COSTEA PROJECT WASTEWATER REUSE IN AGRICULTURE

REGULATION AND GOVERNANCE OF THE REUSE OF TREATED WASTEWATER IN AGRICULTURE
A COMPARATIVE STUDY OF SIX COUNTRIES: ALGERIA, BOLIVIA, MOROCCO, PALESTINE, SENEGAL, TUNISIA

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SUMMARY

This study compares the regulatory frameworks and governance arrangements in six countries for the reuse of treated wastewater in irrigation and the agricultural recovery of sewage sludge. The six countries involved in this COSTEA initiative of AFD are three Maghreb countries (Algeria, Morocco and Tunisia), Bolivia, Palestine and Senegal.

All of the dimensions of the regulatory frameworks are analysed and compared in an integrated manner: rights of access to treated wastewater (authorisation procedures and conditions); various restrictions on authorised crops and irrigation systems, as well as standards related to hygiene practices and consumption methods (barriers); quality standards for treated water; monitoring and control mechanisms; and public funding schemes. The comparison is based on four cross-cutting criteria: **scope, clarity, applicability and consistency**. It is conducted in the light of major international recommendations, particularly those of the World Health Organization, the Food and Agriculture Organization of the United Nations, and the US Environmental Protection Agency.

The study also provides an overview of the various national governance mechanisms for agricultural reuse and suggests ways to improve them, again based on four evaluation criteria: **scope, coordination, inclusion and accountability**.

This analysis allows various observations and recommendations to be made. These concern, in particular, securing the right to reuse, which requires clear specification of the procedures for suspending and renewing authorisations; the problems of applying too many 'barriers', which calls for a principle of fairer measurement; the need for a genuine institutional coordinator for agricultural wastewater reuse, in the absence of a single leader; and the importance of specifying the public financial support mechanisms that can be used, with their eligibility criteria. The ultimate challenge for regulatory frameworks and governance arrangements is to integrate wastewater into the framework of integrated water resource management, both quantitively and qualitatively.

COSTEA PROJECT
WASTEWATER REUSE IN AGRICULTURE

LIST OF ACRONYMS

ABH	Water Basin Agency (Morocco)
AFD	Agence Française de Développement
AFEID	Association Française pour l'Eau, l'Irrigation et le Drainage (French Association for Water, Irrigation and Drainage)
ANPE	Agence Nationale de Protection de l'Environnement (National Environmental Protection Agency, Tunisia)
COD	Chemical oxygen demand
COSTEA	Comité Scientifique et Technique pour l'Eau Agricole (Scientific and Technical Committee for Agricultural Water)
CRDA	Commissariat Régional de Développement Agricole (Regional Agricultural Development Commission, Tunisia)
DALY	Disability adjusted life year
5BOD	Five-day biological oxygen demand
EPA	US Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
MTE	Metal trace element
MALE	Ministry of Local Affairs and of the Environment (Tunisia)
MARHP	Ministry of Agriculture, Hydraulic Resources and Fisheries
MSP	Ministry of Public Health (Tunisia)
ONAS	Office National de l'Assainissement du Sénégal (National Sanitation Office of Senegal)
ONCA	Office National de Conseil Agricole (National Agricultural Advisory Office, Morocco)
ONSSA	Office National de Sécurité Sanitaire des Produits Alimentaires (National Food Safety Office, Morocco)
PSI	Palestine Standards Institution
SM	Suspended matter
TWW	Treated wastewater
TWWR	Treated wastewater reuse
TWWRI	Treated wastewater reuse for irrigation
WHO	World Health Organization
WWTP	Wastewater treatment plant

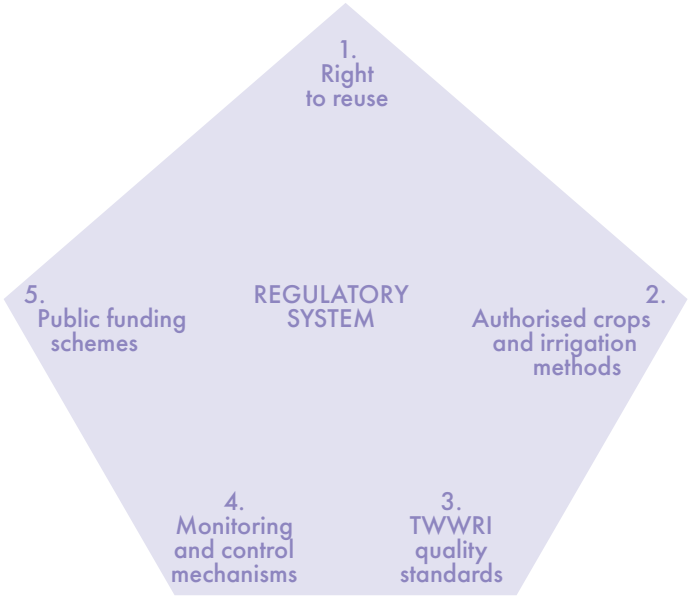
1. GENERAL INTRODUCTION: FRAMEWORK, ANALYSIS GRID AND METHODOLOGY

This study compares the regulatory frameworks and governance arrangements in six countries for the reuse of treated wastewater in irrigation and the agricultural recovery of sewage sludge. The six countries involved in this COSTEA initiative[1] are three Maghreb countries (Algeria, Morocco and Tunisia), Bolivia, Palestine and Senegal. All of them, with the exception of Senegal, are in regions (North Africa, the Middle East and Latin America) where wastewater reuse is primarily for agricultural purposes[2].

A close examination of the regulatory frameworks is necessary if we accept that the success of reuse strategies does not only depend on the efficiency and technological adequacy of treatment systems, but also requires a management and **institutional framework** that ensures that reuse is legally secure for its users, without significant risks for human health and the environment, properly financed and socially legitimate[3]. In this respect, by comparing a relatively limited number of legislations in depth, this study differs from several major regulatory benchmarks[4] already carried out in at least two respects.

Firstly, it mobilises a **broad, systemic conception of regulation**. Existing studies have largely focused on the reduction of health risks. They have therefore primarily considered the quality standards applicable to treated wastewater used for irrigation, as well as the numerous additional 'barriers' erected to regulate agricultural practices. This focus on health is understandable, but it is only one of several necessary elements of regulation. Indeed, **quality standards and barriers** can only provide an adequate legal environment if they are properly articulated with three other key elements: a clear definition of **access rights** to treated wastewater (TWW); **monitoring and control mechanisms**; and actionable **public funding schemes** justified by a certain 'public interest'. These five elements constitute the pillars of the 'regulatory systems' of treated wastewater reuse for irrigation (TWWRI), which may be more or less comprehensive and consistent depending on the country (see Figure 1).

Figure 1: The regulatory system of treated wastewater reuse (TWWR)



More specifically:

- Broadly speaking, the **right to reuse** includes all of the procedures and conditions for authorising TWWRI, as well as the conditions for renewing and revoking these authorisations.
- The **authorised crops and irrigation methods** include all restrictions on agricultural and consumption practices: classification of authorised crops, crops expressly prohibited, irrigation and harvesting methods, and ways of consuming products. The definition of these restrictions has been debated since TWWRI was first put on the international agenda in the 1970s, contrasting a '**treatment-focused approach**' (or more accurately, a 'fit for purpose approach') with a '**multi-barrier approach**'. While the former emphasises the guarantee of constantly obtaining a quality of treated water that is perfectly adequate for its intended uses, the latter stresses the difficulties that such an objective may encounter and seeks to supplement it with additional precautionary measures (barriers). We shall see, however, that this contrast should not be exaggerated. Indeed, even treatment-focused approaches erect at least one additional barrier to reuse, namely different quality standards depending on the types of crops and irrigation systems.
- **Quality standards** for TWWRI include microbiological and parasitic parameters, which are often specific to TWWRI, as well as physicochemical and toxic parameters, which are often the same as for conventional irrigation water.
- **Monitoring and control mechanisms** include all arrangements for the regulatory monitoring of the quality of water, crops, soils and receiving environments, as well as the procedures for the inspection and compliance control of this quality, and where appropriate, for sanctioning (policing).
- **Public funding schemes** include all types of public financial support provided for and defined by legislation, or explicitly planned by local authorities.

1. Financed by AFD and led by AFEID, COSTEA is a community of widely diverse experts in terms of their geographical anchorage, skills, institutions and professions, whose common subject of work is irrigated agriculture. Their aim is to help improve the efficiency of irrigation policies and projects. www.comite-costea.fr

2. Of the new reuse facilities installed between 2011 and 2021, 50% were for irrigation in the MENA region, and 65% in Latin America, cf. Global Water Intelligence- International Desalination Association (2021), Desalination & Re-use Handbook, 2021-2022, p. 3.

3. On the importance of institutional frameworks for these different variables, see Lawrence, P., Adham, S., & Barrott, L. (2003). Ensuring water re-use projects succeed — institutional and technical issues for treated wastewater re-use. Desalination, 152(1-3), 291–298. doi:10.1016/s0011-9164(02)01076-.

4. See, for example: Novec (2012). 'Expériences internationales en matière de réutilisation des eaux usées et issues stratégiques d'optimisation pour le Maroc' in Etude du plan directeur de réutilisation des eaux usées traitées en irrigation, Kingdom of Morocco, Ministry of Agriculture and Maritime Fisheries, chap. 2, pp. 11-43; Ecofilae (2016). 'Réutilisation des eaux usées pour l'irrigation agricole en zone péri-urbaine de pays en développement : pratiques, défis et solutions opérationnelles', report Ecofilae, COSTEA, 63 p.; Shoushtarian F, Negahban-Azar M. Worldwide Regulations and Guidelines for Agricultural Water Reuse: A Critical Review. Water. 2020; 12(4):971. https://doi.org/10.3390/w12040971. See also, the project 'ReWater MENA: More and safer water reuse in the Middle East and North Africa' of the International Water Management Institute (IWMI): https://rewater-mena.iwmi.org/.

The second originality of this study lies in the use of **systematic analysis criteria** to organise the comparison. Based on a review of governance analysis[5], four criteria have been used to analyse and contrast the regulatory frameworks: scope, clarity, applicability and consistency.

Table 1: Four criteria for analysing regulations

Scope	Extent of coverage of the regulations; conversely, extent of identified 'gaps and deficiencies.
Clarity	Degree of specificity of the rules and terminological definitions; extent to which they limit ambiguities and uncertainties with regard to the actors involved in their implementation.
Applicability	Adequacy between the regulatory requirements and the resources of the organisations in charge of enforcing and monitoring them; level of probable acceptability among users of the degree of constraint imposed by these standards.
Consistency	Compatibility, or lack thereof, of the rules with each other and with other regulations (e.g., those related to discharges of non-reused wastewater).

The same applies for the analysis of governance, which is understood here as **all the systems for the distribution of roles and responsibilities, and especially the mechanisms of exchange, coordination and arbitration that these systems organise between the various stakeholders**. Four analytical criteria are also used: the extent of governance arrangements, the degree of coordination, inclusion and accountability.

Table 2: Four criteria for analysing governance

Scope	Breadth of explicitly assigned responsibilities: no major function without a clearly identified responsible person.
Coordination	Minimisation of overlapping responsibilities; existence of institutionalised, predictable procedures for coordination between the actors involved, both at the level of individual projects and of national policy, to maximise consistency between the different objectives and between the resources mobilised.
Inclusion	The possibility for all stakeholders to make their views heard at all stages of decision-making on TWWRI policy.
Accountability	Obligation to regularly inform and explain the actions undertaken so that they can be properly evaluated; transparent information and communication allowing this evaluation.

1.1 An analytical posture: a comparative benchmark rather than a classification benchmark

The six countries analysed here have very contrasting situations, as much from the perspective of their water realities (i.e., intensity of water stress, access of peri-urban agriculture to surface- or groundwater resources as alternatives to TWW), as in terms of their TWW volumes and quality, and their administrative organisation. It is important to recognise this diversity, as it leads to a **comparative benchmark** rather than **a classification benchmark**, which would seek to position all the cases on a single scale with a reference model at the top.

In doing so, it is not a question of denying that some provisions and some legislations may be inherently 'better' than others in certain respects. There is little doubt, for example, that some countries have more comprehensive and precise regulatory frameworks, often linked to earlier experiences of planned TWWRI on the field. This is the case, for example, in Tunisia, where the 1989 decree, promulgated in the same year as the World Health Organization's second generation of guidelines[6] and supplemented a few years later by a joint decree defining extremely precise specifications for users, was a reference legislation at the international level. Morocco then issued its first decree specifically devoted to reuse in 1998, followed by Algeria in 2007. In contrast, Senegal and Bolivia have less extensive regulations, particularly with regard to authorisation schemes and monitoring and control mechanisms, with Palestine in an intermediate position.

However, there are two strong limitations to a benchmark-classification approach to TWWRI:

- On the one hand, a good regulation is firstly a **regulation adapted** to the specific hydrological, technological and administrative conditions of a country, inherited from its long history. It is also a regulation adapted to the crops sought to be promoted and to the levels of treatment already existing (i.e., the triptych level of treatment-uses-standards). Finally, it is a regulation adapted to the financial and technical resources of the irrigators intended to use it.
- On the other hand, a good regulation is a **coherent regulation**: overall integration is more important than the relevance of a given provision taken in isolation, and can only be appreciated on the scale of a legislation as a whole.

The aim of this report is therefore to help national leaders to better situate themselves in the international regulatory landscape, particularly when they are faced with the question of changing their legislation. It should enable each country to better reflect, in the light of other experiences, on its own way of dealing with the issues and trade-offs inherent in TWWRI. The approach is therefore to 'compare to specify[7]' rather than to establish standardised recommendations.

1.2 Documentation used

This report is firstly based on a review of all the relevant **legal texts** in the six countries: laws, decrees and orders. Some of these texts are explicitly devoted to TWWRI. Others are more general and concern the management of irrigation water or water resources (see annex 1 for an exhaustive review of the documents examined). These legal sources are more or less voluminous and more or less collected depending on the country. In Bolivia, for example, there is no regulatory text specifically devoted to reuse. However, certain provisions relating to the use and protection of water resources are sufficiently explicit in their general scope for it to be relevant to consider that they also apply to TWWRI.

5. See in particular: Jiménez, A, Saika, P., Giné, R., Avello, P., Leten, J., Lymer, B., Schneider, K., Ward, R. (2020). Unpacking Water Governance: A Framework for Practitioners. Water, n. 12, 827, 21 p., accessible at: https://www.mdpi.com/2073-4441/12/3/827.

6. WHO (1989) 'Health guidelines for the use of wastewater in agriculture and aquaculture'.

7. For an explanation of this position, see: Bayart J.F. (2008). 'Comparer en France. Petit essai d'autobiographie disciplinaire', Politix, vol.3, no. 83, p. 223 and following.

This study also draws on numerous **public policy documents**: sectoral strategies, master plans, technical guides and documents related to integrated water resource management. Although they are not legally binding, these documents can describe objectives and make recommendations concerning TWWRI. They also allow the link between TWWRI and more general irrigation and water resource management policies to be measured.

Finally, the national information is based on **national syntheses** prepared by the COSTEA expert pairs for the six countries, regular exchanges with these pairs (bilateral discussions and collective meetings) and their written comments.

In addition, the regulatory frameworks of the six countries are analysed in the light of major **international recommendations**. In view of their influence, three major reference documents were selected from a wider corpus that was reviewed (see Table 3). These are the **recommendations of the World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO) and the US Environmental Protection Agency (EPA)**. The first two are traditionally associated with multi-barrier approaches, while the third is more in line with an 'adapted treatment' approach. Insofar as the EPA's recommendations were largely inspired by Californian regulations, an international pioneer of the treatment approach, these regulations are recalled in Annex 2.

This study therefore systematically reviews the different dimensions of the regulatory frameworks in the six countries in the light of these international guidelines. Finally, it provides an overview of the different **governance arrangements** and suggests ways in which they could be improved.

2. THE RIGHT TO REUSE: GENERAL AUTHORISATION PROCEDURES AND CONDITIONS

The procedures and conditions for authorising TWWR have not, to date, been the subject of systematic international comparisons. International bodies address this dimension to a relatively limited extent, probably in recognition of the fact that arrangements in this area are highly dependent on national administrative traditions. For example, in its 1989 and 2006 reports, the WHO does not mention the right to reuse, nor does the FAO.

The US-EPA is an exception. In its 2012 guidelines, it stresses that while there is no imperative for TWWRI to be subject to a specific authorisation system, the regulations should clearly indicate the existing authorisation system that applies (see section 4-2, p. 125). It also makes the following two recommendations:

- The regulations should clearly state all the documents required to apply for authorisation.
- They should also specify not only how users can obtain the right to use TWW, but also the 'rights of end user[s] to ***refuse*** reclaimed water if not demanded' (p. 125).

Given the rather cursory nature of these recommendations, the right to reuse appears in practice to be largely left to the discretion of each State. However, it is not peripheral to the success of projects. The clarity and coherence of authorisation procedures, as well as those for renewal and revocation, are decisive factors for the rapid, secure and socially accepted implementation of projects. The table below summarises the state of play of these authorisation schemes in the six countries.

Table 3: International standards: a selection of three reference documents

Date	Country / institution	Document analysed
1918	United States (California)	Title 22: Criteria for water recycling in California (Water Code, division 7, art. 7)
1969	California	Porter-Cologne Water Quality Control Act (Title 22 of California's Code of Regulations)
1973	WHO	WHO guideline for the safe use of wastewater, excreta and greywater-volume II—wastewater use in agriculture
1980	EPA	Guidelines for water reuse
1987	FAO	Wastewater quality guidelines for agricultural use
1989	WHO	Health guidelines for the use of wastewater in agriculture and aquaculture
1992	FAO	Wastewater Treatment and Use in Agriculture - FAO irrigation and drainage paper
1999	Israel	Israeli guideline for wastewater reuse
2002	Jordan	Jordanian standard (JS: 893/2002) [
2006	WHO	Guidelines for the Safe Use of Wastewater, Excreta and Greywater, Volume II.
2012	EPA	Guidelines for Water Reuse; US Environmental Protection Agency.
2014	ISO	Standard ISO/TC 282/SC 1 :Treated wastewater reuse for irrigation
2017	European Commission	Minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge
2019	California	State Water Resources Control Board's Water Recycling Policy (Title 22 of California's Code of Regulations)
2020	European Union	Regulation 2020/741 on minimum requirements for water reuse

Table 4: Authorisation schemes in the six countries

	Morocco	Algeria	Tunisia	Palestine	Senegal	Bolivia
Authority issuing the authorisation	Water basin agency (ABH).	- The 'territorially competent' Wali[1]. - Where the scheme straddles several wilayas, order of the minister responsible for water resources.	Ministry of Agriculture, Hydraulic Resources and Fisheries (MARHP) 'after agreement' with the Ministries of: - the Environment, - Spatial Planning, - Public Health.	The Palestinian water authority 'in cooperation and coordination with the relevant authorities', notably: (i) the Ministry of Agriculture and Irrigation, (ii) the Environmental Quality Authority.	ONAS and the sanitation department.	The governor (departmental).
Parties responsible for the technical examination of authorisation applications	Commission including: - ABH director, - Services of the ministry in charge of the environment, - Services of the ministry in charge of equipment, - Services of the ministry in charge of public health, - Service of the ministry concerned with TWW use.	The water services of the wilaya, *'in consultation with the agricultural, health and environmental protection services'*.	- MARHP. - Ministry of Local Affairs and of the Environment (MALE) for the approval of environmental impact assessments. - Ministry of Public Health (MSP).	- The Palestinian water authority. - Ministry of Agriculture.	Sanitation department within the Ministry of Water and Sanitation.	- The governor. - The Ministry of the Environment determines the classification of water bodies, on which the required quality of TWW depends, on the proposal of the governor.
Main documents to be submitted for the authorisation application	- Deed of free disposal of the land to be irrigated. - Technical study indicating the quality of the TWW to be used and justifying the project. - Plot plans of the land to be irrigated. - Plan of the collection system for treated wastewater. - Drainage system plans - Assessment of the project's impact on public hygiene and health and the preservation of water quality in the public water domain.	- Written agreement from the WWTP manager to supply the required quantity and quality of TWW. - Analysis sheet less than 3 months old of the TWW whose quality must comply with regulatory standards. - Plot plan of the areas to be irrigated. - Model of the contract between the farmer and the concessionaire. - Plan of the TWW transmission and distribution structures.	- Technical study of the scheme. - Environmental impact assessment (approved by ANPE and MSP).	- Ministry of Agriculture form to be filled in specifying the potential TWWRI uses. - Field inspections to verify the accuracy of the information provided. (Authorisation is based on the 'economic and social feasibility' of the project)	The composition of the technical application is not currently defined (in progress).	- Proof of quality in compliance with the standards of the Water Pollution Regulation (RMCH, Table 1, Annex A). - Environmental impact assessment, with different requirements depending on the characterisation of the environment (categories 1, 2 and 3).
Main features specified by the authorisation	- Type of crops irrigated. - Volume to be used. - Measures to be taken to protect the natural environment. - Conditions of use of TWW. - Conditions of monitoring, control and technical assistance by the ABH.	- The concessionaire must also draw up and keep up-to-date lists of the names of farmers and their workers who handle TWW. - The concessionaire must transmit these lists to the health services of the wilaya in order to schedule their sanitary control. - The concessionaire must inform farmers and their employees who are in direct contact with TWW of the health risks it poses and the precautions to be taken.	_ (But detailed specifications - decree of 28 September 1995 - valid for any particular authorisation.)	- Types of crops to be cultivated. - Irrigation system. - Water quality.	_	_
Duration of the authorisation	≤ 20 years, renewable	≤ 10 years, renewable	_	1 year	_	_

1. The Wali represents the State at the level of a wilaya, an administrative subdivision in Algeria.

	Morocco	Algeria	Tunisia	Palestine	Senegal	Bolivia
Reasons / procedures for revocation	The authorisation is revoked without compensation if: - the conditions it imposes are not complied with; - it is assigned or transferred without the approval of the ABH; - the water is put to a use other than that authorised. However, the ABH may, when 'the available water resources are not sufficient', allow the limit values for the physicochemical parameters to be exceeded.	The concession may be modified, reduced or revoked at any time: - in the event of non-compliance with the terms of the specifications, without compensation. - for reasons of general interest, with compensation to the beneficiary if he/she suffers damage. - Final revocation may occur 6 months after the provisional suspension.	In case of non-compliance of quality, temporary suspension by the control services until quality is restored.	In case of non-compliance of quality.	–	–
Direct aquifer recharge authorisation	–	–	–	Prohibited	–	–
Specific authorisation schemes for sewage sludge						
Authority authorising the use of sewage sludge for agricultural purposes	Prohibition of any use.	*'the agricultural services concerned'*.	–	- Ministry of Agriculture. - Ministry of the Economy. - Palestine Standards Institution.	The minister responsible for sanitation, on the advice of the minister responsible for the environment.	The governor, subject to adequate quality.
Main documents / conditions of eligibility of the application for authorisation	Prohibition of any use.	The sludge must be gathered in a protected area.	Proof of sludge maturation.	Compliance with the technical specifications for sludge (PSI, 2010)	- Plans of the land on which the sludge is to be spread. - Impact assessment specifying: (i) the suitability of the soil to receive the residues and its perimeter; (ii) materials and facilities for temporary storage between application periods. (iii) Potential disturbance or nuisance to the neighbourhood.	- Analyses demonstrating compliant quality for agricultural use. - Functional stabilisation processes before use.
Conditions of use			Specifications signed by the farmer and submitted to the Regional Agricultural Development Commission (CRDA, Commissariat Régional de Développement Agricole) and the Regional Department of Health (DRS), specifying: - the rate of sludge production, - the quantity of sludge produced, - the quantity of sludge intended for spreading, - the state of the sludge to be spread, - the date of its analysis.		- The matter must be spread evenly on the soil and then ploughed in deeply within the first few days after spreading. Derogations are tolerated depending on the location of the application site. - Aerial spraying is prohibited.	

Scope

Generally speaking, the table shows a **very uneven development** of the right to reuse. At one end, Senegal has no legal provisions specifying the procedures and general conditions for authorising TWW. These are therefore left to the discretion of the (pilot) projects being implemented. Bolivia also has a number of undefined parameters: content and duration of the authorisation, and renewal and revocation procedures. In these two countries, the absence of any provision concerning revocation procedures poses a problem for the legal safeguarding of TWWR.

The three Maghreb countries have more extensive regulations, although this does not prevent certain 'gaps' therein. For example, Algeria does not specify the content of the authorisation, and Tunisia does not precise its duration, even though this country undoubtedly has the most extensive regulations on the matter.

It also appears that strong **inequalities in development** can exist **within the same national regulation**. For example, in Senegal, the regulatory framework is quite detailed regarding the agricultural use of sludge (i.e., documents to be submitted with the application for authorisation, conditions of use). Furthermore, the official missions of ONAS include the recovery of treatment by-products, while nothing is mentioned concerning TWWRI. Morocco, on the other hand, presents the opposite situation, with well-developed legislation for wastewater authorisation schemes, but still lacking standards for the disposal and recovery of sludge, whose legal status is not clarified by law 28-00 on waste.

In all of the countries except Senegal, the regulation of sludge management is much less developed than that of TWW. There are also three gaps that are common to almost all of the countries:

- The procedures for **renewing authorisations are scarcely specified**: are they as demanding as the initial authorisations or simpler?
- Contrary to the EPA's recommendations, **no provisions specify a 'right of refusal'** to reuse in the context of a collective development project. There is therefore a risk that some users may find themselves involved in projects despite their reticence. This shortcoming is linked to a broader regulatory deficiency: none of the regulations specify **the link between individual and collective requests for authorisation**. Can farmers only access TWW as members of an association? Where an association is formed, does it necessarily centralise applications, or are individual applications/refusals permitted?
- There are no specific provisions for the **direct recharge of aquifers**, with the exception of Palestine where it is strictly prohibited.

Clarity

The legal safeguarding of TWWRI requires that the **revocation procedures be formulated as precisely as possible**. This is generally not the case: most of the legislations mention a possible revocation 'in case of non-compliant quality' (Tunisia, Palestine) or 'failure to respect the conditions of authorisation' (Algeria, Morocco). This prospect could be clarified to be less threatening to users, for example by specifying a magnitude of exceedances, the parameters concerned, and the durations of non-compliance for revocations to apply. Provisions such as those in force in Morocco can therefore be discussed. On the one hand, an authorisation can be revoked without compensation if 'the conditions it imposes are not observed', a vague and not very reassuring formulation. On the other hand, the ABH may, if 'the available water resources are not sufficient', allow the limit values for physicochemical parameters to be exceeded. Such a formulation leaves the ABH considerable leeway for interpretation in assessing what can be considered as 'sufficient' water resources.

All of the legislations would also benefit from specifying and differentiating between the criteria that can lead to **temporary suspension** and those that can lead to **permanent revocation**.

Furthermore, some regulations provide for certain functions to be carried out by an authority in 'consultation' or 'coordination' with others, **without the modalities of this coordination being clearly specified**. This is the case in Palestine, where the Palestinian water authority must issue permits 'in cooperation and coordination with the relevant authorities', and in Algeria, where the wilaya's water services must process applications 'in consultation with the agriculture, health and environmental protection services'.

Applicability

The **level of requirements for authorisation procedures and conditions varies significantly between countries**. For sewage sludge, Senegal has the most detailed instructions, which could be a source of inspiration for the other countries. However, in practice, it remains to be verified whether it is feasible for each farmer to have an impact assessment carried out at his/her own expense, as required, specifying the suitability of the soil to receive sludge, the storage materials and devices, and the potential inconvenience and nuisance for the neighbourhood.

The question of realism is particularly acute for **revocation procedures**. 'Cut-off' procedures, such as those mentioned above, are likely to be applied only with great caution by the authorities and to be rarely implemented in practice. **Graduated procedures**, with interim suspensions and defined periods to come into compliance, as in Tunisia, are generally more applicable.

Consistency

The authorisation schemes show different conceptions of TWWRI, **each with its own consistency and rationale**. In Morocco, the pilot for authorisation is the basin agency, which places wastewater management in the context of the search for a more global, integrated management of water resources. In Tunisia and Palestine, the agricultural administration plays a more central role, although in coordination with other actors: TWWRI is primarily considered as agricultural water. Finally, in Algeria and Bolivia, the process is coordinated by prefects and governors, probably because the emphasis is more on land use planning.

The need to ensure consistency between the objective of promoting reuse and the **procedures for revoking** authorisation has already been mentioned; it should be possible to revoke authorisation temporarily and to reinstate it easily if compliance with the standards is achieved.

Finally, there is a need for consistency between the necessarily time-consuming nature of the authorisation procedures and **the duration** of the authorisation, which should be specified and significant. In this respect, while the current duration of one year in Palestine is conceivable for the experimentation phase, it should be extended.

3. AUTHORISED CROPS AND IRRIGATION METHODS

All of the legislations of course demand a certain quality of treated water for reuse. But they all also set out additional conditions to varying degrees, whether it be differentiating the required water quality according to the type of crop, expressly prohibiting certain crops or prescribing specific hygiene practices. These additional conditions form a **'multi-barrier' approach**, officially promoted by the WHO since its 1989 report and more recently in 2006. This approach recognises the fact that the quality of treated water may, at times, not meet all of the quality standards. It aims to compensate for these risks through additional measures all along the food production and consumption chain. These measures include restrictions on permitted crops; irrigation techniques; control of exposure to wastewater; and the washing, disinfecting and cooking of food (see Figure 2).

Figure 2: A simplified multi-barrier approach model

Source : Soudi (2020)*

* FAO. 2020. *Déblocage du potentiel de la réutilisation des eaux usées traitées pour le développement agricole dans les pays du Maghreb*, Morocco Report, prepared by Brahim Soudi.

The usefulness of these measures is based on an **empirical estimate** of their propensity to limit 'lost healthy life time', compared to the theoretical expectation of this healthy life (disability-adjusted life year, DALY). The WHO commonly promotes a DALY target of 10-6, equivalent to a few dozen seconds. It emphasises how the following measures can contribute to this:

- Washing salads, vegetables and fruit with clean water (which reduces pathogens by one logarithmic unit).
- Washing salads, vegetables and fruit with a disinfectant solution and rinsing with clean water (reduces pathogens by two logarithmic units).
- Immersion in boiling or near-boiling water until the food is cooked (pathogen reduction of six-seven logarithmic units).

The table 5 gives an overview of the most common barriers recommended by international guidelines.

It can already be noted that no international recommendations prohibit the irrigation of raw food crops, as long as the treated wastewater reaches a certain quality. The table 6 provides a summary of the regulations in the six countries.

Scope

Generally speaking, the restrictions appear to be much more developed for wastewater than for sludge, for which only Tunisia and Senegal have specified limitations. In addition, the table above points to two deficits common to all of the regulations:

- No country currently lists the crops that can receive sewage sludge as a fertiliser (Morocco has a draft regulation in progress).

Table 5: Main barriers recommended

	WHO	EPA	FAO[1]
Classification of authorised crops	**Unrestricted irrigation:** use of TWW for crops that can be consumed raw by humans. **Restricted irrigation:** use of TWW for crops that cannot be consumed raw by humans.	Raw food crops Other crops (processed food crops) Non-food crops	(A) Crops that can be eaten raw, sports fields and public parks (B) Cereal, industrial and fodder crops, pastures and arboriculture (C) Localised irrigation of category B crops and where there is no exposure to users or the public
Classification principle	Type of crops	Type of crops	Type of crops + groups exposed
Authorisation for raw food crops	Yes (unrestricted irrigation)	Yes (food crops)	Yes (category A)
Recommended restrictions on irrigation methods and practices, especially for raw food crops	Localised irrigation Timing of irrigation Protective equipment	Localised irrigation Crops adapted to salinity Crops resistant to toxic ions Mixtures/combination with other irrigation waters Protective equipment	Localised irrigation Protective equipment
Recommended hygiene measures	Washing, disinfection, peeling Cooking	Washing, disinfection, peeling Cooking	Washing, disinfection, peeling Cooking

1. Wastewater quality guidelines for agricultural use. Accessible à: http://www.fao.org/3/t0551e/t0551e04.htm (consulté le 11 novembre 2021).

- No country, with the partial exception of Morocco, differentiates its barriers according to whether sanitation is collective or autonomous. In Morocco, the standards indicated are explicitly valid only for collective sanitation. Agricultural reuse from autonomous sanitation systems, on the other hand, will only be possible for a list of crops and plantations that will be fixed by regulation (art. 64 of the water law 36-15).

Clarity

All of the regulations **precisely detail the types of crops allowed** and the corresponding water qualities. Tunisia lists 21 authorised crops divided into 5 categories, while Algeria lists 50 crops divided into 8 categories. Algeria is also the country that goes the furthest in specifying restrictions on irrigation modes and practices.

In addition, the four countries that most closely follow the multi-barrier approach (the three Maghreb countries and Palestine) all have **extremely precise provisions regarding restrictions on irrigation practices and harvesting methods**. Algeria, however, does not go so far as to detail mandatory hygiene measures, unlike Tunisia and Palestine. Bolivia, on the other hand, does not specify the quality of water required for crops other than raw food.

Applicability

The multi-barrier approach is marked by a **paradox**. It is presented as a solution to a lack of organisational resources (financial, human, technological, etc.) which would make permanent compliance with demanding quality standards uncertain. However, at the same time, it requires very significant organisational resources to monitor the correct application of each barrier. For example, it is difficult to understand how public organisations that are unable to ensure adequate disinfection of their wastewater would be able to ensure that irrigation stops two weeks before each harvest.

This contradiction argues for the principle of a 'happy medium' in the development of barriers. In most cases, realism should lead to limiting barriers to parameters that are, in the words of the WHO, **'easily and quickly measurable** (p. 32)'. These parameters, which can be verified by spot checks, could include restrictions on certain crops and/or irrigation methods. This is the sense of the draft Moroccan joint decree: it abandons several restrictions established by the 2002 decree on irrigation methods and practices, which were deemed inapplicable and superfluous (such as the prohibition of picking up fruit that has fallen to the ground), in order to refocus on two barriers: adapting the quality of treatment to the uses, and irrigation methods.

On the other hand, the applicability of provisions such as those in Tunisia, which stipulate that 'livestock feed must be stored long enough to minimise the risk of contamination' or that 'fruit that has fallen to the ground must not be consumed or sold', is questionable. The Algerian regulations stipulate that TWW should 'in no case be the cause of water stagnation, bad odours or larvae breeding grounds', a provision that is difficult to enforce. In a real situation, **erecting fewer but more enforceable barriers is clearly preferable to the accumulation of fictitious barriers that are difficult to enforce in the field**.

Consistency

In terms of the overall importance attached to barriers, two groups of countries stand out. The three Maghreb countries and Palestine clearly draw on the multi-barrier approach. In addition to explicitly prohibiting certain crops, they have highly developed provisions for restrictions on irrigation methods and practices, restrictions on harvesting methods, and sometimes mandatory hygiene measures.

In contrast, Bolivia, and to a lesser extent Senegal, place less emphasis on barriers. They do not go much further than prohibiting the production of vegetables and, in the case of Bolivia, only distinguish between water qualities for raw food crops and those for other crops. They are thus more in line with a fit for purpose approach that seeks to best calibrate water quality with the desired uses. The case of Bolivia, however, shows that the boundary between these two approaches is permeable and could potentially evolve. Indeed, there is a technical guide for reuse that uses the multi-barrier approach. This document has no legal value at the moment and is not yet put into practice. However, this situation could change as the number of reuse projects increases.

4. QUALITY STANDARDS FOR TWWRI

The development of quality standards for TWWRI that poses no risks to human health has received much attention from international bodies, especially the FAO and WHO. Regulations on irrigation water quality generally distinguish three types of parameters: microbiological, physicochemical and toxic. **Only the first, whose presence in wastewater can constitute a major health risk, are generally subject to regulations specific to TWW**. In contrast, the physicochemical and toxic parameters are generally applicable to all irrigation water: from this perspective, TWW is irrigation water like any other.

It is worth briefly recalling the main sanitary and agronomic issues surrounding the setting of limit values for these different parameters. We will then summarise the main international recommendations on this matter, before presenting the limit values in force in the six countries. This presentation is intended to be exhaustive. However, for the sake of conciseness, it excludes: certain parameters that measure the same variable (e.g. salinity, for which only electrical conductivity has been retained); and, for the sake of comparability, certain specific parameters that are only taken into account in one country (e.g. certain heavy metals, or total dissolved solids as opposed to suspended matter).

4.1 Microbiological parameters

Pathogen elimination is the main health objective when treated wastewater is used for irrigation. There are many pathogens, and it would be difficult and costly for authorities to control them all. Most regulations therefore tend to focus on three main types of parameter that are good indicators of overall contamination: two

Table 6: Main barriers and restrictions in the six countries

	Morocco	Algeria	Tunisia	Palestine	Senegal	Bolivia
Classification of authorised crops	A: Irrigation of crops intended for raw consumption, of sports fields and of public gardens. B: Irrigation of cereal, industrial and fodder crops, pastures and tree plantations. C: Localised irrigation of category B crops if farm workers and the and the public are not exposed.	No distinction between the different crops authorised. These include 8 categories: fruit trees (16 crops mentioned) citrus (7) fodder crops (6) industrial crops (7) cereal crops (4) seed production crops (3) fodder shrubs (2) floral plants for drying or industrial uses (5).	No distinction between the different crops authorised. These include 5 categories: industrial crops (6) cereal crops (4) fodder crops (4) fruit and forest trees (2), floral plants for drying or industrial uses (5).	A, B, C and D, each with specific uses. On this basis: TWWR for agriculture is prohibited 'unless the water has been treated in accordance with national standards certified by the competent technical authorities'.	Restricted irrigation: market gardening crops, sport and leisure areas. Unrestricted irrigation: woody crops, fodder crops, orchard crops.	All water bodies are categorised in classes A, B, C or D. On this basis: Crops consumed raw require a minimum of class B water: raw vegetables and thin-skinned raw fruit without skin removal. No water quality is specified for other types of crops. However, they would seem to come under grade C, as grade D is reserved for cases of 'extreme necessity'.
Criteria used to establish the classification	Type of crop. Irrigation method. Groups exposed.	Type of crop	Type of crop	Treatment standards.	Type of crop.	Quality of the water body.
Expressly prohibited crops	None.	Pastures.	Direct grazing, Raw vegetables.	Vegetables.	None.	Vegetables.
Restrictions on irrigation methods and practices	Fruit trees: the irrigation most stop two weeks before picking. Sprinkler irrigation is prohibited.	Direct contact between TWW and fruit is prohibited. In particular, sprinkler irrigation of fruit trees is prohibited. Irrigated plots must be at least 100 metres away from roads, houses, surface wells and any drinking water supply facility. Irrigation of parks and green spaces must be done outside of public opening hours.	Sprinkler schemes must be 'sufficiently distant' from roads and built-up areas. No spraying of fruit trees. Prohibition of 'stagnant water, bad odours and larvae breeding sites' 89, art. 11.	Water must be piped in. Localised irrigation is preferred. Sprinklers should be at least 50 m away from dwellings.	–	–
Restrictions on harvesting methods	No fallen fruit may be picked up.	Irrigation must be stopped at least two weeks before harvest. The consumption of fruit that has fallen to the ground is prohibited.	Fruit that has fallen to the ground must not be consumed or sold. Irrigation prohibited 2 weeks before harvest.	Fodder crops must be dried. Fallen fruit must not be collected. Irrigation must be stopped at least 1 week before harvest.	–	–
Mandatory hygiene measures	Assessment of the project's impact on public health and hygiene (part of the application file).	–	Wearing of specific clothing. Mandatory vaccination.	Use of gloves. TWWRI inlets must be marked with a special colour. Mandatory vaccination of all users.	–	Recommendations contained in the technical guide of agricultural TWWR (ex.: wearing of boots, masks, latex gloves, trousers, etc.) ;
Specific restrictions and prohibitions on the agricultural use of sewage sludge	Provisions in the process of being promulgated (decree on 'standards and conditions for sludge recovery'.	–	Spreading on market gardening land prohibited 18 months before planting. Use of liquid sludge and non-sanitised sludge prohibited.	–	The matter must be spread evenly on the soil and then ploughed in deeply within the first few days after spreading. Overhead sprinkling prohibited.	–

bacteriological indicators, faecal coliforms and Escherichia coli (E. coli); and helminth eggs, the main vectors of parasitic diseases where they are endemic.

The general difference between the treatment-focused and multi-barrier approaches mentioned in the introduction is particularly evident with regard to bacterial indicators. Treatment-focused approaches are based on a **theoretical estimate** of pathogen survival in wastewater, plants and soils. They often result in a very restrictive standard of detectable presence, as in California, which authorises only 2.2 or 23 coliforms/100 ml depending on the type of culture. To obtain this quality, the recommended treatment method is secondary biological treatment followed by chlorination. The advantage of this approach is obviously to minimise health risks. The disadvantage is the treatment costs required to sustain it compared to the marginal health benefits derived therefrom which are finally limited. One study estimated, for example, that adopting the Californian standard in all US states, as opposed to a standard of 1000 faecal coliforms/100ml, would be equivalent to spending US$330 million for each person less falling ill with hepatitis A[8].

The alternative approach consists of basing regulatory standards on an **empirical assessment** of the health risks induced by wastewater. This involves the generalisation and refinement of a quantitative microbial risk assessment (QMRA). QMRA seeks to measure the infection rates of individuals by different diseases, depending on the different qualities of treated wastewater to which they are exposed. These empirical approaches have gained legitimacy as it has become apparent that the actual risks from TWW are much lower than predicted by the theoretical models. They are therefore generally less restrictive. The emblematic shift in this respect is that of the WHO, which switched from theoretical extrapolations in its 1973 recommendations to the use of epidemiological studies in its 1989 report.

However, this empirical approach is not without its limitations. The main one is the **necessarily contextual nature of the results obtained**, and therefore the difficulties of extrapolating these results on the scale of different countries, or even between different regions of the same country[9]. To take account of this variability and uncertainty, the empirical epidemiological approach is often combined with a multi-barrier approach, although there is not necessarily a link between the two.

4.2 Physicochemical parameters

Physicochemical parameters, in addition to their potential effects on human health, are crucial for agricultural yields, but to a greater or lesser extent depending on the sensitivity of the crops. The most commonly used parameters in national regulations are:

- **pH**, an easily measurable indicator of water acidity or alkalinity which is included in most of the legislations on irrigation water quality. It can also indicate the presence of toxic ions[10]. The range for irrigation that is safe for human health is generally estimated at 6.5 to 8.4[11]. A pH outside this range can impair the growth and health of plants, cause nutritional imbalances, and lead to corrosion of pipes and drippers. A pH that is too low also allows heavy metals to move more easily through soils, contaminating crops and water bodies.
- **Salinity**, which is certainly a major agronomic risk associated with TWWRI. In particular, high salt concentrations increase the water stress of soils, requiring more energy from plants to extract water, which is detrimental to their development. Salinity also increases the presence of toxic ions.
- Suspended matter **(SM)** together with dissolved solids, which are composed of a wide range of plant and animal matter, as well as human and industrial waste. As they are easily measured and provide relevant information on overall quality, they are commonly used in regulations. A restrictive standard may be justified, as in Morocco, to avoid the clogging of drippers in the case of localised irrigation.
- Five-day biological oxygen demand **(5BOD)** and chemical oxygen demand **(COD)**, which are two of the most common indicators of the presence of organic matter. Organic matter can promote microbial growth and adversely affect disinfection processes. However, excessive attenuation is not desirable in the case of TWWRI, as it would unnecessarily deprive the soil and crops of organic matter.
- The most essential nutrients for plant growth are **nitrogen** (N), **phosphorus** (P) and **potassium** (K). While nitrogen is the most critical nutrient of the three, excessive concentrations of it lead to the degradation of plant quality, delayed maturity and excessive leaf growth. Similarly, excessive concentrations of phosphorus can increase rates of eutrophication, one of the major problems facing surface waters on a global scale. This phenomenon reduces the amount of water actually available and lowers its oxygen content. Excess potassium can stimulate algal growth and bacterial development leading to clogged irrigation systems[12].
- Finally, **toxic ions** are beneficial to crops at low concentrations. However, above certain critical thresholds, they cause a reduction in yields. Three of them are especially present in irrigation water and are particularly scrutinised: sodium, chlorides and boron.

4.3 Toxic parameters

These elements, such as lead, cadmium and mercury, are usually present at low concentration levels in wastewater. Despite this, they are rarely included in routine analyses of irrigation water. The condition of drinking water and wastewater pipes, as well as the possible connection of industrial units to the sewage system, can lead to increased concentrations, reducing plant growth and causing groundwater pollution[13]. The toxic effects of these elements are difficult to estimate precisely because they are

8. Shuval, H.; Lampert, Y.; Fattal, B. Development of a risk assessment approach for evaluating wastewater reuse standards for agriculture. Water Sci. Technol. 1997, 35, 15–20.
9. Another significant limitation of these approaches is that they generally do not take into account secondary transmissions.
10 Lazarova, V.; Bahri, A. Water Reuse for Irrigation: Agriculture, Landscapes, and Turf Grass; CRC Press: Boca Raton,
11 Hanjra, M.A.; Drechsel, P.; Wichelns, D.; Qadir, M. Transforming urban wastewater into an economic asset: Opportunities and challenges. In Wastewater; Springer: Berlin/Heidelberg, Germany, 2015; pp. 271–278.
12 Sharpley, A.; Beegle, D. Managing Phosphorus for Agriculture and the Environment. Pennsylvania State Univ. 2001, 1, 1–16.
13. Hussain, A.; Alamzeb, S.; Begum, S. Accumulation of heavy metals in edible parts of vegetables irrigated with wastewater and their daily intake to adults and children, District Mardan, Pakistan. Food Chem. 2013, 136, 1515–1523.

Table 7: Pathogens: main international recommendations

	Exposure scenario	Health objective (DALY/pers./year)	E.Coli	Faecal coliforms	Helminth eggs (no./l)
WHO (1989, 2006)[1]	Unrestricted irrigation				
	Lettuce	10^{-6}	10^3 - 10^4	$\leq 10^3$	≤ 1
	Onion	10^{-6}	10^3 - 10^4	$\leq 10^3$	≤ 1
	Restricted irrigation				
	Highly mechanised agriculture	10^{-6}	10^5	No recommended standard (1989)	≤ 1
	Labour intensive agriculture	10^{-6}	10^3 - 10^4	No recommended standard (1989)	≤ 1
	Drip-irrigated tall crops	10^{-6}	10^2	Not applicable (1989)	≤ 1
	Drip-irrigated low crops	10^{-6}	10^4	Not applicable (1989)	≤ 1
FAO (1992)	A	10^{-6}	-	≤1000 (<200 for green spaces)	≤ 1
	B	10^{-6}	-	No recommended standard	≤ 1
	C	10^{-6}	-	Not applicable	-
EPA (2012)	Raw food crops	-	-	Absence	-
	Processed food crops	-	-	≤200	-
	Non-food crops	-	-	≤200	-

1. World Health Organization. Guidelines for the Safe Use of Wastewater, Excreta and Greywater; World Health Organization: Paris, France, 2006; Volume II, p. 182.

Table 8: Physicochemical parameters: main international recommendations

	WHO		FAO			EPA		
	Degree of restriction of use		Degree of restriction of use			Types of crop		
	Unrestricted irrigation	Restricted irrigation	None	Moderate	Severe	Raw food crops	Processed food crops	Non-food crops
Salinity								
Electrical conductivity (dS/m)			< 0,7	0,7-3.0	> 3.0			
Totally dissolved solids (mg/l)			<450	450-2000	>2000			
Nitrogen (mg/l)			<5	5-30	>30			
pH			6.5-8.0			6.5-9.0		
5BOD (mg/l)	20	20				≤ 10	≤ 30	≤ 30
SM	40	40				≤ 5	≤ 30	≤ 30
Toxic ions								
Sodium			<3 (surface) <3 (sprinkle)	3-9 (surface) >3 (sprinkle)	>9 (surface)			
Chloride			<4 (surface) <3 (sprinkle)	4-10 (surface) >3 (sprinkle)	>10 (surface)			
Boron			<0,7	0,7-3	>3			

strongly dependent on the type of crop and other environmental parameters such as soil pH. They seem to be systematically higher in acidic soils[14].

The main international recommendations on these three main classes of parameter are as follows (Table 7, 8 & 9).

14. Lazarova, V.; Bahri, A. Water Reuse for Irrigation: Agriculture, Landscapes, and Turf Grass; CRC Press: Boca Raton, FL, USA, 2004; ISBN 0203499409.

Table 9: Toxic parameters: a selection of international recommendations

	EPA		FAO		Israel	Jordan
	Long term	Short term	Long term	Short term		
Cadmium (Cd)	0,01	0,05	0,01	0,05	0,01	0,01
Chrome (Cr)	0,1	1	0,1	1	0,1	0,1
Nickel (Ni)	0,2	2	0,2	0,2	0,2	2
Iron (Fe)	5	20	5	20	5	2
Arsenic (As)	0,1	2	0,1	2	0,1	0,1
Copper (Cu)	-	-	0,2	5	0,2	0,2
Lead (Pb)	-	-	5	10	0,1	5
Cobalt (Co)	0,05	5	0,05	5	0,05	0,05
Zinc (Zn)	2	10	2	10	2	5
Aluminium (Al)	5	20	0,5	0,5	5	5
Manganese (Mn)	0,2	10	0,2	10	0,2	0,2
Beryllium (Be)	0,1	0,5	0,1	0,5	0,1	0,1
Selenium (Se)	0,02	0,02	0,02	0,02	0,02	0,05
Lithium (Li)	2,5	2,5	2,5	2,5	2,5	2,5
Mercury (Me)	-	-	-	-	0,002	0,002

With regard to these three classes of parameters, the standards of the six countries are as follows (Table 10).

Table 10: Limit values for TWWRI in the six countries

	Morocco	Algérie	Tunisia	Palestine	Senegal	Bolivia[1]	
Microbiological parameters							
Faecal coliforms (colony forming units [CFUs]/100 ml)	Faecal coliforms (colony forming units [CFUs]/100 ml)	<100 (raw consumption) <250 (cooked consumption) <1000 (arboriculture, cereals and fodder) No standards (arboriculture, cereals and fodder with drip irrigation)	-	≤200 (water class A) ≤1000 (other classes)	≤1000 (Restricted irrigation) NS (unrestricted irrigation)	Class B (raw consumption) <1000; and <200 in 80% of samples	Class C (other crops) <5000; and <1000 in 80% of samples
Helminth eggs (arith.av. /l)	Absence (A and B) NS (C)	Absence (raw consumption). <0.1 (cooked consumption) <1 (arboriculture, cereals and fodder) No standards (arboriculture, cereals and fodder with drip irrigation)	≤1	≤1	≤1	-	
Physicochemical parameters (affecting sensitive crops)							
PH	6,5-8,4	6,5-8,5	6,5-8,5	6-9		B 6,0-9,0	C 6,0-9,0
Salinity: Electrical conductivity (uS/m)	12000	3000	7000	-		-	
Total nitrogen (mg/l)	30	30	-	A 30 B 30 C 45 D 60		12 c. N	

1. See Annex A-1 of the Water Contamination Regulation (RMCH), on maximum permissible values for different water bodies.

	Morocco	Algérie	Tunisia	Palestine				Senegal	Bolivia[1]	
Total phosphorus (mg/l)	_	-	-	-					0.5 c. orthophos-phate	1 c. orthophos-phate
Temperature (°C)	35	-		-						
SM (mg/l)	2000 (gravity) 100 (sprinkle)	30	30	A 30	B 30	C 50	D 90		-	-
5BOD (mg/l)	_	30	30	A 20	B 20	C 40	D 60		<5	<20
COD (mg/l)	_	90	90	A 50	B 50	C 100	D 150		<10	<60
Total dissolved matter	-	-	-	-					≤1000	≤1500
Quality standards for sewage sludge	-	-	-	-					-	
Toxic parameters (mg/l)				A	B	C	D			
Cadmium (Cd)	0,01	0,05	0,01	0,01	0,01	0,01	0,01		0,005	
Chromium (Cr)	0,1	1	0,1	0,1	0,1	0,1	0,1		0,6 (Cr+3) / 0,05(cr+6)	1,1 (Cr+3) / 0,05(cr+6)
Nickel (Ni)	0,2	2	0,2	0.2	0,2	0.2	0,2		0,05	0,5
Iron (Fe)	5	20	5	5	5	5	5		0,3 c. Fe	1 c. Fe
Arsenic (As)	0,1	2	0,1	0,1	0,1	0.1	0,1		0,05	0,1
Copper (Cu)	0,2	5	0,5	0,2	0,2	0,2	0,2		1	
Lead (Pb)	5	10	1	0,2	0,2	0,2	0,2		0,05	0,1
Cobalt (Co)	0,05	5	0,1	0,05	0,05	0,05	0,05		0,2 c. Co 1	
Zinc (Zn)	2	10	5	2	2	2	2		0,2	5
Aluminium (Al)	5	20	-	5	5	5	5		0,05 c.Al	0,1 c.Al
Manganese (Mn)	0,2	10	0,5	0,2	0,2	0,2	0,2		1	
Beryllium (Be)	0,1	0,5		-	-	-	-		0.001 c. Be	
Selenium (Se)		0,02	0,05	0,02	0,02	0.02	0,02		0.01 c. Ce	
Lithium (Li)	2,5	2,5	NS	-	-	-	-		2.5 c. Li	
Mercury (Me)	0,001	0,01	0,001	-	-	-	-		0,001	
Magnesium (Ma)	-	-	0.5	-	-	-	-		100 c. Mg	
Toxic ions (mg /l)				A	B	C	D			
Chloride	350 (surface) 105 (sprinkle)	10	2000	400	400	400	400		-	
Sodium	9 (surface) 69 (sprinkle)	_	_	200	200	200	200		-	
Boron	3	2	3	0,7	0,7	0,7	0,7		-	

Scope

On the whole, all of the countries have quality standards on numerous parameters: **these are probably one of the most developed aspects of the regulations**. Senegal, however, does not have quality standards for toxic parameters. Despite this well-developed aspect, two transversal deficits can be noted:

- None of the countries currently has regulations on **sewage sludge quality standards**. Similarly, none of them has quality standards defining the soils suitable for receiving sludge as organic fertiliser[15].
- None of the countries include regulations on **emerging pollutants**. This is an internationally recognised and highly debated issue, with consumer protection groups advocating their inclusion in Europe and the US. These pollutants, whether synthetic or naturally occurring chemicals (pharmaceuticals, pesticides, antibiotics, detergents, cosmetics, etc.) can be present in considerable quantities in untreated wastewater[16]. Conventional treatment processes are not designed to remove them, and most of them are not monitored by wastewater treatment plant managers. Including these pollutants, of which there are thousands, on a massive scale in regulations

15. The decree currently being validated in Morocco contains provisions on the soil suitability index as well as on the conditions of use, for example when spreading sludge on soils upstream of dam reservoirs.
16. Pennington, M. J.; Rothman, J. A.; Jones, M. B.; McFrederick, Q. S.; Gan, J.; Trumble, J. T. (2018). Aspects of contaminants of emerging concern on Myzus persicae (Sulzer, Hemiptera: Aphididae) biology and on their host plant, Capsicum annuum. Environ. Monit. Assess., 190, 125.

Table 11: Reuse standards and discharge standards in Tunisia and Morocco

	Tunisia		Morocco	
Parameters	Reuse standards	Domestic discharge standards in the public water domain	Reuse standards	Examples of general (and specific) limit values for domestic discharges
PH	6,5-8,5	6,5-8,5	6,5-8,4	5,5-9,5
Salinity: electrical conductivity (uS/m)	7000	5000	12000	2700
SM (mg/l)	30	30 40 if the maximum daily flow does not exceed 15 kg/d 50 in the case of a lagoon-based treatment plant with a maximum daily flow not exceeding 15 kg/d	100 (localised irrigation)	150
5BOD (mg 02/l)	30	30 40 if the maximum daily flow does not exceed 15 kg/d 50 in the case of a lagoon-based treatment plant with a maximum daily flow not exceeding 15 kg/d	_	120
Total nitrogen	-	50	30	40
Total phosphorous	-	2	-	15
Toxic ions (mg /l)	-	-		
Chlorure	2000	700	350 (surface) 105 (sprinkle)	-
Sodium	_	700	9 (surface) 69 (sprinkle)	-
Boron	3	2,4	3	-
Lead	1	0,1	5	1
Mercury	0,001	0,005		
Nickel	0,2	0,2	2	5

would be prohibitively expensive and undoubtedly excessive in relation to the potential health benefits. Nevertheless, the competent public bodies should study these pollutants further (their physicochemical properties, their risks to health and the environment) in order to be prepared to include a certain number of them in the future, should this prove justified.

Clarity

Since the quality standards are by definition in numerical form, they are unambiguous and the question of clarity does not arise at their level.

Applicability

It can be seen that all of the countries, without exception, comply with a helminth egg standard of less than 1/litre. Morocco is even more restrictive, with the requirement of a total absence for water categories A and B (see decree of 2002; nevertheless, a draft decree, currently being validated, re-evaluates this standard at < 1 for market gardening). This requirement has been justified by studies showing that nematode eggs constitute the most serious risk to human health, particularly when vegetables are eaten raw by children and when irrigation is carried out by sprinkling[17]. Nevertheless, **this standard is extremely stringent, and in the vast majority of contexts excessively restrictive** in relation to the results of epidemiological studies[18].

With regard to faecal coliforms, all of the States comply with the minimum standard of ≤1000/100 ml, which is in line with international recommendations. A partial exception is Bolivia, which allows higher values for its class C (<5000 and <1000 in 80% of samples) and D (<50000 and <5000 in 80% of samples) water, which cannot, however, irrigate crops edible raw. At the other end of the spectrum, Algeria (≤100 for raw food crops) and Palestine (≤200 for class A water) have particularly stringent standards.

In contrast, some standards appear to be more accommodating when compared to the classical references of Ayers and Westcot (1987). This is the case of the limit values for **salinity** in Morocco and Tunisia, that are much higher than the threshold of 3000 uS/m which, according to the authors, indicates the need for 'severe'

17. Lazarova, V.; Bahri, A.; Water Reuse for Irrigation: Agriculture, Landscapes, and Turf Grass; CRC Press: Raton, FL, USA, 2004; ISBN 0203499409.

18. Adegoke, A.A.; Amoah, I.D.; Stenström, T.A.; Verbyla, M.E.; Mihelcic, J.R. (2018). Epidemiological evidence and health risks associated with agricultural reuse of partially treated and untreated wastewater: A review. Front. Public Heal, 6, 337

restrictions. It is also the case of the limit values for chlorides in all of the countries, which far exceed the threshold of 5 mg/l which marks the limit at which severe restrictions are necessary.

Generally speaking, **the applicability of this abundance of standards is a massive problem**. With regard to pathogens, the WHO itself admits that for helminth eggs, tests that allow for single-unit-per-litre detections are expensive and difficult to carry out routinely (2006, p. 41). Many studies also note the inadequate technological levels in many countries to meet all of these standards[19]. In Bolivia, the existing standards, particularly for Class B water required for raw drinking water, are considered a bottleneck. In Palestine, Class A water is stricter than Israeli standards and effectively only allows TWWRI for fodder and fruit trees. The recovery of sewage sludge is also subject to strict standards.

Consistency

One of the main issues of consistency is the **often very significant difference between value limits for domestic wastewater discharge and reuse standards**. The fact that these standards are different is in itself normal, since not all wastewater is intended to be reused and the vast majority of WWTPs were not built with reuse in mind. However, WWTP managers are only responsible for discharge standards, which is problematic when these are less stringent than reuse standards. The question of who is responsible for the necessary additional treatment, and its operation, then arises acutely. The table below (Table 11) illustrates these discrepancies for Tunisia and Morocco. **This pleads for reuse to be systematically considered in the future, from the design of WWTPs and the choice of treatment systems**. Moreover, there is also the issue of regulating **industrial wastewater when it enters the sewage system**.

Table 12: Monitoring and control mechanisms in the six countries

	Morocco	Algeria	Tunisia	Palestine	Senegal	Bolivia
Party responsible for the quality control of TWW	- The ABH carries out 'the controls necessary to preserve public health and hygiene'. - The WWTP operator is subject to obligatory controls according to specifications.	- 'Regular control' by: the concessionaire, the farmer, - the manager of the wastewater treatment plant, - the wilaya directorates of water, health, agriculture and trade. But 'particular responsibility' of the wilaya's water services.	- ONAS (self-monitoring at the WWTP outlet). - MSP (sanitary control). - CRDA (at perimeter level).	- Autorité Palestinienne de l'Eau - Autorité de la qualité environnementale (AQE) - Ministère de la Santé (MS) - Ministère de l'Agriculture (MA)	- National hygiene service (Ministry of Health). - ONAS.	The competent environmental authority, under the authority of the governor (department).
Frequency of quality analysis of TWW	- 4 per year (1 per quarter) for heavy metals - 24 per year (1 every 15 days) for bacteriological, parasitological and physicochemical parameters.	-	- At least once a month for the following physicochemical parameters: pH, 5BOD, COD, SM, chlorides, sodium, ammoniacal nitrogen and electrical conductivity. - At least once every six months for the following heavy metals: arsenic, boron, cadmium, chromium, cobalt, copper, iron, fluoride, manganese, mercury, nickel, organochlorine, selenium, lead, zinc. Once every 15 days for parasite eggs.	- Ministry of Health: monthly, only for microbiological parameters. - Ministry of Agriculture: variable depending on the quality standards. - Supplier: daily.	Once a month for all water treated in ONAS plants.	Biannually.
Monitoring the health of exposed workers	Hygiene and health services under the Ministry of Health (Directorate of Epidemiology and Disease Control - Direction de l'épidémiologie et de la lutte contre les maladies, DELM).	- Wilaya health services. - Concessionaire (respect of personal hygiene).	-	Ministry of Health.	Ministry of Health.	-
Quality control of produce irrigated with TWW	ONSSA (National Food Safety Office).	- Agricultural services of the wilaya (phytosanitary control). - Trade services of the wilaya (biological and physicochemical control).	Ministry of Public Health: biological and physicochemical control and control of 'exposed environments'.	Ministry of Health.	-	-

19. See, for example: Shoushtarian F, Negahban-Azar M. Worldwide Regulations and Guidelines for Agricultural Water Reuse: A Critical Review. Water. 2020; 12(4):971. https://doi.org/10.3390/w12040971; Jaramillo, M.F.; Restrepo, I. (2017). Wastewater Reuse in Agriculture: A Review about its Limitations and Benefits. Sustainability , 9, 1734.

	Morocco	Algeria	Tunisia	Palestine	Senegal	Bolivia
Quality control of receiving environments	- ABH in the previously established monitoring network. - Water police established. - Environmental police established with approved inspectors.	Agricultural services of the wilaya (soil impacts).	ANPE.	Environmental Quality Authority.	-	The competent environmental authority, under the authority of the governor (department).
Technical support of farmers	Department of Agriculture, particularly through the National Agricultural Advisory Office (ONCA, Office national de conseil agricole).	- 'The concessionaire must organise, together with the wilaya's water and health services, training sessions for those who operate and maintain the equipment as well as for the farmers. This training should include technical, environmental and health aspects.	-	- Ministry of Agriculture. - NGO.	Ministry of Agriculture (Horticulture Department) and Agronomic Research Institute of Senegal (ISRA, Institut sénégalais de Recherche agronomique).	
Reporting mechanisms	- Report on the state of the environment (ABH). - Groundwater quality monitoring report (ABH).		-	Biannual report of the Water Sector Regulatory Council (WSRC) on the performance of sanitation services to the Council of Ministers	-	-
Education and awareness-raising for risk-free uses	-	Farmers need to be made aware of crop restrictions and the precautions to be taken.	CRDA, ONAS and Ministry of Public Health.	NGO and Ministry of Agriculture depending on the projects.	-	-
Monitoring and control mechanisms specific to sewage sludge						
Quality control of sewage sludge	If used, ONSSA (responsible for the control of agricultural inputs).	-	Ministry of Public Health for health risks at farm level. Not specified for the rest.	Ministry of Agriculture.	ONAS and private operators that run the treatment plants, such as DELVIC.	- (general monitoring by the governor)
Control/monitoring of use	- Regional directorates of agriculture. - ONSSA	-	CRDA: impacts of sludge on the quality of soils, groundwater, watercourses and agricultural produce (pH, N-P-K, MTEs, coliforms and helminth eggs). + leachate collection.	Ministry of Agriculture.	ONAS and Ministry of Agriculture.	-

5. MONITORING AND CONTROL MECHANISMS

The establishment of numerous quality standards and multiple barriers is only useful if control mechanisms are in place to ensure their effective application and to sanction violations. These mechanisms are therefore of considerable importance, including to create and maintain consumer confidence in reuse.

In this respect, the WHO report of 2006 makes three general recommendations:

- Emphasis should be placed on monitoring parameters **that can be measured quickly and easily**, and that indicate whether the wider process that they represent is functioning satisfactorily.
- The frequency of analysis should be **relatively high for microbiological parameters**: in urban areas, once every 15 days for E. coli, and once a month for helminth eggs; in rural areas, once a month for E. coli, and once every 1-2 months for helminth eggs. The EPA, on the other hand, is much more demanding, recommending daily measurement of faecal coliforms, and weekly measurement of pH and BOD.
- With regard to the management of excesses, the general philosophy is to **avoid cut-off sanctions**. They should be graduated and above all adapted to local contexts. For example, the WHO (1989) emphasises that exceeding the limit values for helminth eggs should be assessed according to the endemic nature of parasitic diseases in the territory concerned (p. 41).

The table 12 summarises the control, evaluation and sanction mechanisms for the six countries in the study.

Scope

There is a **significant difference between monitoring measures for TWW and sewage sludge everywhere**. Nowhere is the latter clearly specified, with the partial exception

Table 13: Public funding schemes provided for in the regulations

	Morocco	Algeria	Tunisia	Palestine	Senegal	Bolivia
Public funding of supplementary treatment and storage facilities	Possible: - Subsidies by the ABH, - Distribution between WWTP managers and users according to 'mutual agreement'.	-	-	-	-	Possibility from the Ministry of the Environment and Water.
Public funding of hydro-agricultural infrastructures with TWW	Yes: Ministry of Agriculture, including the Agricultural Development Fund (FDA) for localised irrigation.	Yes: Ministry of Agriculture.	Yes: Ministry of Agriculture (CRDA).	Yes: Ministry of Agriculture.	Yes: Ministry of Agriculture.	Possibility from the Ministry of the Environment and Water.
Formal possibilities of subsidies for O&M	No. Principle of full O&M cost recovery from the farmers.	No ('the concessionaire is responsible for the preventive maintenance and repair of the facilities and pipes of the treated wastewater distribution network').	Yes (distributor organisations for preventive maintenance and repairs).	Yes (pumping costs can be subsidised).	No. Farmers bear the costs but current projects foresee that ONAS will cover them.	For all irrigated perimeters, O&M is to be paid by the irrigators (the principle of the 'economic sustainability' of services).
Formal possibilities of public funding for analyses	Yes ('users, owners or managers of treatment plants').	No (to be covered by the concessionaire).	Yes (distributor organisations).	Yes - Laboratories of the Ministry of Agriculture (limited). - Laboratories of the Ministry of Health (limited).	Yes. The analyses are carried out by the laboratories of ONAS.	-
Conditions of access to financial assistance	The project must: - achieve 'water savings'; - stop contamination of receiving environments. Submitted to the opinion of a commission composed of representatives of: - the ABH - the finance authority - the equipment authority - the environment authority; - the authority on which the TWW user sector depends.	-	-	-	-	-
Possibilities of subsidies for the use of sewage sludge	Yes, ABH (for collective and autonomous sanitations).	-	-	-	No (impact assessment to be paid by the applicant).	-

of Tunisia. There is also a significant difference in the development of regulations between the different countries, with that of Senegal and Bolivia being limited to date.

In addition, certain dimensions generally appear to be neglected by the regulations. This is the case for **technical support for farmers**, which is only specifically provided for in Algeria, even though the handling of wastewater raises particular issues in terms of crop choices, fertigation and the maintenance of irrigation equipment. The same applies to **reporting mechanisms**, which are only mentioned in Palestine. No arrangements for informing elected officials or the public are explicitly provided for in the other countries.

Clarity

In several cases, notably in Algeria and Palestine, many parties are responsible for the analysis of TWW, and the **modalities for their coordination** are not precisely stated.

Furthermore, there are no regulations specifying the **sampling points for the analyses**: should they be carried out at the level of the storage basins or on the agricultural plots? This is a non-negligible issue due to the possibility of recontamination, including bacterial recontamination, in the irrigation networks. At the same time, frequent controls on individual plots would be difficult to implement. It could be interesting to consider mixed systems, in which most of the analyses would be carried out at the station outlet, but would be supplemented by more ad hoc and random controls on the agricultural plots.

Applicability

The **frequency of the analyses** of TWW quality is only clearly specified in Morocco and Tunisia: a pathogen analysis every 15 days, which corresponds to the low range of international standards (i.e. C&D classes of the EU regulation, and where the EPA recommends daily measurements for coliforms). In Morocco, the 2002 decree also provides for a quarterly analysis of all

heavy metals, a requirement that is not always justified and that should be alleviated in the next decree currently being published: this latter stipulates that heavy metal analyses are only imperative in the case of connection of industrial units to the WWTP.

As a matter for reflection, it can be noted that in most of the international standards (EPA, EU, etc.) the frequency of controls varies according to the water class.

It can also be noted that nowhere, with the exception of Morocco[20], **are the control mechanisms put in place accompanied by specific sanctions**, such as legal reminders or financial penalties. The only sanction officially foreseen remains the pure and simple temporary or definitive suspension of the authorisation, as described in section 2. It can naturally be expected that the authorities would be very reluctant to take such a decision, which would generate local tensions. In this respect, it should be noted that the 2019 EU Regulation states that only when non-compliance presents a significant and immediate risk to the environment, human health or animal health, is the operator entitled to immediately suspend the distribution of TWW. Similarly, for toxic parameters, the EPA and FAO distinguish between long-term limit values, which serve as a reference, and short-term values, which indicate momentarily acceptable deviations. Thought could be given to the establishment of similar gradation mechanisms in the six countries, which would be more applicable.

Furthermore, it is to be expected that the implementation of **sewage sludge quality control** will be particularly challenging in several countries, regardless of any future regulations that may be enacted. In Senegal, for example, many secondary towns manage their sludge without taking into account the current regulations. In Dakar itself, there is still a considerable amount of informal management outside the plants operated by ONAS. In Bolivia, since 2018, AAPS (the authority for the taxation and control of drinking water and basic sanitation) has been developing a technical guide for plant managers that includes an indicator on sludge treatment that must be reported. However, the last monitoring report for this indicator (in the second half of 2019) indicated that less than half of the WWTPs had actually reported information on their sludge treatment to the regulator.

Consistency

The main lack of consistency concerns the link between controls and sanctions. Apart from the outright revocation of authorisations, which is often impractical in practice, the legislation does not specify **who risks what for which infringements**. In order to be credible, these sanctions should be proportionate to the fault observed and the health risks actually incurred.

6. PUBLIC FUNDING SCHEMES

Most observers agree that unlike industrial reuse or reuse for green spaces and golf courses, it is difficult to envisage full cost recovery through fees when it comes to TWWRI. First of all, this raises the question of the **public funding of investments** and the distribution of these costs: additional treatment, storage basins, pumping and filtration equipment, irrigation network, and more general development of the scheme.

But such public funding of investments is much better accepted internationally than **operating subsidies**, which are strongly discouraged. The EPA advocates that 'revenues from fees and subscriptions should cover the full cost of repairs, preventive maintenance and improvements of the scheme' (2012, section 7-1, p. 261)[21]. In most countries, however, operating subsidies are practised without being assumed by the public authorities, even if the principle of incentive pricing in the name of a general interest (such as saving water, maintaining local peri-urban agriculture, preserving the environment, etc.) is beginning to find some support.

Whatever the actual funding mechanisms may be, they are hardly enshrined in the regulations, as the table 13 shows. They are thus often effectively left to negotiations on a case-by-case, project-by-project basis.

Scope

Generally speaking, and with the partial exception of Morocco, no country has truly formalised its financial support mechanisms for TWWR by including them in its regulations.

This deficit firstly concerns investment expenditure. As far as hydro-agricultural infrastructures are concerned, it can easily be imagined that the financing circuits are the same as for conventional irrigated schemes, through ministries of agriculture. **Greater uncertainty, however, surrounds funding for additional treatment and the construction of storage facilities**. The fact that the regulations are largely silent on this key issue is likely to slow down the adoption of projects.

The legislations are more explicit regarding operating expenses. **The approaches differ significantly between countries**. While Algeria and Bolivia clearly state that the rate charged to farmers should cover the full operating costs, the other countries open the door to operating subsidies: Morocco for pumping and conveyance costs, Palestine for pumping costs, and Tunisia for preventive maintenance and repairs. These three countries also provide for the possibility of public funding for analyses, a major point as it weighs heavily on operating costs.

Clarity

In general, the legislations only provide for general possibilities of public subsidies, without specifying their allocation criteria. This lack of precision opens the way to 'customised' support, with little

20. Article 139 of Law 36-15 provides that 'anyone who contravenes the provisions of Articles 65 and 66 of this law [relating to the authorisation of TWWR] shall be sanctioned by 1 to 3 months' imprisonment and a fine of 1 000 to 5 000 dirhams, or by one of these two penalties only.

21. The EPA also prescribes the establishment of a specific accounting system and of a dedicated account for the management of TWWRI, without amalgamating them with other revenues and expenses. The 'water pays for water' principle should apply.

codification. It also calls into question the ability of projects to be in line with clearly defined objectives, a point to which we return in the 'consistency' section.

Applicability

Compared to conventional irrigation schemes, schemes irrigated with TWW **are often marked by a cost-price squeeze**, characterised by both higher operating costs and lower willingness to pay.

Of course, the difficulty of setting fees that recover full operating costs is not unique to TWWR. Almost everywhere, irrigators' associations have difficulties in sustainably operating their schemes based on the fees and charges paid by their members alone. It cannot be stressed enough that TWWRI projects are irrigation projects like any other, facing the same challenges and risks of malfunctioning as any other. However, compared to conventional schemes, schemes irrigated with TWW have additional operating costs. A key issue here is the **financing of quality analyses**. In many cases, it is difficult to envisage farmers paying for them in full. Tunisia fully recognises this difficulty by assigning these analyses to the distributors (the WWTP manager and the CRDA). Moroccan law, for its part, mentions this possibility but does not, for the time being, arbitrate between the responsibilities of the distributor and those of the users. However, the National Reuse Plan (PNREUT) provides that the price of treated water should be less than or equal to that of conventional water; as the price of the latter is highly subsidised, this implies de facto operating subsidies for TWWRI.

At the same time, willingness to pay may be lower since almost always, in semi-arid contexts outside coastal cities where discharges are to the sea, **raw or treated wastewater was already being reused prior to the planned projects**. This reuse could be direct or indirect, with pumping from rivers containing the effluent. The farmers were not charged for this water. When 'new' beneficiaries overlap with 'old' users, willingness to pay for a previously free resource is typically limited, and fee negotiations are difficult[22]. This is likely to be the case in all six countries studied.

It would therefore be appropriate to better assume the possibilities of operating subsidies, while clarifying and supervising them. Transitional support could be envisaged for the first few years, as suggested by the EPA (2012, section 4.3., p. 125), and as Jordan, for example, commonly practices. On a more permanent basis, if necessary, the logical approach would be to first negotiate the fees with farmers based on their ability to pay, and to subsidise the remaining part. But to be legitimate, such support must be consistent with a general interest, a point to which we return in the next section.

Consistency

With regard to the consistency of the financial arrangements, two cross-cutting deficits can be identified.

The first concerns the purposes that the public funding should serve. The question can be put simply: **what is the reason for financing (part of the) reuse with public funds?** This question should be addressed by **specifying the conditions of access to financial support**. Only Morocco is currently doing this, by making financial assistance subject to one of the following two conditions: the achievement of 'water savings'; and/or the capacity to stop contamination of the receiving environments.

In fact, operating subsidies can only be justified on the basis of a **clearly identified general interest**, such as, for example: the maintenance of small-scale local agriculture; substitution for other overexploited water resources; or better protection of receiving environments (in the latter case, in the same way as sanitation itself, which is largely subsidised in the six countries). In Spain, for example, support for local agriculture which can supply short circuits justifies the solidarity of urban users and the partial funding of TWWRI by sanitation bills.

Whatever the case, the 'territorial construction of a common good'[23] can only be legitimate if it is debated and validated in an inclusive process, which means involving civil society very early on in the decision-making process. This general interest must then be the project's main objective and not be lost sight of afterwards.

The second challenge of consistency concerns the articulation between **the funding of additional treatment, of storage facilities and of hydro-agricultural developments**. When the first two are not systematically covered by the Ministry of Agriculture, regulations could specify the framework for dialogue between the different ministries concerned, to enable the financial arrangements for projects to be determined more quickly. The methods of funding these infrastructures and developments should also be consistent with the practices in force for conventional water.

These various observations ultimately highlight the need to **institutionalise public support mechanisms for TWWR by enshrining them in regulations**, in order to provide a facilitating framework for negotiations specific to each project, and to mobilise funding agencies more by offering clear financial returns for their interventions.

7. OVERVIEW OF THE ARRANGEMENTS FOR GOVERNANCE AND THE COORDINATION OF ACTORS

The five main regulatory components reviewed so far all include some provisions for the governance of TWWR. As stated in the introduction, the term governance here refers to the schemes for allocating roles and responsibilities, as well as the mechanisms for exchange, coordination and arbitration between the different stakeholders that they provide. These provisions, however, have been treated in a scattered manner. Moreover, not all of the governance mechanisms are always clearly enshrined in legal

22. Aït-Mouheb, N., Mayaux, P.L, Mateo-Sagasta, J., Hartani, T., Molle B (2020), 'Water Reuse: A Resource for Mediterranean Agriculture', in M. Zribi, L. Brocca, Y. Tremblay, F. Molle, (eds.) Water Resources in the Mediterranean Region, Elsevier, chap. 5, p. 107-36.

23. Lascoumes, P., Le Bourhis, J.-p. (1998). 'Le bien commun comme construit territorial. Identités d'action et procédures', Politix, vol.2, no. 2, pp. 37-66.

Table 14: TWWRI governance: key roles and responsibilities

	Morocco	Algeria	Tunisia	Palestine	Senegal	Bolivia
Project ownership	-	-		-	-	Farmers
Authorisation to irrigate with TWW	Director of the water basin agency (ABH)	- The territorially competent' Wali. - 'Where the scheme straddles several wilayas, order of the minister responsible for water resources.	Ministry of Agriculture (MARHP) 'after agreement' with the Ministries of: - the Environment, - Spatial Planning, - Public Health.	The Palestinian Water Authority 'in cooperation and coordination with the relevant authorities', notably: (i) the Ministry of Agriculture and Irrigation, (ii) the Environmental Quality Authority.	Ministry in charge of sanitation via the ONAS.	Prefect / governor (department).
Authorisation to use sewage sludge	All use prohibited.	'Agricultural services concerned'.	Ministry of Agriculture + Ministry of the Environment (joint decree).	- Ministry of Agriculture. - Ministry of the Economy. - Palestine Standards Institution (PSI).	The minister responsible for sanitation, on the advice of the minister responsible for the environment.	Prefect / governor (department) subject to adequate quality.
Development / revision of quality standards for reused TWW	Department of Water Department of the Environment	- Ministry of Water Resources - Ministry of Agriculture - Ministry of Health	- MARHP - MALE - MSP	- PSI - Palestinian Water Authority. - Ministry of Agriculture.	- (Standards are being developed by the Department of Sanitation in collaboration with the Senegalese Standardisation Association [Association Sénégalaise de Normalisation])	-
Distribution of TWW	-	-	MARHP	-	-	-
Quality control of TWW	The ABH carries out 'the controls necessary to preserve public health and hygiene'.	'Regular control' by: - the concessionaire, - the farmer, - the manager of the treatment plant, - the wilaya directorates of water, health, agriculture and trade, but 'particular responsibility' of the wilaya's water services.	- ONAS (self-monitoring at the WWTP outlet) - Ministry of Public Health (sanitary control) - CRDA (at scheme level)	- Palestinian Water Authority. - Environmental Quality Authority. - Ministry of Health. - Ministry of Agriculture.	- National hygiene service (Ministry of Health). - ONAS.	-
Quality control of produce irrigated with TWW	ONSSA	- Agricultural services of the wilaya (phytosanitary control). - Trade services of the wilaya (biological and physicochemical control).	Ministry of Public Health: biological and physicochemical control and control of 'exposed environments'.	Ministry of Health	Ministry of Water and Sanitation	-
Sewage sludge quality control	-	-	Ministry of Public Health for health risks on farms. Not specified for the rest.	Ministry of Agriculture	-	- (General monitoring by the departmental prefecture.)
Training and support of farmers	Department of Agriculture / ONCA	-	- CRDA - Agricultural Extension and Training Agency (AVFA, Agence de la Vulgarisation et de la Formation Agricoles)	- Ministry of Agriculture - NGO	- Ministry of Agriculture - ISRA - NGO	
Financing of additional treatment and of storage facilities	(Possibility of support from the ABH.)	-	-	-	-	-
Financing of hydro-agricultural infrastructures using TWW	Ministry of Agriculture	Ministry of Agriculture	MARHP (CRDA)	-	-	-
Funding of analyses	User, owner or distributor	Concessionaire	MARHP (CRDA)	-	-	-

corpuses. It is therefore useful to present a synthetic overview, as well as a specific discussion, of the TWWR governance arrangements in force in the six countries.

In order to draw up this overview and allow for comparison, we have selected **12 functions that are essential for the sustainable success of projects**. The table below describes the distribution of roles and responsibilities for each of them in the six countries.

This summary table (table 14) makes it possible to formulate certain cross-cutting observations based on the four criteria of the scope, coordination, inclusion and accountability of governance mechanisms. These observations constitute a number of areas of reflection for the continuation of the COSTEA initiative.

Scope

Firstly, in most of the countries, **project ownership does not appear to be sufficiently clarified by law**: Who is the initial proponent of the need for reuse? Who defines the project's main objective, timetable and budgetary limits? Who commissions the first feasibility studies? The fact that the regulations usually start with a description of the authorisation procedures may suggest that everything starts with the expression of a spontaneous request from farmers. This is officially the case in Bolivia, where all requests must first be made by farmers to the municipalities. The projects are then defined jointly between the farmers and the municipalities. Elsewhere, however, formal TWWR projects are often promoted by public bodies. The prerogatives in this area could therefore be better clarified.

Several project owners may be envisaged: local administrations of the Ministry of Agriculture, municipalities, pre-constituted irrigators' associations, water treatment operators, etc. However, these different options would benefit from being clarified in the regulations, as much to gain in structure as to guarantee that the project owner truly expresses a strong and majority demand among the farmers of the territory, which could translate into a solid legitimacy of the project and a real willingness to pay. Project ownership is too important to be left to the uncertainties of local initiatives.

Secondly, **the distribution of costs remains a neglected area of governance arrangements**. It would be useful to institutionalise the available public funding mechanisms, whether they concern capital or operating expenses, by including them more clearly in the regulations. Such a framework would facilitate the financial arrangements for individual projects. The arrangements for subsidising operation and maintenance, in particular, would benefit from clarification and regulation. Their necessity seems to be implicitly recognised by the fact that the regulations barely mention the possibility of delegating the operation of TWWRI schemes to the private sector, even though the latter can be active in the delegated management of WWTPs, as in Tunisia or soon in Senegal. This seems to indicate that it is hardly thought that it could be a lucrative activity. In this case, it would be better to assume and delineate it.

Coordination

In terms of coordination, the most important cross-cutting deficit is undoubtedly that there are no regulations that formally define a veritable **institutional coordinator** for TWWR in agriculture at national level. In the absence of a national leader, intersectoral collaboration remains insufficiently structured. Of course, de facto collaboration still exists, if only through networks of professionals who constantly exchange expertise, feedback and points of view. At the local level, in many cases there are also project agreements which define responsibilities and coordination mechanisms at the scale of individual projects.

However, such coordination without coordinators has its limits. Several countries have experimented with horizontal intersectoral committees, such as the 'Reval' committee in Morocco at the turn of the 2010s, or the Joint Intersectoral Commission in Bolivia. In Tunisia, there is a Joint National Commission to monitor the use of treated water, for which the Directorate-General of Rural Engineering and Water Use (DGGREE) provides the secretariat, and since 2017, joint regional commissions are chaired by the governor. However, the fact that these committees have not been institutionalised in the long term (in Morocco and Bolivia) or that their activity levels are highly variable (in Tunisia), supports the WHO's diagnosis (2006) that the intersectoral committee approach 'has not produced an adequate solution. The committees are generally under-resourced, not mandated to produce binding recommendations, and lack a member with a leadership role' (pp. 15-16).

Contrary to what the WHO may imply, however, the search for a single leader is probably not realistic in most cases, as the success of TWWRI projects depends on a strong and voluntary commitment from different administrations (sanitation, agriculture, health, environment, urban planning, etc.), which is difficult to decree from above. On the other hand, it does not seem realistic to rely on the spontaneous cooperation of multiple actors who already have their priorities well established and their work routine. TWWRI, and TWWR more generally, therefore need a **clear coordinator to take on the role of executive secretariat for coordination**: convening meetings, drafting agendas and minutes, setting activity schedules, archiving, disseminating and capitalising on information, and drawing up the first versions of framework documents.

A remit of this kind corresponds roughly to that of the National Coordination Committee for Reuse in Jordan. In Bolivia, the National Irrigation Directorate, housed in the Vice-Ministry of Water Resources and Irrigation, is trying to play this role but with limited success so far.

It could take the form of a dedicated committee within the higher water resources planning body, where there is one (such as the National Water Council in Tunisia or the Palestinian Water Authority). **Substantial human resources should then be allocated to the coordination activities themselves, and these activities would benefit from being framed by a formalised document**. This document would be an opportunity to formally include, ahead of decision making, representatives of consumers and of civil society concerned by agricultural, health and environmental issues. In addition to providing a space

for coordination, such a body would provide a platform for regular consultation between all stakeholders, and a forum for exchanging information and capitalising on experience.

In terms of coordination, there is also a fairly general lack of **operational governance of projects**. Indeed, the legislations above all organise the distribution of major strategic decisions: authorisations, prohibitions, setting and revision of quality standards, controls and sanctions. However, they rarely enter into the concrete organisation of projects, which is essential for their long-term success. Here we are thinking of parameters such as: the identity of the distributor; the assumption of responsibility for the costs of pumping or replacing irrigation equipment (filters, ramps, drippers) in the event of clogging that has a greater impact than anticipated; the technical support of farmers, particularly during the first few years; the resolution of disputes between farmers and the distributor in the event of non-compliant water quality, etc. These variables, far from being secondary, can condition the effective success of projects. They should therefore undoubtedly be better clarified in the corresponding decrees, or in **model agreements** between stakeholders.

An example of this is agricultural advisory services, which are very useful for handling non-conventional water. Apart from the fact that little provision is made for providing agricultural advisory services in the legislations, these services are unfamiliar with the specific characteristics of these resources and often do not have adequate human resources to provide effective support to farmers in the area of reuse[24]. Training programmes for trainers should therefore be planned. In terms of inter-institutional coordination, a central role could be given to WWTP operators, similar to the **risk management plans** set up by the new European regulation. The latter requires the WWTP operator to draw up a risk management plan for reuse. This requires consultation with all stakeholders, including end users. The plan includes a description of the entire system, from the entry of the wastewater into the plant to the points of use. It identifies the parties involved and describes their roles and responsibilities. In short, as the EPA points out, it is fundamental that reuse projects be considered as **'permanent programmes'** (2012, p. 124) rather than simple projects for the development and water supply of a scheme whose subsequent operation would not pose any particular problem.

Finally, the management of **TWWR appears to be insufficiently incorporated into integrated water resource management**. Authorisation applications, where they are specified in the legislations, clearly illustrate this lack of linkage: the way in which TWW is part of quantitative management (substitution, supplementation, low-water support, etc.) or qualitative management (improvement in quality parameters compared with the previous situation or the counterfactual situation) on the scale of a basin, is not a criterion for authorising projects. In this respect, some countries have levers that are easier to activate than others. In Morocco, it is the Water Basin Agency that issues authorisations, which could enable it to condition projects on their contribution to the sustainability of water uses in the territory. In its integrated water resource development and management plans, the agency must also propose plans for the mobilisation of non-conventional water (art. 91 of law 36-15). Similarly, in Bolivia, the water basin management plans (Planos de cuencas -PDC) must specify the arrangements for mobilising the different water resources in the long term. However, only a few of these plans include agricultural reuse objectives. In practice, planning and implementation are still carried out in a sectoral manner, with, in particular, limited coordination between sanitation and irrigation. All of this argues for **TWWRI to be included much more systematically in the integrated quantitative and qualitative management of water resources in the territories concerned**.

Inclusion

No governance mechanisms assign an official role to **local authorities**. This may seem surprising given that ambitious decentralisation processes are underway (in Tunisia, Morocco) or are already well consolidated (in Bolivia). Municipalities, in particular, are generally responsible for sanitation and wastewater treatment: their role in reuse (project formulation, management and control) could be further clarified. In countries with significant decentralisation, mechanisms could be established to ensure effective feedback loops between national and sub-national officials, and thus ensure regular **multi-level coordination**. In some cases, initial decision-making (project ownership) could be undertaken by the municipalities.

The existing systems scarcely formalise their **mechanisms for consulting farmers and consumers** in the crucial project design phase. Only Bolivia specifies that initial requests can only come from farmers' groups. A thorough and open consultation prior to any decision, is however, essential to ensure that the project really corresponds to a broad and strong social demand in the territory, to guarantee the existence of functional collectives of irrigators to manage the operation and subsequent maintenance, and to ensure that the delimitation of the scheme (the definition of beneficiaries and non-beneficiaries) does not give rise to intense conflict.

Generally speaking, the inclusion of all stakeholders implies a **territorial approach** to TWWR. It is at this scale, which is much larger than that of the project, that all of the stakeholders concerned in various capacities by reuse are included: envisaged farmers and their representatives; urban consumers, who are particularly concerned in the case of short chains; local authorities; possible beneficiaries of wastewater discharges existing prior to a project; State services (agriculture, water, land use planning, environment, health, etc.); industrial water processors, etc. An approach on this scale also allows the whole range of costs and benefits generated by the project to be taken into account in the decision-making process, over and above its mere economic profitability for farmers. It should therefore be supported by cost-benefit analyses and life cycle analyses so that all stakeholders can make relevant decisions on the appropriateness of the project, and particularly on public assistance if it is required. The territorial scale would also be appropriate if risk management plans were to be drawn up, as currently provided for in the European Union regulation.

24. For a case study in Morocco, see: Mayaux, P.L, Bensmaïl, A. (2019). 'A la recherche de la réutilisation des eaux urbaines en agriculture : rationalités techniciennes et impensés institutionnels dans le projet d'irrigation de Settat-Sidi El Aidi', Alternatives rurales, no. 7, p. 1-19.

Table 15: Main recommendations

Issues	Recommendations
1. Transversal governance	
Institutional coordination	Designate a national coordinator for agricultural TWWR acting as the executive secretariat for coordination.
Territorial approach	Prior to any decisions, organise an in-depth and inclusive territorial consultation process based on cost-benefit and/or life cycle analyses, so that all parties concerned are able to give their opinion on the collective interest of the project.
Project ownership	Clarify the allocation of project ownership.
Integrated water resource management (IWRM)	Integrate TWWR projects into IWRM instruments and arenas (planning, project authorisation criteria, basin committee where existing, etc.).
2. Authorisation schemes	
Renewal of authorisations	Clarify the arrangements for renewal, considering the possibility of simplified procedures.
Revocation of authorisations	Specify the terms of revocation, organising temporary suspension procedures.
Collective commitment of farmers	Consolidate a right of refusal in the context of collective projects, thereby ensuring that all the farmers involved genuinely support the project.
Aquifer recharge	Specify the possibilities for recharging aquifers using TWW.
3. Authorised crops and irrigation methods	
Use of sewage sludge	Establish a list of crops suitable for receiving sewage sludge as fertiliser.
Differentiation between collective and autonomous sanitation	Consider differentiating certain barriers depending on the collective or autonomous nature of the sanitation.
Applicability of barriers	Erect a limited number of enforceable barriers.
4. Quality standards	
Helminth eggs	Consider changing the standard of ≤ 1 egg per litre, which is very restrictive in relation to the results of epidemiological studies.
Use of sewage sludge	Clarify quality standards for sewage sludge.
Emerging pollutants	Support research on emerging pollutants (physicochemical properties, health and environmental risks) in order to be prepared to include a number of them in the future, should this prove relevant.
Gap between domestic discharge standards and reuse standards	Move towards reducing the gap between domestic discharge standards and reuse standards; in the future, study the feasibility of TWWRI projects at the design stage of WWTPs in order to adapt the choice of treatment systems accordingly.
5. Monitoring and control mechanisms	
Monitoring and control of reclaimed sewage sludge	Specify the monitoring and control procedures for reclaimed sewage sludge.
Analysis frequency	Specify the frequency of analysis.
Public information	Draw up the necessary regulations, or apply existing regulations related to public information (analysis results, partnership agreements, plans of the schemes concerned, etc.).
6. Public funding schemes	
Investment subsidies	Specify, where necessary, the public funding arrangements for additional treatment and the construction of storage facilities.
Operating subsidies	Clarify the criteria for access to operating subsidies (i.e. for network maintenance, energy or analysis costs).

Accountability

In most of the countries, provisions for project accountability could be improved. TWWRI projects are generally subject to public enquiry procedures, which allow the public to learn about the project and to make comments to an independent third party. However, subsequent information to the general public is often limited: either there are no specific provisions for this or they are poorly implemented. For example, the basic parameters of projects (results of analyses, scheme plans, agreements) are not easily accessible in any of the six countries. By way of comparison, the new European regulations contain an obligation to provide information on the results of compliance checks. They require a range of information to be publicly available, online or otherwise, and updated every two years, including: the quantity and quality of water supplied; the percentage of water reused in the country as a proportion of the total amount of wastewater treated; and authorisations granted or modified.

8. CONCLUDING THOUGHTS

The systematic comparison of the regulatory frameworks undertaken in this study has revealed **clear contrasts in the scope of the existing regulatory frameworks**. The three Maghreb countries and Palestine have more extensive regulations than Senegal, and to a lesser extent Bolivia. That said, a number of transversal points of concern have been identified, which point to possible recommendations. The main ones are summarised below. It should be noted that **not all of the countries are concerned by each of the points** as some already have sufficient provisions in their legislative arsenal. However, these are the most transversal issues (see Table 15).

Two transversal areas for work should be highlighted, one national, the other international. Firstly, the provisions related to TWWR are often dispersed, while the linkage with other texts on water resource management and irrigation is not always sufficiently explicit. This calls for reflection, following the example of Egypt, on the constitution of **reuse codes**, which bring together the authorisation procedures, quality standards, various crop restrictions, irrigation methods, hygiene practices, monitoring and control mechanisms and public financing schemes in a single corpus of texts.

Finally, the persistent differences in approaches, particularly in the parameters taken into account and limit values, raise the question of the **international harmonisation of standards**. Brissaud (2008) had already argued that excessive differences in standards between countries could be a serious obstacle to securing trade, and consequently make exporting farmers reluctant to engage in reuse projects[25]. This is particularly important in a context where international trade is already facing multiple shocks that are disrupting economies: the Covid-19 pandemic, geopolitical rivalries and conflicts, and the climate crisis, which make the volumes of foodstuffs placed on international markets more uncertain. Moreover, the wide variety of national regulations and of risks deemed 'acceptable' are likely to arouse incomprehension and ultimately distrust among the public.

The way to international harmonisation is undoubtedly through a more systematic and convergent anchoring of legislation in the existing epidemiological studies and the quantitative assessment of microbial risks. The **Stockholm framework**, on the risks of waterborne diseases in general, could constitute a first common reference framework. It provides criteria for the development of recommendations based on health objectives and microbiological risks associated with sanitation problems. It led the WHO to recommend levels of health protection comparable to those tolerated for drinking water (maximum threshold of 10-6 DALYs per person per year) in its 2006 guidelines, which corresponds well to a 'one water' approach.

The **'one health'** approach could serve as a second framework for international convergence, highlighting the fundamental interdependencies of human health with animal, plant and environmental health. Faced with these complex interconnections, it invites a systemic analysis of the risks, for example of certain pharmaceutical products on the final health of water consumers, as well as on that of the soil and the environment.

The collective interest in convergence should lead the various countries to set up permanent international platforms for sharing experience and knowledge. These platforms would clarify the uncertainties surrounding the respective regulations, and point to priority needs for scientific research. In doing so, the focus should be on defining an acceptable level of risk to human health and the environment in a transparent and inclusive manner. The informed consent of citizens can only be achieved through quality public information and the involvement of local civil societies from the initial formulation to the social monitoring of projects.

25. Brissaud, F. (2008). Criteria for water recycling and reuse in the Mediterranean countries. Desalination, 218, 24–33.

ANNEXES

ANNEX 1: MAIN REGULATORY TEXTS ANALYSED

Country	Text	Year
Algeria	Law 05-12 on water instituting the granting of the use of purified wastewater for irrigation purposes. Algerian standard 17683 'Réutilisation des eaux usées épurées à des fins agricoles, municipales et industrielles - Spécifications physico-chimiques et biologiques' (Reuse of purified wastewater for agricultural, municipal and industrial purposes - Physicochemical and biological specifications) is available from IANOR, Algeria's National Standards Institute.	2005
	Decree 07-149 laying down the conditions for granting the use of purified wastewater for irrigation purposes as well as the related standard specifications.	2007
	Inter-ministerial orders of 2 January 2012 In application of executive decree 07-149, these orders set out: the specifications of purified wastewater used for irrigation purposes, in particular with regard to microbiological and physicochemical parameters; the list of crops that can be irrigated with purified wastewater.	2012
	Algerian standard 17683 'Réutilisation des eaux usées épurées à des fins agricoles, municipales et industrielles - Spécifications physico-chimiques et biologiques' (Reuse of purified wastewater for agricultural, municipal and industrial purposes - Physicochemical and biological specifications).	2014
Morocco	Law 10-95 on water	1995
	Decree 2-97-657 of 4 February 1998 on the use of wastewater.	1998
	'Arrêté conjoint du Ministre de l'Equipement et du Ministre chargé de l'Aménagement du Territoire, de l'Environnement, de l'Urbanisme et de l'habitat n° 1276-01' (Joint order 1276-01 of the Minister for Equipment and the Minister in charge of Spatial Planning, the Environment, Urban Planning and Housing) of 17 October 2002 fixing the quality standards of water intended for irrigation.	2002
	'Arrêté des Valeurs Limites Spécifiques domestiques' (Order on specific domestic limit values)	2006
	'Arrêté des Valeurs Limites Spécifiques de rejet des industries de la pâte à papier, du papier et du carton' (Order on specific discharge limit values for the pulp, paper and cardboard industries)	2006
	Law 36-15 on water in particular arts. 64-71, on the reuse of treated wastewater and sewage sludge.	2016
	Moroccan standard CEN/TR 13983 Sludge characterisation. Good practices for sludge recovery in soil reconstitution.	2016
	Moroccan standard CEN/TR 13097 Sludge characterisation. Good practices for sludge recovery in agriculture.	2016

Country	Text	Year
Tunisie	Water code (law 75-16)	1975
	Decree 89-1047 (1989) amended by decree 93-2447 (1993) laying down the conditions for using TWW for agricultural purposes.	1989
	Decree 91-362 on environmental impact assessment.	1991
	Order of the Minister for Agriculture 21 June setting out the list of crops that can be irrigated with treated wastewater.	1994
	Specifications setting out the specific terms and conditions for the use of TWW for agricultural purposes.	1995
	Standards 106-02 Discharge of TWW into water environments.	2002
	Tunisian standards 106.20 a Fertiliser materials - sludge from urban wastewater treatment plants.	2002
	Tunisian standards 106-03 defining the quality to be respected, the parameters and the frequency of physicochemical and bacteriological analyses.	2003
	Joint order of the Minister for Agriculture and Water Resources and the Minister for the Environment and Sustainable Development of 29/12/2006 setting out the specifications fixing the conditions for the use of sludge from wastewater treatment plants in the agricultural field and the management methods by farmers.	2006
	Decree 2007-13 setting out the conditions and methods for the management of sludge from treatment plants with a view to its use in the agricultural field.	2007
	Decree 2018-315 setting the limit values for effluent discharges into the receiving environment.	2018
Bolivia	Ley 1333 del Medio Ambiente	1992
	Decreto Supremo n° 24176 Reglamento de Prevención y Control Ambiental; Reglamento en Materia de Contaminación Hídrica	1995
	Ley de Riego Nº 2878	2004
	Ley 031 Ley Marco de Autonomías y Descentralización Andrés Ibañez	2010
	Ley de la Madre Tierra nº 300	2013
	Resolución Ministerial 583/2018 Guía técnica para el reúso de aguas residuales en la agricultura, aprobada mediante, Vice ministère aux ressources hydriques et à l'irrigation.	2018

Country	Text	Year
Palestine	Decree No. 90/1995 establishing the Palestinian Water Authority (PWA).	1995
	Law on the environment, no. 7 This basic enactment of the Palestinian Legislative Council creates a framework for the protection of the environment, public health and biodiversity in Palestine including marine areas. Its 82 sections are divided into 5 Titles: Definitions and general provisions (I); Environmental protection (II); Environmental impact assessment, licensing, inspection and administrative procedure (III); Penalties (IV); Final provisions (V). Article 1 contains an extensive list of definitions, including 'natural reserves'.	1999
	Law 3/2002 Palestinian Water Law	2002
	Guidelines for Using Reclaimed Wastewater In Agriculture	2010
	The Palestinian Treated Wastewater Standard (Technical Specification)	2012
	Decree Law No.14 of 2014 relating to the Water Law This Law, consisting of 68 articles divided into 12 chapters, aims at a better water management and development of Palestinian water resources, through establishing for a new phase for the water and wastewater sector, its governance and management. It states that the Water Authority will be under the responsibility of the Cabinet, splitting policy from regulatory functions, which was previously carried out by the Palestinian Water Authority (PWA) since its establishment.	2014
	Law 4 on water users' associations	2018
Senegal	Law 2009-24 of 8 July 2009 on the Sanitation Code. Particularly: its articles L74 to L78 'reuse of purified water of domestic and industrial origin'. its articles L79 to L88 on sludge management.	2009
	Implementing decree 2011-245 of 17 February 2011 on the reuse of wastewater and sludge	2011

ANNEX 2: THE 'FIT FOR PURPOSE' APPROACH: THE CALIFORNIAN REGULATION[1]

Type of irrigation	Level of treatment			
	Tertiary treatment with disinfection	Secondary 2.2. type treatment with disinfection*	Secondary 23 type treatment with disinfection**	Secondary treatment without disinfection
Crops where TWW comes into direct contact with the edible parts of plants	✓	✗	✗	✗
Food crops with surface irrigation without edible parts coming into direct contact with TWW	✓	✓	✗	✗
Parks and playing fields	✓	✗	✗	✗
Residential green areas	✓	✗	✗	✗
Golf courses with limited access	✓	✓	✓	✗
Pasture for dairy farming	✓	✓	✓	✗
Non-edible vegetation with controlled access to prevent use as a park or playing field	✓	✓	✓	✗
Orchards with no contact between TWW and fruit	✓	✓	✓	✓
Vineyards with no contact between TWW and fruit	✓	✓	✓	✓
Food crops processed using pathogen-killing methods	✓	✓	✓	✓

* Water disinfected so that the median total coliform concentration does not exceed the most probable number (MPN) of 2.2/100 ml, based on the bacteriological results of the last 7 days for which tests have been conducted; nor does it exceed the MPN of 23/100 ml in more than one sample taken in any 30-day period.

** Water disinfected so that the median total coliform concentration does not exceed the MPN of 23/100 ml, based on the bacteriological results of the last 7 days for which tests have been conducted; nor does it exceed the MPN of 240/100 ml in more than one sample taken in any 30-day period.

1. California Code of Regulations. Available online: https://govt.westlaw.com/calregs/Browse/Home/California/CaliforniaCodeofRegulations?guid=IE8ADB4F0D4B911DE8879F88E8B0DAAAE&originationContext=documenttoc&transitionType=Default&contextData= (accessed on 21 January 2022).