when comparing with other countries, that Italian legislation mandates have very stringent limits for numerous compounds, being one of the strictest legislation for water reuse in Europe much more than other Mediterranean countries such as Spain, for example, – before each country implemented the Regulation (EU) 2020/741 thus creating a more harmonized set of standards across the EU – especially for *E. coli* and metallic compounds.

Structural and governance problems were also identified as barriers to the adoption of non-conventional water uses *"The real problem is the governance: the water authority has to treat water up to standards and deliver it for free, and then the irrigator can charge the farmer*". With regards to promoting paybacks for the reuse, the interviewee noted that water scarcity was the real trigger for authorities to promote treated water, for example with the water tariff scheme promoting reuse introduced by the Italian Regulatory Authority for Electricity Gas and Water (*Autorità di Regolazione per Energia Reti e Ambiente*).

When going into the implementation of the legislation, several water treatment plants that are applying the Ministerial Decree perform water reuse, which – however – in Italy is only allowed for irrigation and not for aquifer recharge, which is still forbidden in Italy.

From users, such as farmers or consumers, the use of non-conventional water was perceived as positive whenever it is accompanied by economic advantages "*Farmers are not reluctant to use non-conventional water reuse, as far as this is cheaper than water from the 'Consorzi di Bonifica' (i.e. irrigators); the problem is not even on the consumers' skepticism as often the*

water with which a product was irrigated is not reported to consumers. The obligation to report by sellers is contained in Business2Business sale, but this is not displayed to consumers. Reporting this information could even be a trigger for consumers to opt for a more sustainably irrigated product. But of course, it depends on the type of consumer".

A big concern of the consumers in Italy is that they often distrust the (water) management from the authority. As a result, they also frequently do not trust the safety of drinking water as well as innovation in the sector, partially due to failed risk communication strategies by the competent authorities (Carrozza and Fantini, 2016). Social revulsion may extend as an effect of the COVID-19 pandemic (traces of the virus were found in sewages of Italian cities) and the relater water safety concerns, affecting especially the social acceptance of reuse (Dettori et al., 2019; Mancuso et al., 2021; Reuters Staff, 2020).

Key stakeholders in Italy

Irrigators and farmers, as well as water utilities, are identified as relevant in this field. Before the EU regulation, they had to find an agreement every time they wanted to initiate a water reuse experience. The new Regulation does not require finding this case-by-case agreement. , while it will include an overarching harmonized process suggested by the EU benchmark. Another stakeholder, consumers, are not perceived as key by the expert, as often they are not informed and they should be 'educated first'. "*In Singapore, they are treating water up to drinking water levels! There, it resulted that the highest the education level of the person, the more their skepticism towards non-conventional water. Targeted education may help. But cost-effectiveness is the* real drive".

Environmental organizations (which have been already very active in desalination-related discussions) like Legambiente bringing a different perspective and often reflecting the (or, better, 'a') civic perspective on the matter should also be considered as relevant actors in this field. While at the institutional level, Ministries of the Environment and Environmental Protections Agencies were mentioned as central players as well.

Spain

The Royal Decree 1620/2007 (Real Decreto 1620/2007, in Spanish) was identified by the expert as the key instrument which regulates all types of reuse, including industry, forestry, and municipal reuse. The decree was also an inspiration source for other countries in Europe. Once this Roya Decree was launched, it was very innovative, boosting reuse in Spain by up to 11% thanks to a detailed legal framework. The survey also indicates that Regulation (EU) 2020/741 on minimum requirements for water reuse was a relevant tool to be considered for Spain.

The expert remarked on the fact that the provision is quite recent, from 2007 as "*Spain did not have the same perception as for example Israel of the pressing need to reuse. However, for cultural differences, we cannot compare Spain to Israel. Around the '80s Spain experienced numerous droughts, but until recently they did not have much of this need. However, especially in the area of Murcia where the need for water for agriculture was pressing, they were pushing for reuse".*

The answers provided in the survey are aligned with this trend, reporting that in those areas where water scarcity is pressing, water reclamation is more accepted than in other areas with lower needs. Regarding social acceptance, there is still a way to go, as the adoption of this water use cannot easily be adopted, with several challenges identified into technicalities and uncertainty o long effects on pollutants remaining in reclaimed water.

In April 2023, Spain published their national regulation, the Royal Decree-Law 4/2023 (Real Decreto-Ley 4/2023 in Spanish), to implement the Regulation (EU) 2020/741, aiming to better regulate the use of non-conventional water reuse, especially in those areas of the country more affected by water scarcity. The expert did not mention this regulation because it was issued after the interviews were conducted.

Key stakeholders in Spain

The influence of the irrigators' community is key in this field due to their water sensibility, in terms of quantity and quality, followed by consumers. An example of irrigators is the Spanish National Federation of Irrigators and the Mediterranean Federation of Irrigators, while consumers would be the Spanish *Confederación de Consumidores y Usuarios*. Lastly, cross-EU environmental NGOs such as Greenpeace and organic producers' associations.

France

The Decree of 2014 modifying that of 2010 and regarding only irrigation (agricultural and recreational areas including golf courses and sports fields) presents the legislative framework (Arrêté du 2 août 2010, in French). In the 2014 revision, a mandatory experimental phase of 6 months considered to be too expensive and too burdensome was removed from the 2010 original text. France also released a Decree in August 2023 (Decrét n. 2023-835 du 29 août 2023, in French) to prepare the adaptation of the French regulation to the Regulation (EU) 2020/741. The current state of this document still needs to include information referring to the use reclaimed water in agriculture.

The expert qualified the legislation as very well enforced, corroborating the fact that all new projects have to comply with it. According to the expert, the legislation is very strict in terms of security distances between non-conventional water use points and sensitive areas, mainly when using sprinkler irrigation, thus making it more difficult to use for irrigation in urban green areas.

In the subsequent survey, a response for France mentioned the Order of 26 April 2016 (Arrêté du 26 avril 2016, in French) on the reuse of wastewater for crops, which amended the order of 2 August 2010 on the use of water from urban wastewater treatment for the irrigation of crops or green spaces, by postponing the compliance of existing installations scheduled for 2016 to the end of 2019, which may signalize existing difficulties to comply with the stringent regulations.

Part of the acceptance of non-conventional water will rely on prices, as farmers are not used to paying as much for water "*The major problem is with socio-financial acceptance in terms of willingness to pay. Consumers' scepticism is instead getting better as they seem to consider more and more the environmental and socio-economic benefits behind water circular economy*". Another factor highlighted was the presence of COVID-19, as consumers' opposition may increase, and there may be a tendency to associate treated water with viruses.

Key stakeholders in France

As seen in other countries, Municipalities are crucial stakeholders. They are often the project leaders, which also report to the national level. Other governance levels such as Regions are key as they are the major subsidizers together with water agencies. Water private companies, in particular the large ones (such as Veolia and Suez) are also important in driving and shaping the standards. "*Farmers associations are still organizing themselves in the field: water reuse is still a new topic for them*". Instead, consumers and NGOs were not that central in the debate in France, according to the expert, but they need to be put at the core of the discussion (especially citizens).

Greece

The Common Ministerial Decision on Measures, Limits and Procedures for Reuse of Treated Wastewater n. 145116 of 2011, updated in 2013, both for industrial and municipal water reuse are the pillar legislation named in the interviews. Prior to 2011, there was a Health Code (E1b/221/1965) that vaguely regulated wastewater reclamation. This code was updated in 2008 with very strict legislation (Ministerial Decision n. 133551/FEK 2089/9-10-2008) that set extremely stringent criteria for wastewater reclamation.

The reuse in Greece is very low compared to neighbour countries such as Cyprus and Israel, notwithstanding the dedicated law. "*The direct reuse of treated water is less than 2% of all Greek water. The 'mixed reuse' is a bit more, around 7%*", noted the expert. An interesting aspect was raised by the expert: "*The problem is that in Greece the majority of the people live in Athens and Thessaloniki, thus the location of the demand is far away from the location (agricultural areas) where non-conventional water is produced (cities). The costs of bringing water from where it is produced to where it is needed are very high. Even if we would water all of Athens' green areas with non-conventional water produced in Athens, we would never reuse enough water. Provided that we can increase this amount, we would still not go for more than 10-15% of the reuse. There is an overarching, structural problem of matching demand with supplies. This is different from cities such as e.g. Italy where many smaller cities are closer to agricultural lands."*

The expert was positive towards the legislative intervention: "*The law, anyways, is a big step ahead boosting reuse, but we have a bottleneck that is not social but it is really about how Greece is structured*. The main barriers identified are related to geographical and technical, rather than legal features are hampering reuse in Greece". Greek legislation was also said to be very 'infant' as it does not address the reuse of rainwater and grey water. Mandated limits for nitrogen and phosphorus (nutrients) are not very strict, whereas Greece has strong limits in terms of biological compounds, *E. coli* etc. These nutrients could be even beneficial for crops as having a fertilizing effect. The survey also reported this feedback, where a respondent for Greece noted that a major driving force in the policy field is needed to promote water reuse.

Key stakeholders in Greece

Municipalities are key as they are often responsible for drinking water treatment, drinking water distribution, wastewater collection and wastewater treatment or reuse. Other stakeholders are tourist associations and hotel structures due to the intrinsic need for water used in the touristic facilities. The touristic activity embodies a great demand for water (for irrigating gardens and tourist areas) while generating an increase in the production of water to be theoretically reclaimed.

Tunisia

The Tunisian Water Code of 1975 (Law n. 75-16 of 31 March 1975, Loi n. 75-16, in French) and its modification by Law n. 87-35 of 06 August 1987, Law n. 88-94 of 02 August 1988 and Law n. 2001-116 of 26 November 2001 (Loi n. 2001-116, in French) was one of the two types of legislation highlighted by the expert in terms of treatment and reuse of non-conventional water resources.

The Water Code presents the overarching legislation covering the water sector and all decrees and ordinances that apply to water and wastewater treatment refer to that code. The Code is under revision since 2016 and should be released in an updated version shortly (as also discussed in Akissa, 2001). Differently from other countries studied, Tunisia has all-embracing legislation covering the water sector that applies to water and wastewater treatment. The still ongoing revision of the Code will also have an impact on non-conventional water reuse

regulation according to the expert. However, "*Many other African countries are turning to regulate water reuse just now, so we are frontrunners, but the problem for us is implementation*".

In the second stage, the Tunisian standard NT 106-02 of 1995 (Norme Tunisienne 106.002 (1989) relative aux rejets d'effluents dans le milieu hydrique) was highlighted. This standard contributes to the proper application of Decree n. 85-56 of 02 January 1985 (Décret n. 85-56, in French) relating to the regulation of discharges into the receiving environment and of Decree n. 79-768 of 08 September 1979 (Décret n. 79-768, in French), regulating the conditions of connection and discharge of effluents into the public sanitation network. It was elaborated by four different Ministries showing how transversal is this matter considered. The standard, approved by the Decree of the Minister of National Economy of 20 July 1989 (Arrêté du ministre de l'économie nationale du 20 juillet 1989, in French) aims at defining define specifications relating to effluent discharges into the public maritime domain, the public hydraulic domain and public sanitation pipelines.

The quality of the effluent is defined according to the type and specificity of the receiving environment. The Decree n. 2001-1534 is regulating the conditions of connection and discharge of effluents into the public sewerage (Décret n. 2001-1534, in French). In addition, the Decree n. 2005-1991 is defining the modalities of environmental impact assessment (Décret n. 91-362 in French). Since March 2018, this standard has been revised by the Decree n. 2018-315, setting limit values for the release of effluents in the environment (Décret n. 2018-315, in French). Annex 1 provides the limits for the three receiving environments of treated wastewater, namely (1) public hydraulic domain (rivers and similar streams), (2) sanitation facilities and (3) public maritime domain (sea or salt lakes). Annex 2, in the view of the expert, is the most innovative as the standard identifies industry-specific limits for treated water. These particularities in the standards reflect the fact that different industries have different impacts on the environment in terms of the quality of the water they release.

Furthermore, the Tunisian standard NT 106-003 of 1989 (Norme Tunisienne 106.002 (1989) relative aux rejets d'effluents dans le milieu hydrique), defines the physical, chemical and biological specifications of treated wastewater to be used for agricultural purposes and was a relevant document raised by the expert. This complements the Decree n. 89-1047 of 28 July 1989 (Décret n. 89-1047 du 28 juillet 1989, fixant les conditions d'utilisation des eaux usées traitées à des fins agricoles), setting the conditions for the use of treated wastewater for agricultural purposes and the frequency of control of each parameter, and its modification by the Decree n. 93-2447 of 13 December 1993 (Décret n. 93-2447, in French).

Different decisions were issued, for example, the Decision of the Minister of Agriculture of 21 June 1994 which listed the crops that can be irrigated with treated wastewater (Arrêté du ministre de l'agriculture du 21 juin 1994 in French), or the Decision of 28 September 1995 (Arrêté des Ministres de la Santé Publique, de l'Environnement et de l'Aménagement du Territoire et de l'Agriculture du 28 septembre 1995, in French) introduced to regulate the requirements for agricultural wastewater reuse projects. Moreover, the Common Decision of the Minister of Agriculture and the Minister of the Environment and Local Affairs was issued on 29 December 2006 (Arrêté conjoint du ministre de l'agriculture et des ressources hydrauliques et du ministre de l'environnement et du développement durable du 29 décembre 2006, in French), in relation to sewage sludge uses in the agricultural sector and the modalities for their management by the farmer.

The expert highlighted the innovation denoted by the Decree n. 2018-315, as it set parameters for the release of effluents in the environment. "*The new regulation brought forward a change that was asked by environmentalists, experts and industrials. The idea is to push actors to foster*

better protection of the environment. But sometimes it is just technically difficult to respect the environment, especially for the majority of industries in Tunisia e.g. the olive oil production mills which are small having limited human and financial resources. Tunisian industrial tissue is mainly composed of manufacturing industries, e.g. textile and agri-food industries that do produce not much-added value that can then be reinvested in the environment. Meanwhile, they have a major negative environmental impact that make pressure on water resources and generates high amounts of polluted effluents. So the context is difficult!"

When discussing the implementation of the new standards: "*The new regulations of 2018 have given a period of adaptation of 5 years, but – with a lot of political turmoil since the revolution of 2011 and now with the COVID-19 outbreak – it is difficult to apply rigorously the regulation as it may cause a social disturbance. However, compared to the situation in the other African and Arab countries, the Tunisian context is more advanced in terms of respect for the environment with a regulatory and institutional framework more developed*.", affirmed the expert.

In the survey, some respondents expressed doubts regarding the application of this legislation framework locally, while it was proposed the use of penalisation tools for those industries polluting the water with measures to guarantee the water comes back to non-polluted status.

Key stakeholders in Tunisia

From the beginning of the food supply chain, farmers and industries are key as are directly involved in the wastewater treatment and reuse ecosystem, while environmentalists and environmental professionals are also relevant in this debate.

Israel

In this country, above 85% of the treated wastewater is used for irrigation (UNECE, 2019). The standard legislation for water reuse includes; permits for Agriculture from 1999 issued by the Israeli Health Ministry; the Principles for effluent reuse for the city, recreation and industry from 2003; the Ministry of Health Regulation of 2005 and Effluent Quality Standards and Rules for Sewage Treatment Regulations of 2010, providing for agricultural irrigation and inspired by the California Code of Regulations of 2000 (Title 22 division 4, chapter 3).

In the survey, it was highlighted that the Israeli Health Ministry permits for infiltration of flood water in drinking water aquifers, already from the '90s.

The expert indicated that "*both the use of treated and of desalinated water for irrigation is not innovative at all in Israel. Actually, it is quite standard, we have been reusing for many years as we did not have other options than to reuse. In Europe instead, the practice is rather new as it is a pressing demand that emerged just now associated with climate change-related distress."*

Public acceptance was also noted under positive terms: "*In Israel, people accepted the reuse of non-conventional water also more easily, as they needed to, for being food-independent.*"

This country is perceived as a leader in the field due to different innovative aspects such as "*it is in how we do that, which is also related to regulation"*. In particular, in the view of the expert, innovation is in how Israel regulates the discharge of water into the sea to avoid high levels of nitrogen and prevent algal bloom in the sea (for this aim, regulations dictate limits and obligations to remove nitrogen from the sea); how they reduce energy consumption for performing reuse operations (for reducing CO_2 emissions associated with reuse entails high energy consumption); and how the country looks for ways for faster irrigation rates.

Responses from the survey indicate that the regulations for water reuse and non-conventional water use are mandatory and properly enforced by governmental offices. The social acceptance of reuse is widespread and the implementation is elevated with high-quality standards, while work is still needed to make regulation authorities stronger, i.e. well budgeted and respecting the law.

Key stakeholders in Israel

The main actors in the field are innovators in academia, innovators in utilities (such as Mekorot) and innovation providers (those that provide commercial products). Israel Ministry of Health determines which kinds of crops can be irrigated with recovered wastewater. Israel Water Authority mandates maximum levels of chloride and boron in desalinated seawater so that it can be used for agriculture after it has been used for the domestic supply. Therefore, these two public actors play a key role in Israel.

Turkey

Annex 7 of Wastewater Treatment Plants Technical Factsheet published in Turkish Official Gazette dated 20 March 2010 n. 27527 issued by the Ministry of Environment and Urbanization, which has replaced and incorporated the former Bulletin of 1991 regulating irrigational wastewater reuse is the main reference legislation in Turkey. Annex 7 provides for treated water to be used for feeding wetlands designated for recreational purposes; as industrial cooling water and as industrial process water. In Bareera and Büyükgüngör (2019) a practical overview of non-conventional water and reuse trends in Turkey can be found.

Current standards applied in Turkey are based on the regulations of 2010 and the former legislation from 1991 (which resembles the EU Regulation in as much as it often refers to the Urban Waste Water Treatment Directive of 1991). The expert reported that *there will be a new regulation considering whether the direct use of treated non-conventional water can be admissible*.

Even though several efforts are put in place to promote safe wastewater reuse, the expert considers that they are not enough, being the industry the actor imposing some standards "*but farmers would irrigate with whatever, so this is more a concern of us experts"…*"*the authorities only check whether treatment processes are appropriate based on the quality standards set by the industry".* Contrary, for water discharge into effluents, the Ministry of the Environment and Urbanization has to perform stricter checks.

Experts deemed that the 1991 regulation is well implemented and enforced, while currently changes are occurring, as the authority is in the process of trying to change it (e.g. for what regards colour parameters), there are quite some protests on that (e.g. the textile industry was strongly against the colour parameter).

From the survey, it is perceived that water reuse from non-conventional water resources is not implemented at high levels, while it is mostly done by metropolitan municipalities. There is no enforcement on water reuse. A limit identified is in the use of untreated sewage directly for irrigation, under water scarcity conditions, by local farmers without any permission. It is pointed out that the irrigation water resource is not controlled, and the social acceptance could be higher if data on the irrigation water quality is shared publicly and/or if it is certified as appropriate for irrigation by a public or private institution for the crops, fruits, etc.

Key stakeholders in Turkey

The food industry, encompassing all segments of the supply chain up to the industry is relevant in this field. Moreover, it was noted that "*Consumers, on their side, rarely pay attention to the*

source of water with which the products they buy are irrigated, this also applies for example pesticides. Therefore, they are not big stakeholders in the field now."

Analysis of country's position

The previous sections provided an analysis of each participating countries' legislative framework for water reuse, the overarching EU framework including the new Water Reuse Regulation and each participating country's position towards the practice in general and with regards to the new Regulation, more specifically. Based on that, distinctive traits having both a positive and a negative impact on the realization of the practice are isolated as barriers or opportunities, and analysed.

The following list indicates the distinctive trait associated with a country or countries (country(ies) "standing" out compared with others as a distinctive trait) and the implication of the new EU regulation on this particular trait.

- Strictness of the reclaimed water standards: in Italy, this represents a barrier to reuse, and this could push the new regulation to more relaxed limits.
- Cumbersome governance of reclaimed water processing: in Italy, this represents a barrier to reuse, the new Regulation streamlines the governance process.
- Miscommunication on the risks associated with water reuse: in Spain and Turkey (in the past) this represented a barrier to reuse, the new Regulation imposes the obligation of information to the public and among actors in the process. It does apply to Spain but not to Turkey.
- Strict regulation of the space between permitted use of non-conventional water and urban areas: In France, this represents a barrier to reuse, the new Regulation incentivizes the reuse by relaxing such minimum distances.
- Applying certain standards to all types of water reuse applications: In France, this represents a barrier to reuse, the new Regulation provides for tailor-made application of stricter standards: i.e., only for the uses with the highest health risk.
- Tradition of 'cheap' water for farmers: In France, Greece, Tunisia, and Turkey this represents a barrier, as farmers they might give for granted getting "cheaper" water, therefore the new Regulation stimulates the introduction of financial incentives for farmers adopting water reuse practices.
- Cultural beliefs, e.g., the idea that non-conventional water is 'impure': In Tunisia, it represents a barrier to reuse, the new Regulation does not apply but Tunisia could take inspiration from the relevant provisions on communication to the public
- Innovative standards, stringent but not excessive, balancing interests: in Spain, this could boost reuse, the new Regulation takes inspiration from the Spanish standards.
- Matchmaking offer and demand, especially in tourist areas: In Greece due to the difficult geographical conformation, this combination would boost reuse, the new Regulation takes inspiration from experiences of matching offer and demand.
- Creation of eco-labels to inform the consumers of the positive environmental footprint: In Turkey, this could boost reuse as it could increase public awareness, the new Regulation stimulates measures to engage the public and share knowledge on the benefits of water reuse, while does not apply directly to this country.

Integrated results

An integrated per-country and comparative analysis of the legal data coupled with data on usage, implementation, enforcement, and social perception of the instruments discussed, collected through interviews with key informants, lead to the following results.

Among factors hindering and triggering reuse, the key aspects have been reported in Table 1.

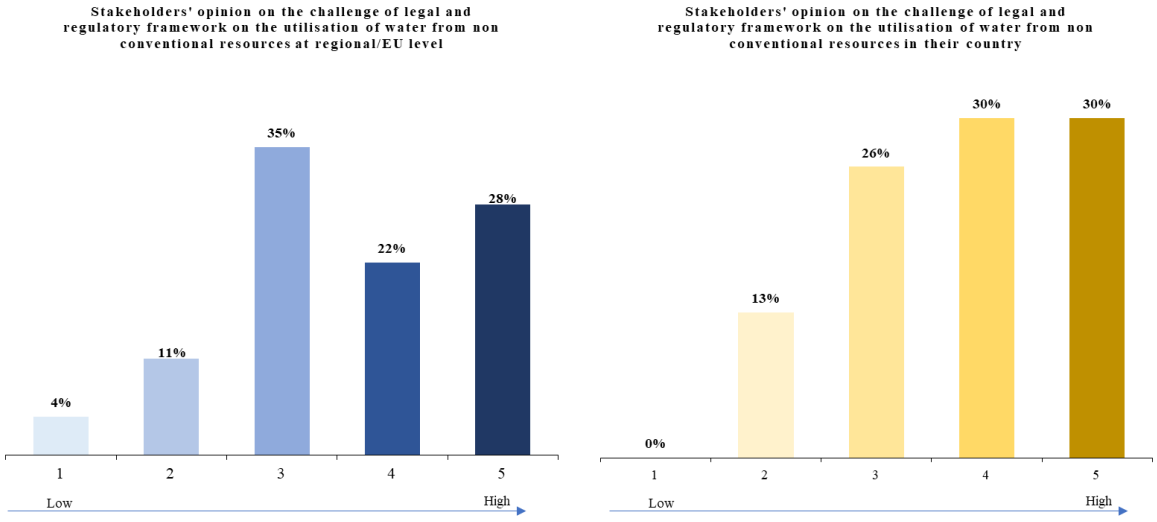
Table 1. Factors hindering and triggering reuse in most of the studied countries.

	Technical	**Administrative/legislative**	**Financial**	**Stakeholders**	**Other**
Factors hindering reuse	Technical problems have been highlighted in several countries; Limited capabilities in assessing real risks for water quality.	Stricter limits at the national level, compared to the EU standards; Cumbersome water governance structures; Unclear paperwork brought by the new EU Regulation which may be long and complex; Need to respect minimum distance from urban areas for using treated water in irrigation; Denial of permission once already built the treatment plant; Political turmoil that pushes the authority to be more lenient with industries in terms of complying with regulation; Relatively late adoption of reuse regulation compared to other countries, thus still infant legislation or scarcely applied.	Not sufficient monetary incentives for reusing water; High reuse costs for farmers who do not want to pay for water.	Lack of agreements between stakeholders; Lack of trust: of farmers' operators or consumers in general towards the public operator (governance issue); Strong lobbying against this type of water use; Miscommunication of the risks associated with water reuse or lack of transparency towards farmers/users; Industries too weak for innovating (e.g. mostly manufacturing industries that produce not much-added value that can then be reinvested in the environment, such as the textile industry in Tunisia); Gap between awareness among the different named stakeholders	Unfavourable country structure: where the location of the demand (e.g. for Greece, the majority of the population lives in Athens) is far away from the location (agricultural areas) where non-conventional water is produced (cities), and the costs of bringing smaller cities closer to agricultural lands); Cultural barriers (e.g. Tunisia, water containing urine is impure).
Factors triggering reuse	Being technologically 'ready'; Stimulating trust among the users.	The EU single benchmark can harmonize the standards adopted EU-wide and in neighbouring countries; It could remove bottlenecks due to different standards and push the non-EU country to align with them if they wish to trade with Europe; An EU legislation that streamlines the water reuse processes with a strong political will; innovative legal framework for water reuse used as a stimulus for other geographical contexts.	Incentives in the water tariff as currently in the EU Regulation; Crops sold at a higher price; More willingness to pay for water or that do not survive if not irrigated sufficiently	Water scarcity is perceived as an urgent issue (longstanding or more recent perception) reuse could be perceived as a way to support food security and overall national independence/security from other countries; Synergies between various organizations; engagement of environmental organizations bringing a different perspective and often mirroring the (or 'a') civic perspective; the willingness of non-EU countries to show alignment with EU legislative status quo; targeted education for all stakeholders; training and support for farmers; strong lobbying in favour; Sharing best practices among countries with different standards	Touristic areas with large demand need for water (e.g. for irrigating gardens, or hotel facilities)

Among the divergences, the Regulation (EU) 2020/741 on minimum requirements for water reuse will be very relevant for the EU countries studied (that are, Italy, Greece, France and Spain), while other Mediterranean countries are perceived as more advanced in this field (e.g. Israel), and for them the proposed text is not perceived as innovative. Another noteworthy aspect is the circularity of the production chain. Crops – when irrigated with wastewater – can result in more sustainably irrigated products. This is seen either as a trigger for consumers to opt for a certain products over another (e.g. Ecolabels in Turkey and Greece) but also as a potential disincentive, discouraging consumers, such as in France. Currently normative does not include any obligation to inform consumers about source of water for irrigated products, and this absence of obligation could make consumer perception on water reuse less relevant.

Figure 2 shows the results from the survey regarding stakeholders' opinions from 9 countries (from those analysed in this work, plus Germany and Portugal). While at the EU or regional level, around 35% of the respondents consider a moderate challenge to the utilisation of non-conventional resources due to the legal and regulatory framework, followed by 28% considering this topic a high challenge; at the country level, most of the respondents (around 60%) considering this a high challenge. These results might show more clarity in instructions given at a higher level than in the country.

Figure 2. Results from the survey on stakeholders' opinions.



Aligned with the results of the interviews, over 85% of the respondents consider that the utilization of water from non-conventional resources increases water security for society.

Main limitations

This work does not capture all country-specific nuances and the other local legislative progress, as well as other socio-legal and perceptive influences that stakeholders in participating countries are witnessing. In fact, the selected expert interviews and the survey's responses cannot be considered representative of the views and perceptions of different sectors and segments of society. Furthermore, most of the interviews and the survey were performed remotely, whereas a period of field research could have helped the researchers to deepen their understanding of the recounted dynamics.

This study discusses a matter in rapid progress as the new EU Regulation is leading a movement of adaptations in each country, affecting both EU MSs and non-EU countries and future research should be monitored closely.

From a methodological perspective, future research should meet systematic empirical insights into the effects of the recent EU Regulation on public acceptance of treated water reuse in the sector. A multi-stakeholder approach should be considered, taking on board unstructured ordinary citizens, beyond the most targeted ones (e.g. consumer organisations or industries). Applied research should also investigate the influence of public engagement in the process on individual and collective trust attitudes towards reuse practices, such as under the engagement of lay citizens in research on (treated) water quality ('water citizen science') and of the use of citizen-operated water monitoring technologies based on sensors combined with advanced data analysis techniques and maps ('water citizen sensing'). Innovative science communication methods – for example using audio-visuals and comics – could ensure that risk communication over the issue is appropriate and reaches the sought audience.

A successful example is the recent citizen science project – named 'Off the Roof' – launched in the U.S. to respond to increasing demands on diminishing water supplies and to the need of using more local water supplies. The idea was to use the alternative water source represented by roof runoff for household use for both potable and non-potable applications. Due to a lack of data on the potential human health risks, a data-gathering task was entrusted to local volunteers which collected samples from rain barrels, delivered thanks to the help of students to the laboratory in charge of the analysis. The intent of the project is to collect data that would ultimately support development of treatment targets for use of roof runoff. Despite targeting a different type of alternative water source, the project's lessons could be conceivably extended to a future reclaimed water citizen science initiative. Other examples related to agricultural and water management are the On Drought project and the Citizen Observatory of Drought (EU-citizen, 2023). Such participatory initiatives can be both valuable for increasing people's acceptance of alternative water sources, and for supporting the development of treatment targets and health standards for the safe use of such sources (the so called "policy uptake" outcome, discussed in Berti Suman 2021). Especially in the wake of the new EU Water Reuse Regulation, it can be imagined that local competent authorities will turn to citizen science initiative to explore and foster human acceptance of non-conventional water sources in agriculture.

Conclusion

This research presented a review of the current legislative and policy frameworks addressing non-conventional water resources treatment and application in agriculture in selected Mediterranean countries, linking literature review and stakeholders' opinions. This EU legislative scene has been examined at a cross-national level and concerning EU and non-EU countries.

The influence of the EU framework on non-EU countries, and vice versa, suggest that lessons can be learned from a comparative analysis to tackle the common challenge of water scarcity while guaranteeing food security. The non-EU countries targeted in this study showed more advanced strategies in using non-conventional resources in terms of effectiveness and convenience for agricultural purposes, which could help extend their best practices into the EU context.

The legislative frameworks in each participating country are very diverse (in terms of the 'age' of the provisions; implementation; users' perceptions) as different are the triggers and concerns of the actors in the sector, yet some common trends have been found and illustrated with

concrete examples along the manuscript. Conceivable and reported factors enhancing or hindering the successful implementation of the practice have been pinpointed, bearing in mind the importance of context dependence, which inevitably will determine the success or failure of an initiative.

At the EU level, a key barrier identified was the absence of common EU environmental/health standards on the matter and the potential obstacles that could derive from the free movement of agricultural products irrigated with reclaimed water. This could lead to increase scepticism from the interested public (from experts to lay people). The new EU Water Reuse Regulation has the characteristics to tackle this obstruction by bringing an integrated legislative instrument setting minimum requirements for water reuse in agriculture. This Regulation can be considered an important milestone toward creating a shared consensus on common standards for non-conventional water use in the EU agricultural sector.

The analysed regulation contained measures to motivate efficiency, cost-savings and innovation and streamline the process's governance. Stakeholders along the supply chain play a key role in the functioning of this type of innovation, from the technical side to making it happen to consumers willing to accept this water use. Therefore, stakeholders' consultation and integration into decision-making could also be key to the success of non-conventional resources water use.

An avenue to promote greater stakeholder engagement is to foster new and support existing citizen science initiatives revolving around the matters of water scarcity, water reuse and in general sustainable practices in agriculture. Civic initiatives developed within sectors of interest, e.g., groups of farmers, could be useful to inform the policy and scientific debate on how to best adapt to the new EU Regulation.

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