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# WATER QUALITY IN AGRICULTURE: **Risks and risk mitigation**

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Chapter 10

# The cultural, economic and regulatory environment affecting the adoption of marginal quality water and risk reduction measures

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Water resources are becoming increasingly scarce around the globe, both in quantity and quality. This trend underscores the need to adopt water supply and demand management alternatives to cover the food needs of a growing population and to lessen the impacts of droughts and heatwaves (FAO, 2018).

The use of marginal quality water (MQW) – like saline water or wastewater for irrigation – offers such an alternative (Qadir *et al.*, 2007) although more often involuntary than planned. Globally, more than 75 million ha of farm land are affected by human-induced salinization, more than 50 percent of which occurs in irrigated landscapes (Sakadevan & Nguyen, 2010). In addition, informal use of wastewater-polluted irrigation water takes place on about 29 million ha downstream of urban centres where wastewater treatment capacities are insufficient or absent (Thebo *et al.*, 2017). Conversely, conscious use of treated wastewater (reclaimed water) to tackle water scarcity is used on less than 1 million irrigated ha (Drechsel, Qadir & Galibourg, 2022). The implication is that any discussion on the enabling environment of MQW use should not only address its promotion in line with the Sustainable Development Goal 6, but also the common reality of ongoing use and related environmental and health hazards.

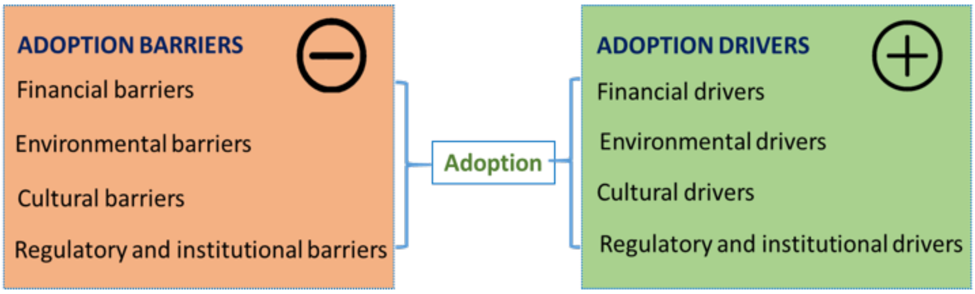
The economic, environmental, socio-cultural and regulatory implications of e.g., planned versus unplanned wastewater use differ in many respects although they converge around the need for safety and behaviour change. For example, education and awareness creation as well as incentive systems are often needed to promote the use of reclaimed (safely treated) wastewater and address reluctance or hesitation among potential users, especially when conventional water sources remain available. On the other hand, where no treatment capacities and alternative water sources to polluted irrigation water exists, awareness creation about the possible risks and/or incentive systems for adopting safety measures should have the highest priority. In both cases, financial considerations vis-à-vis public and private health concerns might influence adoption, while in the case of salinity the primary factor is usually the financial investments needed to prevent loss of farm land.

This chapter provides guidance on how to facilitate adoption of the technical solutions and risk mitigation measures presented throughout this publication, taking into account financial, environmental, social and regulatory-institutional adoption barriers and drivers. It also considers internal factors such as the need for behaviour change and external environmental factors such as policies or the availability of technology (Favin, Naimoli & Sherburne, 2004; Drechsel, Otoo & Hanjra, 2022).

The identification of driving forces and barriers to the adoption of MQW can facilitate the choice of existing risk mitigation measures or incentives tailored to the specific biophysical and institutional context as well as farmer's ability to invest. It also enables feedback for the design of required institutional policies, incentive systems or alternative technical options which could have better adoption potential.

This chapter therefore aims to provide a brief overview of drivers and barriers affecting the adoption of MQW by farmers. To this end, previous water reuse experiences provide insights and examples of site-specific factors affecting adoption decisions, following a basic conceptual framework (Figure 10.1). The framework is applied to the three scenarios of MQW adoption: (i) the use of reclaimed (safely treated) wastewater where freshwater is becoming scarce, (ii) risk mitigation practices where polluted water is already used in the absence of any alternative, and (iii) soil salinity mitigation measures.

**Figure 10.1. Conceptual framework of barriers and drivers to adoption**

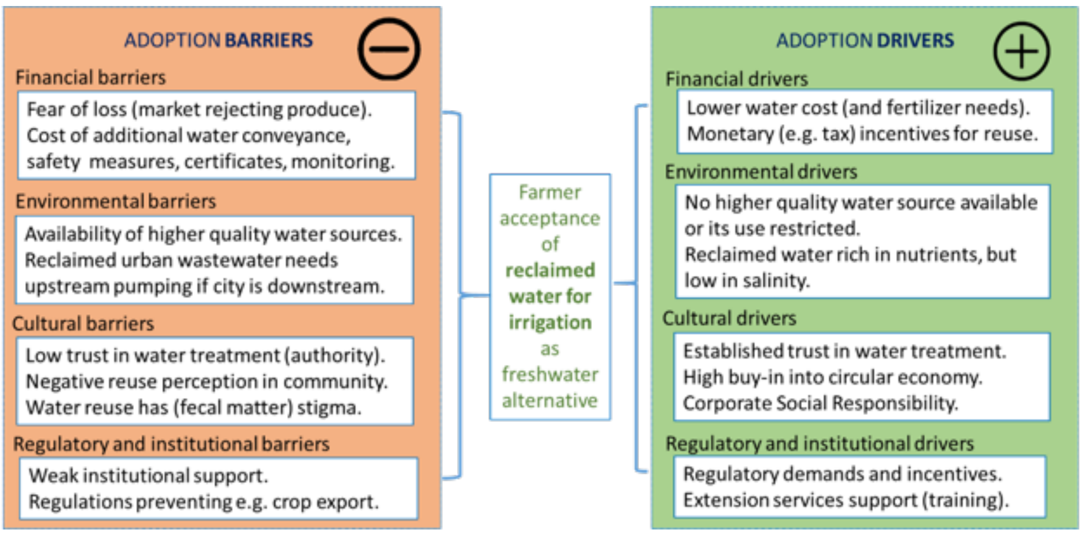



Source: Authors' own elaboration

### 10.1. Factors affecting the adoption of reclaimed wastewater as an alternative water source

Farmers' acceptance or rejection of well treated (reclaimed) wastewater is influenced by location-specific cultural, religious and socio-economic conditions, as well as water costs, the structure of irrigation networks and cropping patterns (Ganoulis, 2012). However, social factors have been recognized as the main challenges to more effective water management compared with technical factors (Ricart, Rico & Ribas, 2019). Moreover, reuse often offers non-market benefits which justify its implementation, as they exceed the average treatment costs (Alcon *et al.*, 2010, 2012). In many countries, adoption barriers refer to perceptions and can be overcome by designing proper awareness campaign or educational initiatives (Figure 10.2). The relationship between barriers to adopting reclaimed water and options to address them are described in the next sections.

**Figure 10.2. Adoption drivers and barriers for the acceptance of treated wastewater as an alternative irrigation water source**




Source: Authors' own elaboration

### 10.1.1. Financial factors

Where both freshwater and reclaimed water are available, farmers may opt to use reclaimed water only if it is offered at a lower price or free, the quality is unquestionable and its use is accepted by society. However, the willingness to accept reclaimed water is growing in line with water scarcity (Deh-Haghi *et al.*, 2020). In some instances, farmers are asked to release their freshwater rights for higher quality use (industrial and urban needs) in exchange for reclaimed water. In these cases, a higher volume obtained than released and the higher reliability of wastewater supply can constitute important incentives. Other possible incentives include subsidies for irrigation equipment or lower taxes linked to the adoption of a freshwater-saving alternative, drawing on mechanisms such as the Green Climate Fund.

Where reclaimed water is made available to farmers, the absorption of additional costs for water conveyance and monitoring must be agreed on between the provider and the farming community (Pistocchi *et al.*, 2018). However, as long as farmers have an alternative water source it will be difficult to charge them or the community for water treatment costs. On this basis, a comprehensive cost-benefit analysis is recommended (Alcon *et al.*, 2013; Winpenny, Heinz & Koo-Oshima, 2010) to determine the gains and costs for the different sectors involved.

### 10.1.2. Environmental factors

Where reclaimed water has a negative image, the most significant environmental barrier to its acceptance by any sector is the continuing availability of freshwater. In such contexts, MQW sources are deemed a viable alternative only when and where freshwater (surface and groundwater) becomes scarce and expensive (Drechsel, Mahjoub & Keraita, 2015). Another barrier can be the quality of the reclaimed water which might suit some reuse options (or crops) but not others. Where untreated wastewater should be replaced by treated wastewater, a particular challenge can be a preference among farmers for (nutrient richer and/or less saline) untreated wastewater (Hanjra *et al.*, 2018). Finally, providing farmers with wastewater can be topographically challenging and costly in pumping terms, especially where cities are situated in lowlands and farms upstream.

As reclaimed water can requires the introduction of alternative farm management practices, capacity-building programmes will be essential, for example to implement a water quality monitoring program.

### 10.1.3. Cultural factors

Cultural factors and perceptions play a dominant role in the adoption of reclaimed water. These may include religious considerations but are more often founded in (lack of) education and risk awareness vis-à-vis trust in alternative water sources. Interestingly, such negative perceptions are found more often in the community than among farmers (Ricart, Rico & Ribas, 2019) – and language can play an important role in this regard (Box 10.1). Other adoption criteria are more of agronomic or technical in nature, such as the compatibility of the reclaimed water with site-specific irrigation technology, soil and crop requirements. For example, wastewater may be saline and subsequent treatment (via pond systems) may increase its salinity further, which might not support crops grown for the local market. Conversely, the wastewater might have a significant nutrient load, allowing farmers to save on fertilizers (Drechsel, Otoo & Hanjra, 2022).

**Box 10.1. The role of language in the adoption of treated wastewater**
In any community programme, care must be taken to avoid the use of negative language and images that could stigmatize wastewater use, and instead identify and use locally appropriate language. For example, terms such as "treated wastewater" may hinder unbiased thinking and generate fear, stigma and disgust. Similarly, technical terms such as "reclaimed water" might not support adoption, while alternative terms such as "recycled water" may trigger more positive reactions (Ricart, Rico & Ribas, 2019). More terminological options should be explored in cases where the reclaimed water is augmenting freshwater and/or desalinated seawater.

There is a general consensus that to achieve widespread acceptance of planned wastewater use schemes, especially in a social environment with the power to influence implementation, it is important to ensure active public involvement from the outset – from the planning phase through to full implementation (USEPA, 2012; WHO, 2006). Public involvement begins with early contact with potential users and can involve the formation of an advisory committee, and public workshops on the rationale, benefits and risks of reuse. In addition to creating trust among farmers, the water source has to be accepted by the market. Thus, any awareness creation programmes must target the community at large, including consumers, with a view to addressing their concerns (Parris, 2011; Mateo-Sagasta & Turral, 2018). Media involvement and the use of positive language are key components as can be seen from the case of Jordan (Box 10.2). The Tunisian case study 7 in the annex re-emphasizes the importance of close stakeholder involvement for successful reuse projects.

**Box 10.2. Multi-media reuse promotion in Jordan**
Jordan succeeded in informing and convincing its population about the importance of wastewater use in agriculture by implementing an active educational campaign with strong community outreach. Key components included the dissemination of newsletters and guidebooks, the coverage of water issues in newspapers and on television and radio, dedicated websites, and the education of land-use decision-makers. In addition, targeted educational materials were distributed in schools, universities and libraries. As in Kuwait and Tunisia, religious concerns regarding the use of wastewater were expressed, but were not among the top reasons cited by farmers for their reluctance to use reclaimed wastewater for irrigation (Drechsel, Mahjoub & Keraita, 2015).

### 10.1.4 Regulatory, institutional and policy factors

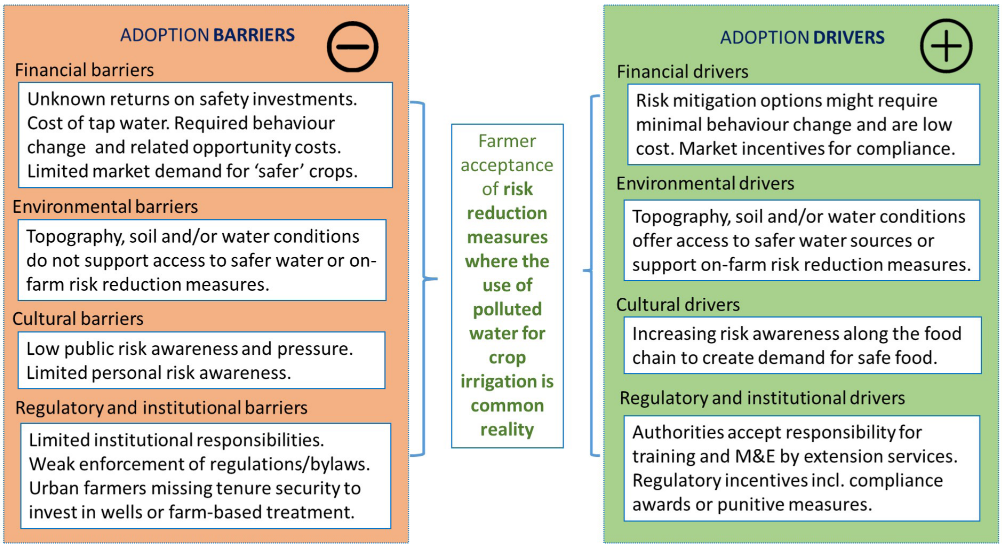
Political and regulatory norms affecting farmers can influence decisions around the adoption of MQW in several ways. These might include crop restrictions that have significant financial implications (Kampa *et al.*, 2011), or instruments such as tax havens, waivers on duties, subsidies or green tariffs that support the use of alternative water sources (Di Mario, Rao & Drechsel, 2018).

National or international water quality criteria for the use of reclaimed water must be adopted to monitor water quality. However, where crops might be exported, it is important to ensure compliance with the criteria in importing countries. International frameworks for water reuse and related quality standards (e.g. European Commission, 2019; Council of the European Union, 2020) can help creating common water quality reuse protocols.

## 10.2. Factors affecting the adoption of risk mitigation measures where farmers use unsafe irrigation water

In many urban and peri-urban areas of (mostly) developing countries, water bodies may be polluted to varying degrees, while constituting the only available irrigation source for thousands of farmers. In such regions not only are treatment capacities limited, but the level of risk awareness, institutional responsibilities and enforcement of public health regulations are often correspondingly low (Figure 10.3). In the absence of greater risk awareness among farmers and consumers, there will be little incentive to change business as usual. In fact, some farmers might be unaware of the pathogenic risks posed by unsafe irrigation water, instead considering the water rich in nutrients. Consequently, any attempt to implement the WHO-FAO-UNEP guidelines on risk reduction between farm and fork (WHO, 2006) e.g. based on the Sanitation Safety Planning manual (WHO, 2022) must start with increasing risk awareness at multiple levels. This includes institutional capacities, as "wastewater irrigation" is often an informal sector with limited institutional attention and support.

**Figure 10.3. Adoption drivers and barriers for the acceptancE of risk mitigation measures where irrigation water is heavily polluted due to the lack of wastewater treatment capacities**




Source: Authors' own elaboration

### 10.2.1. Financial factors

At the farm level, the adoption of safety practices promoted by FAO, such as drip irrigation, requires investments which farmers might not be able to afford. Additionally, cropping restrictions might have a significant impact on farm finances if there is no market for the permitted crops. Other changes in irrigation timing or watering practices might not have financial implications but require knowledge and behaviour change. Without appropriate risk awareness or a clear incentive, such behaviour change carries opportunity costs.

A central challenge for any safety investment on farms or by traders is the uncertainty of market demand from risk-aware customers, regarding their willingness to pay a premium for the extra investments needed to produce safer food. At present, public risk awareness is low, and the educated market is still too small to change production at scale. The main criteria for buying irrigated vegetables or fruits remain their appearance and low price, not their origin, type of water used or other food safety criteria (Keraita & Drechsel, 2015). This situation makes an integrated approach to awareness creation for both farmers and consumers essential or alternative strategies to change behaviour (see 10.2.3).

Another option for the government could be to invest at the community level in treatment facilities and sewerage networks, and to subsidize the additional costs faced by farmers to maintain irrigation safety standards via the (waste)water bill.

### 10.2.2. Environmental factors

Farm-based risk mitigation measures exist that farmers can adopt where wastewater treatment is absent; however, these are not generic and have site-specific limitations. For example, recommended crop species that pose a lower health risk to consumers might not grow locally, or recommended irrigation systems may not be supported by the slope of the terrain or the quality of the water (e.g. drip clogging). Recommendations must therefore be farm-specific and will require extension services trained in MWQ challenges and risk mitigation options (e.g. FAO, 2019) to facilitate adoption. The alternative use of safe tap water has cost implications, might be unreliable, and under increasing water scarcity also forbidden.

Where different water sources are available but none are sufficient, the joint use of MQW and clean freshwater can provide win-win scenarios in terms of quantity, quality and reliability.

Where technological solutions are adopted and water use is safe, positive externalities include reduced pressure on local freshwater resources and food production, and employment creation (Birol, Koundouri & Kountouris, 2010), which in turn generates important non-market benefits (Alcon *et al.*, 2010). In many areas, land-based water "treatment" by irrigating farmers might absorb more water than official treatment plants (Lydecker & Drechsel, 2010). Internalizing these externalities can help policies to support the investment in awareness creation and training, and incentivize farmers through result-based payments (Sidemo-Holm, Smith & Brady, 2018).

### 10.2.3. Cultural factors

Among cultural factors, (limited) health education and related risk awareness among farmers are critical factors for the adoption of safety measures. Limited risk awareness applies in particular to the common situation of farmers facing diluted wastewater (indirect use), compared to the use of raw sewage or situations where chemical contamination is visually evident. The lack of connection made between symptoms of potential illnesses and exposure are linked to the fact that farmers often explicitly grow crops for the market that they do not consume at home. As such, they do not experience the same illnesses as consumers, who in turn are rarely able to identify the source of their illness, let alone trace it back to a specific farm. To compensate for these educational gaps and circumvent the challenges involved in explaining invisible threats, such as those from pathogens, social marketing strategies or nudging could be employed to stimulate behaviour change (Drechsel, Qadir & Galibourg, 2022), for example by using triggers such as the "yuck factor" to induce hand-washing (Karg & Drechsel, 2011).

### 10.2.4 Regulatory, institutional and policy factors

Where national water reuse standards are available, they must be supported by wastewater treatment capacities able to generate water suitable for irrigation. As water may still be considerably polluted, even in cases of 90 percent secondary treatment, there is a need for regulatory bodies to monitor the irrigation sector and ensure compliance with risk reduction measures, and enforce water and crop quality testing. In the absence of national regulations, the US standards compiled by the United States Environmental Protection Agency (USEPA, 2012) or the World Health Organization (WHO, 1989) can provide guidance (see Chapter 3). However, in places where the required treatment is not feasible, the enforcement of standards – if actually possible - would result in irrigation being banned in many urban and peri-urban areas, affecting thousands of livelihoods and compromising the urban supply of highly perishable vegetables where cool transport from rural areas is not possible (Drechsel & Keraita, 2014).

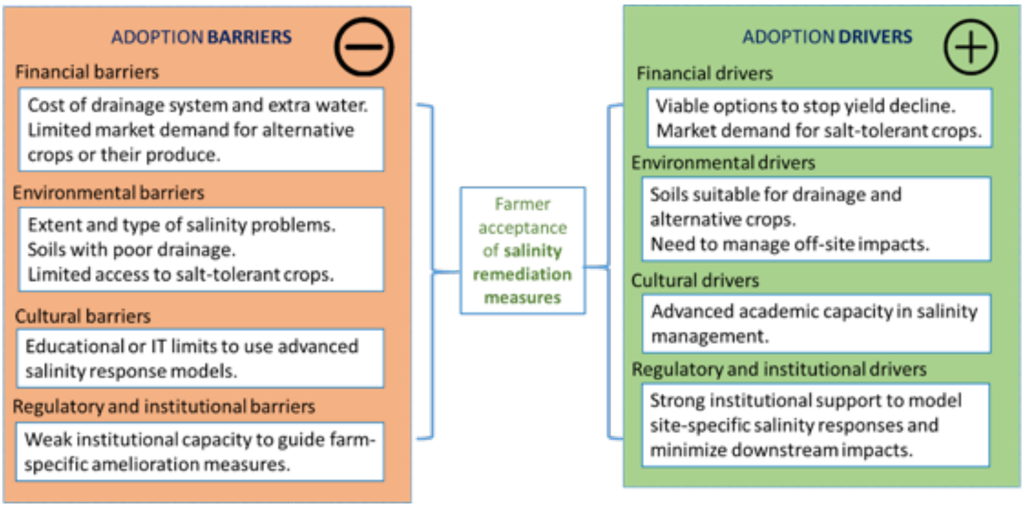
In 2006, WHO, in collaboration with FAO and UNEP, adopted a multi-barrier approach to address the widespread lack of wastewater treatment plants, a situation which makes it impossible to treat water to desirable quality thresholds. Rather than promoting water quality thresholds, the approach taken by WHO (2006) favours the promotion of multiple interventions (barriers) from treatment to farm to fork, which when implemented (ideally in combination) reduce significantly the health risks prior to food consumption (Amoah *et al.*, 2011; Mara *et al.*, 2010). The barrier approach has been adopted since then e.g. by the EU and ISO water reuse guidelines (see chapter 3). These barriers are based on stakeholder actions which necessitate at a minimum behaviour change and require related research into incentive options and institutional support. Training alone is unlikely to facilitate the required adoption of safety practices (Drechsel, Qadir & Galibourg, 2022).

Measures to support behaviour change can include access to credit, labelling, dedicated marketing chains, tax exemptions, the provision of extension services and awards, as well as restrictive regulations where these are enforceable. However, urban farmers often lack any type of land tenure security and can be expelled from their plots from one day to the next. Offering tenure security in such cases can be an appreciated incentive for the adoption of safety measures, like seeking safer groundwater. Labelling of food products in a manner that reveals safe farming practices will support a market response if accompanied by changing consumer risk awareness (Drechsel & Karg, 2013).

## 10.3. Factors affecting the adoption of salinity mitigation measures

Farmers whose land is affected by salinity have little choice but to adopt mitigation measures in order to avoid financial loss. Farmers are usually well aware of these risks, as salinity (compared e.g. to pathogens) is directly affecting them. However, no single universal mitigation technology is suitable for all soils. Prior to setting up a site-specific soil reclamation plan, it is therefore essential to review the available resources (farmer budget, availability and quality of water, etc.) and the reclamation and yield target objectives to suit the specific needs of the farm. Chapter 5 outline various salinity management options. The most promising interventions usually consist of a specific selection of crops and the leaching of salts out of the root zone. Figure 10.4 shows the typical barriers and drivers for the adoption of salinity mitigation measures, which in contrast to wastewater management have a much stronger off-farm or catchment dimension.

**Figure 10.4. Adoption drivers and barriers for the acceptance of salinity mitigation measures**




Source: Authors' own elaboration

### 10.3.1. Financial factors

The economic costs and benefits of reducing salinity can easily be quantified at the farm level. A key requirement is to optimize the management response in accordance with the nexus of biophysical and technical factors for a given size of land. The more factors the model can consider, the higher the probability of optimizing the drainage requirements and the related costs and benefits. However, more complex systems often come at a cost (e.g. software and hardware needs, service charges, education, etc.). This makes free access to advanced salinity management models with (ideally limited) data demands and a user-friendly interface (including for non-specialists) key factors to consider.

### 10.3.2. Environmental factors

Local site conditions determine to a significant extent the options available to farmers for salinity management. These range from the crops that can be grown to the success of drainage. In contrast to the management of wastewater-related risks, which aim at minimizing the contact between water and crop on farm, the management of salinity has significant off-site implications as the main management tool is to remove salts, with excess irrigation water from the rooting zone discharged off-farm through an appropriate drainage system. These downstream impacts on other irrigated fields, or ecosystems such as aquifers or wetlands, and the environment within each catchment area, have to be monitored and minimized (see below). In this context, payment of farmers for environmental services rendered could be associated to farm management practices based on the environmental benefits achieved.

### 10.3.3. Cultural factors

Compared to the "invisible" risks  of heavy metals or pathogens in wastewater, the need to raise awareness among farmers of soil and water salinity and related amelioration measures is low. The main cultural factor relates to education and access to advanced information to manage salinity, which requires in principal access to laboratory data and computers, and access to advanced soil-water models. Many such models are freely available and come with user-friendly interfaces and a broad range of parameters to minimize data needs (see chapter 5). Alternatively, well-trained extension officers can assist farmers with analysis to calculate optimal leaching requirements and the resulting economic benefits for different crops and soils.

### 10.3.4 Regulatory, institutional and policy factors

Institutional support to guide farmers in the best salinity management practices, crop choices and drainage requirements for their area is a key requirement in ensuring the most appropriate salinity response. However, salinity management is a catchment task and communities in many salt-affected areas have worked with the government and individual farmers on regional or basin-specific Water Quality and Salinity Management Plans to set salinity targets and to identify and promote sustainable land uses beyond the individual farm plots. This approach enables these communities to protect local groundwater and surface water resources, reinforce environmental values and, where possible, rehabilitate degraded environments. Water Quality and Salinity Management Plans require regulatory support for inter-institutional collaboration towards concerted and cooperative action where no central agency like a basin authority, is in place. Hart *et al.* (2020) share useful lessons from Australia.

## 10.4 Conclusions

The here presented framework covers key factors which commonly steer context-specific pathways towards improving water quality and the safe use of MQW. It tried to address the very different challenges resulting from water pollution versus salinity, or planned versus unplanned (but already existing) wastewater reuse. In line with Jiménez *et al.* (2019), the framework is emphasizing existing stakeholder capacities and engagement which will be important for participatory processes and the adoption of best practices. Related incentive systems will have to be location-specific and could include certification programs or subsidies financed e.g., through water pricing, or payments for food safety or ecosystem services (UN-Water 2015).

Finally, this discussion of the enabling environment did not dive into situations where water quality is negatively affected by farm management. These situations could be addressed, e.g. through reducing fertilizer subsidies or higher taxation of pesticides to reduce non-point pollution, or stricter monitoring of guideline compliance for point sources, such as the effluent from fish ponds or livestock barns. The capacity to monitor the improvement of water quality, soil salinity, produce safety or the compliance with performance objectives, will be in all here discussed scenarios or cases a quintessential component of the required enabling environment, while the monitoring can be limited to the most critical control points (WHO, 2022).

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