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# How Governance Regimes Shape the Implementation of Water Reuse Schemes

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**Abstract:** The governance dimensions of water reuse scheme development and operation, such as policies and regulatory frameworks, and public involvement and stakeholder collaboration, can serve to both facilitate and constrain wider adoption of water reuse practices. This paper explores the significance and underlying structure of the key governance challenges facing the water reuse sector in Europe. It presents empirical evidence from interviews and focus group sessions conducted at four water reuse schemes: an indirect potable reuse scheme at Torreele (Belgium), the urban reuse of treated municipal wastewater at the London Olympic Park (United Kingdom) and at Sabadell (Spain), and the reuse of agro-industrial effluent for irrigation at Capitanata (Italy). The findings underscore the importance of clarity in policy arrangements around water reuse, as well as of the financial competitiveness of reuse projects compared to alternative water supply options. Operators of water reuse schemes expressed a preference for water quality standards, which focus on appropriateness for use rather than over-emphasise the waters' origin so that unnecessary treatment and costs can be avoided. Positive public support was widely acknowledged as an important factor in the success or failure of water reuse schemes. We conclude that constructive institutional relationships underpin many of the challenges faced by reuse scheme operators and that greater emphasis should be given to building confidence and gaining trust in water service providers through early identification of how governance regimes shape the viability of new schemes.

**Keywords:** governance; policy; public participation; stakeholder collaboration; water reuse

## 1. Introduction

The world's freshwater resources are under growing stress, and alternative water sources are increasingly being considered as a strategic option to supplement water supplies and protect natural resources [1]. In particular, water reuse offers significant benefits to the integrated management of stressed water regions by providing a dependable alternative water source. An additional benefit of water reuse is reduced environmental pollution of receiving water bodies [2,3]. However, despite its advantages and development potential, the reuse of reclaimed water is to date not widely implemented in many countries.

The successes and failures of water reuse schemes around the world (in contrast with the drivers for such schemes) are shaped by complex interrelationships between technological, economic, and socio-political factors. However, it has long been recognised that the main challenges to more

effective water management are largely socio-institutional rather than technical, with institutional fragmentation, poor political leadership, unproductive intergovernmental relations, limited long-term strategic planning, and inadequate community participation compromising the promise of many innovative responses, including water reuse [4]. Assertions that these challenges are both substantive and significant comes from a variety of sources and have particular ramifications in Europe where regulations pertaining to water reuse schemes are poorly harmonized and often immature with fragmentation of responsibilities for different parts of the water cycle being a significant impediment to progress [3]. There are also insufficient price differentials between reused water and freshwater, exacerbated by a lack of full cost recovery for conventional water resources and a tendency for water reuse projects to be undervalued due to the failure to properly quantify the range of their benefits. Finally, negative consumer attitudes to reuse is considered a critical barrier to implementing successful (in particularly potable) water reuse projects [5] with the use of recycled water for high personal contact potential applications (e.g., drinking or bathing) attracting minimal levels of support from customers [6].

The challenge of developing or adapting governance frameworks to provide a supportive environment for the growth of water reuse applications whilst remaining protective of public health and the environment is a complex one. Although governance issues, such as policies and regulations, financing and pricing, stakeholder collaboration and public participation, are generally acknowledged to be important, there is little understanding of how they have influenced the planning and operation of implemented schemes in Europe. There have been noticeably few attempts to systematically ground assertions about the impact of governance issues in the experiences of operational water reuse schemes. Consequently, important empirical evidence of how these and other governance challenges manifest themselves in practice is scant. In addition, there is only limited systematic insight into the possible response strategies to the governance challenges being faced in operating water reuse schemes. Applying an historical lens, which draws out the detail and interpreted significance of governance experiences can greatly enrich our understanding, thereby helping the water reuse industry to anticipate and make more informed decisions in addressing governance challenges. We would emphasise that the focus here is not on the drivers for reuse schemes (which attract extensive commentary in both scholarly and professional circles) but rather on how the extant jurisdiction's legal, economic, financial, and regulatory rules and preferences moderate an opportunity space for the realisation of reuse scheme design, construction, and operation. The question being posed is: Assuming that water reuse is considered a reasonable option for water resource augmentation, what features of the operating environment serve to expedite or retard implementation of reuse projects and schemes?

In seeking to characterise how the specifics of the regulatory, financial, and administrative operating environments shape investment decisions in water reuse schemes we contribute to an emerging literature, which attracts subscriptions from a range of contexts. These have shown that the likelihood of successful scheme implementation (i.e., investment and operation) is enhanced by (inter alia) there being space for contractors, consultants, and project owners to (co)develop the design [7] and cross-cutting budget allocations being available to support capacity building, upscaling, procurement, and the establishment of both performance standards and end user markets [8]. In the context of water resource management, this programme of research has shown that changes in cultural beliefs for the water profession, new knowledge through evidence and learning, additional water servicing goals and priorities, political leadership, community pressure, better coordinated governance arrangements, and strong market mechanisms all help to legitimise, and smooth the path to implementation of, innovative solutions [9]. Perhaps unsurprisingly, lack of capital is frequently identified as a hurdle for large capital project implementation [10]. However, more ambitious investigations have exposed some nuanced dynamics across jurisdictional scales where a lack of communication between regulators and planners, and the absence of consistent financial evaluation methods have hindered scheme approval [11].

Information gleaned from four European water reuse schemes is used to extend and enrich these understandings. We are motivated by two ambitions here; to corroborate or challenge findings from previous studies (with all due consideration for context), and to improve appreciations of the range and relative influence of different features of the operational environment in shaping the experience of delivering water reuse schemes. These then are issues that are political in nature (to do with the governance of water services), but experiential in terms of the evidence base. Our data is the testimony of individuals who have played a role in scheme delivery. It is thereby coloured by perspective, circumstances, and the post hoc justifications that often come with the luxury of hindsight.

## 2. Methodology

The four reuse schemes whose development histories are used to populate the evidence base for this contribution come from four European locations: Torreele (Belgium), Olympic Park, London (UK), Sabadell (Spain), and Capitanata (Italy). It should be noted that we make no value judgments regarding the relative success of the schemes. They are all operational and, in their own context, have delivered on the objectives set for them. The schemes were selected to provide diversity of operating jurisdiction, for their maturity as full scale or pilot operations, the relatively large body of publicly available information available on their developmental history, and accessibility of key informants (Table 1).

**Table 1.** Characteristics of the wastewater reuse scheme cases.

Site	Reuse Application	Treatment Train	History
<b>Torreele (Belgium)</b>	Indirect potable reuse after artificial recharge	Ultrafiltration and Reverse Osmosis; Soil–Aquifer Treatment	Large scale, well established since 2002
<b>Olympic Park (UK)</b>	Urban reuse (toilet flushing, park irrigation)	MBR Membrane Bioreactor; Ultrafiltration	Investment for the Olympic Games (2012)
<b>Sabadell (Spain)</b>	Urban reuse (street cleaning, park irrigation)	Membrane Bioreactor; Ultraviolet	Aquifer recharge scheme since 2004
<b>Capitanata (Italy)</b>	Food crop irrigation	Membrane filtration; Ultraviolet	Pilot facility operating since 2012

Semi-structured interviews with key informants constituted the main form of data acquisition. A frame of reference for the interviews was generated through a literature review that revealed previously identified governance challenges affecting water reuse schemes. These challenges provided an agenda for data collection, which was formalised through an enquiry template comprising 20 sections, each consisting of several questions on issues such as motivational factors, EU policy and legislation, overarching policy/strategy for water resources (national or regional), quality standards, monitoring and reporting, rules, financing and pricing, stakeholder collaboration, customer engagement, and public participation. Our approach to the interviews followed guidance found in Berg [12] with questions posed in a systematic and consistent order, while at the same time allowing space to ask additional questions to stimulate more mindful and considered responses. We recognise that the semi-structured interview as a fact-producing interaction can be seen as simply generating socially produced perspectives, but would argue that responsibly engaged researchers can elicit perceptions that respondents would otherwise think irrelevant or, in their normal social context, feel inhibited from mentioning [13]. In addition, focus group meetings with users of recovered water (citizens, farmers) were conducted. The focus group members represented a good spread of age, gender, profession, location/region, and education. The unique property of focus groups is that participants not only respond to the researcher's questions, but also react to each other. This process of sharing and comparing ideas and experiences among participants often produces data and insights that would be less accessible without the interaction found in a group [14].

Judgement sampling was used to identify a keynote individual in a senior position at each scheme with snowball sampling used thereafter to access additional respondents. Target respondents included scheme operators, recovered water users, and governance/regulatory bodies. Interviews were conducted either one-to-one or in a group setting (Table 2). Interviews and focus groups lasted 60–90 min and 1.5–2 h, respectively, were conducted in the local language and were either recorded or notated for subsequent analysis. Results were summarised in an interview report which interviewees were invited to review and approve, after which a qualitative thematic analysis was executed generating a detailed case description. Content analysis was adopted as the major form of transcript investigation. Unlike other options, this approach, when applied in a systematic (perhaps even orthodox) form, has a solid theoretical basis in the communicative sciences and allows for a degree of inter-subjectivity through the procedure, helping to make it possible for others to reconstruct or repeat the analysis [15]. A mix of deductive (using classes from the literature review mentioned above) and inductive approaches was deployed, adopting guidance on the use of such a hybrid analysis outlined in Fereday and Muir-Cochrane [16].

**Table 2.** Details of conducted interviews and focus groups.

Site	Number of Interviews and Focus Groups	Participants
<b>Torreele (Belgium)</b>	Five individual interviews	Water services supplier: general manager, operator, researcher/geologist
<b>Olympic Park (UK)</b>	One group interview	Water services supplier: six participants (commercial projects delivery manager, commercial operations manager, treatment plant technician, senior research scientist, water reuse project manager, water innovation manager)
<b>Sabadell (Spain)</b>	Two individual interviews	Water services supplier: director department of sanitation and new water uses Catalonian Water Agency: director of water supply department
	One focus group	Citizens: 13 participants (6 men, 7 women)
<b>Capitanata (Italy)</b>	Two individual interviews	Food company CEO Food processing company: quality assurance manager
	Two group interviews	Research institutions: 11 participants Regional institutions and authorities: 17 participants
	Two focus groups	Citizens: 12 participants (3 men, 9 women) Farmers: 12 participants (6 traditional, 4 organic farmers, 2 plant-breeders)

### 3. Governance Challenges of the Four Water Reuse Schemes

The following sections report on the relative significance of different governance issues in shaping the successful implementation of water reuse schemes. Results are structured by site so as to provide a useful basis for comparison.

#### 3.1. Indirect Potable Water Reuse at Torreele

The Torreele water reuse scheme, located on the south-west coast of Belgium, produces infiltration water from wastewater effluent for indirect potable reuse through artificial recharge of a dune aquifer. Since 2002 the effluent from the municipal wastewater treatment plant at Wulpen has been reclaimed, via the dune system, at the Torreele water plant. The project was financed by the drinking water company who are strong promoters of self-sustaining water supply systems. The production of drinking water derived from reuse is cheaper than the cost of importing water from neighbouring areas.

The plant has a treatment capacity of 2.5 million m<sup>3</sup>/year and applies a double membrane process: ultrafiltration (UF) and reverse osmosis (RO). After artificial recharge of the reclaimed water in the dune aquifer, the extracted groundwater is used to produce potable water for nearby communities.

Currently about 40% of community water consumption is derived from reuse. The natural groundwater extraction has been reduced by 30% or 1 million m<sup>3</sup>/year. As a result, the groundwater levels have increased, thereby enhancing the natural value of the dunes and preventing saline intrusion [17].

As no policy, regulation, or guidelines were in place during initial scheme planning, the start of the Torreele water reuse project was very time demanding. Scheme licensing was a particular challenge as the licensing and permits system is not tailored to reuse schemes and the specific requirements set by the regulator for ecological quality proved to be difficult to adhere to. The drinking water utility developed a bespoke set of quality standards for infiltration water due to the sensitive environmental nature of the dune area to be recharged, which they proposed to the environmental regulator. The fact that the Torreele water plant provides infiltration water of a quality better than delivered drinking water helped greatly in gaining confidence from both government and the public. Respondents noted that standards make things transparent: a requirement that can be measured and reported.

The drinking water utility considers itself to have a high level of collaboration with their governmental stakeholders, such as the Flemish Environment Agency. These relationships are seen as invaluable in the context of permitting procedures. They also have a good relationship with the Agency for Nature and Forest, with the aquifer recharge plan being considered an important component of the ecological management plan for the dunes. Effective collaboration between the drinking water and wastewater treatment operators was also identified as a valuable feature of the scheme, with interviewees from the former in particular commenting on the high levels of confidence that they have in the latter's operations and quality control procedures. Online sharing of water quality information between the two organisations ensures that any irregularities in wastewater effluent quality can be addressed rapidly. A surprising finding from these interviews was that no official contract or agreement exists between the wastewater and drinking water service providers, which covers the quantity and quality of the effluent.

The securing of public trust in the reuse scheme through information provision is widely recognised as a major success of the Torreele scheme. The drinking water company firmly believed that negative public perception of the scheme would have been a major impediment to the securing of necessary permits. Therefore, from the start of the planning period, the approach was to inform the public and be transparent so that trust could be gained. A visitors' centre was built to present the objectives and results of the reuse project, and to the same end, open days and guided tours are organised frequently.

### *3.2. Urban Water Reuse at Olympic Park*

The Old Ford Water Recycling Plant is located on the Queen Elizabeth Olympic Park in London, the site of the 2012 Olympic Games. It is currently the UK's largest community-level wastewater recycling scheme. The plant mines wastewater from a nearby outfall sewer, treats it to a non-potable standard (using membrane bioreactor and granular activated carbon), and feeds it into a dedicated distribution network that supplies several venues on the Olympic Park. The water is used primarily for toilet flushing (in commercial venues such as the velodrome) and urban landscape irrigation.

The lack of wastewater reuse regulations at the national level presented a significant challenge for the progress of the Old Ford scheme resulting in drawn out negotiations to seek approvals and/or regulatory positions from a variety of regulatory bodies. In terms of water quality requirements, in the UK there are legislated water quality standards for potable water only, although there are guidelines for non-potable water quality (specifically from rainwater and greywater systems). The water quality standards used at the Old Ford scheme initially mirrored the US Environmental Protection Agency recycled water quality guidelines for 'unrestricted urban use' applications. Because the Old Ford scheme includes a dedicated distribution network along with dual reticulation systems at point of use, the national Building Code regulations also apply. These accept the inclusion of alternative water sources for non-potable purposes, and in that sense have been instrumental in developing the reuse scheme.

Throughout the development of Old Ford, there was extensive engagement with regulators, namely the Environment Agency and Public Health England. The operator undertook extensive consultation with customers (primarily the Olympic venues and landscape irrigators) throughout the design and implementation phases. Customer views had a significant impact on the implemented quality standards, which had knock-on effects on overall scheme design and the treatment train used. However, there was no direct engagement with the general public through the design and implementation of the scheme. Once the scheme was in place, it was used for public outreach and to gauge public reactions to reuse schemes. A study of public receptivity to the scheme found that levels of support were quite high, which highlights the potential of using high profile events (like the Olympic games) to showcase such reuse practices.

The scheme was made possible through the funding available as a result of the Olympic Games. The price of non-potable water from Old Ford remains subsidised, charged at 90% of the cost of potable water. While these tariffs do not cover the real cost of producing the water, it was felt that customers would not accept a higher charge for what they perceive to be lesser quality water. Respondents noted that the high levels of treatment at Old Ford were pushing up the real cost of the product water.

### *3.3. Urban Water Reuse at Sabadell*

The Sabadell reuse scheme, located within the metropolitan area of Barcelona, is linked to the Riu Sec wastewater treatment plant. The tertiary treatment plant has a design capacity of 2500 m<sup>3</sup>/h and features flat-sheet membrane bioreactors and a disinfection step based on UV irradiation and hypochlorite dosing. The wastewater treatment and reclamation plant was constructed at a cost of €15M of which 65% was funded by the European Cohesion Fund, 20% by the City of Sabadell, and 15% by the Regional Government of Catalonia. Regenerated wastewater is currently used for urban purposes in Sabadell, mainly in commercial areas (flushing toilets), street cleaning, public parks, and private garden irrigation. A separate distribution network has been constructed for urban reuse in commercial areas.

The principal motivation for reuse derives from the challenge of water scarcity. Sabadell is a demonstration site that aims to show that the reuse scheme is safe for public health. The subject of public perception concerning the risk to human health is an important barrier to be overcome. Both local administrative and general public confidence must be built and consolidated. However, so far the general public has not been involved in the development and progress of the Sabadell reclaimed water scheme. In the focus group meeting, citizens expressed a positive attitude towards water reuse for a large range of practices, such as irrigation of green areas, industrial uses, street cleaning, and some domestic use (e.g., toilet flushing). In fact, the citizens felt the government ought to make water reuse mandatory in some sectors (businesses and new houses) to limit fresh water use.

The water service provider to Sabadell sought to involve both the City Council of Sabadell and the Catalonia Water Agency (ACA) in the development of the reuse plan. The City Council created a municipal by-law regulating the use and efficiency of water in Sabadell citing a number of European policies such as the Water Framework Directive. ACA has the power of authorisation over water reuse schemes and is the organisation responsible for licencing operations. ACA studies each individual case following general criteria established for treatment plants. Interviewees consider the technical levels established by existing regulations correct with the exception of indicators relating to groundwater infiltration, which they believe to be exaggerated. Moreover, the frequency of analysis, monitoring and reporting demanded is viewed to be unnecessary, and totally unfeasible for the capacities of small wastewater treatment plant operators.

### *3.4. Water Reuse for Irrigation at Capitanata*

The water reuse scheme in Capitanata is located close to the town of Stornarella in Puglia, a region known for its water scarcity. The site is located within the property of Fiordelisi, an agro-industrial company specialised in the production of sun-dried and semi-dried vegetables, such as tomatoes.

The wastewater treatment plant at Fiordelisi treats wastewater from the industrial processing of vegetables (washing, conditioning, cooking, etc.), and has been upgraded with a tertiary membrane filtration system. The reclaimed water is used for the irrigation of food crops (e.g., tomatoes) on test fields owned by the same company, where an on-line UV disinfection system has also been implemented. The treated volumes strongly depend on the production processes but are about 300 m<sup>3</sup>/day on average.

Recovered water users indicated that they are content to use what is effectively an experimental reuse scheme because they are sensitive to the problem of drought and the need to invest in alternative sources of (irrigation) water. At the same time, however, they acknowledged that the cost of delivered water is the defining consideration. All stakeholders involved in the Capitanata scheme unequivocally pointed out that, as long as the costs for other sources of water are lower compared to the costs of recycled water (which currently is the case), the demand for recycled water will remain very limited.

Italy has specific water quality regulations and standards for non-potable water. Some parameters have limit values similar to those designated for drinking water, even if the reclaimed water is used for irrigation purposes. The Italian threshold values, with regard to microbiological contamination levels in particular, can be considered highly restrictive [18]. The representatives of local research institutions argue that the current limits are unnecessarily strict and would welcome limits based on the specific application of recycled water. Interestingly, policy makers also argue for less strict and (cultivation) specific standards, albeit from an economic point of view. Less strict and rigid limits could reduce the costs of recycled water, and thus stimulate demand.

Bureaucratic complexity and the lead time for acquiring permits for regular activities such as wastewater treatment, disincentivises investment in, and experimentation with, innovative technologies, such as water recycling schemes. Fragmentation was also noted as a significant problem, one that only seems to worsen with time. For instance, when it comes down to the preparation of the management plans for wastewater treatment plants, the great variety of actors that has to agree (municipalities, regional agencies, the province, consortia etc.) results in a lack of action and decisions. According to various policy makers, the problem is not so much that there are various parties/agencies with their own roles and responsibilities; the key problem is the lack of coordination and unified planning.

An additional difficulty in this particular governance environment is the fact that despite the current regulations, and despite the monitoring and control systems in place, there is a distinct lack of trust amongst end-users and the general public towards the use of reused water. It was also suggested that the region's water management arrangements (both the water utility and the environmental control agency operate under the public territorial authority Regione Puglia) may undermine trust, as it feels like auditors marking their own papers.

In the Capitanata project no processes of public participation are taking place. The scheme operator has not actively engaged with customers of their products, even though our study did show that one of their key customers, a food processing company, believes that the use of reclaimed water (eventually) may be used for marketing purposes. Just as some consumers are willing to pay extra for organic food, they foresee a potential market for food produced with renewable energy and recycled water. The farmers in the focus group, however, do not believe that consumers will perceive products irrigated with reused water as better or as more likeable products. In their view, the agricultural use of recycled water may only be successful if the quality of the water as well as the final product is guaranteed and certified, and if the switch to recycled water is accompanied by a comprehensive communication plan to raise public acceptance of recycled water. Also, the citizens that participated in the focus group meeting believe that a very important precondition for the eventual success of water recycling is a well-functioning system of guarantees and certification.

#### 4. Discussion

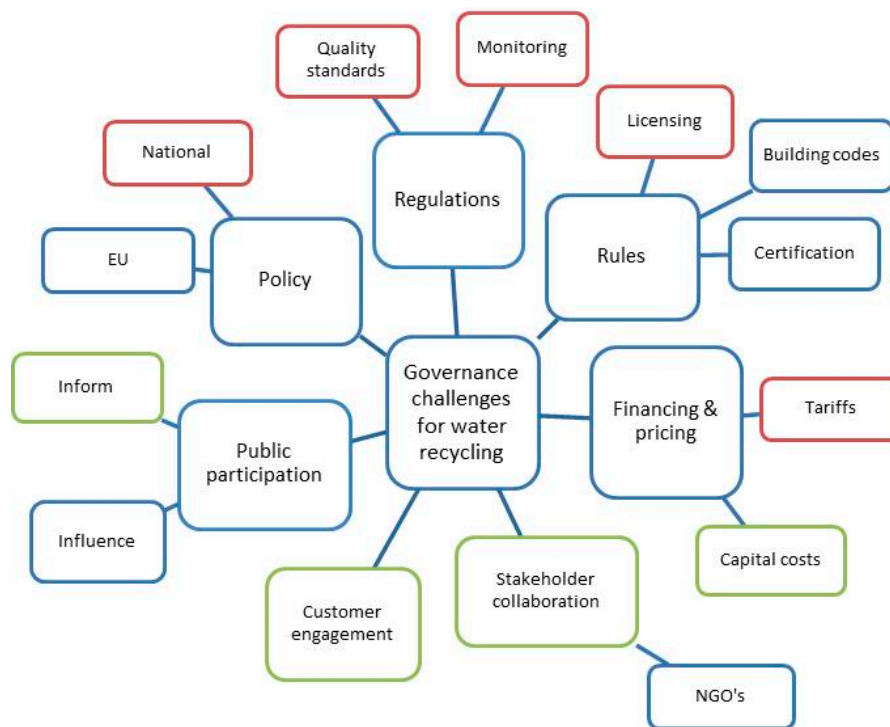
The data acquired from the four schemes is summarised in Table 3 which lists those features of the operating environment that have been observed to enable or constrain the realisation of each scheme. Figure 1 shows an overall ‘governance issues map’, indicating the current enabling and constraining factors in the studied schemes. As subsequently discussed, many of the observations provide nuance and further distinction to previously reported phenomena whilst others suggest new foci for scheme developers to be mindful of.

**Table 3.** Enabling and constraining governance features.

Site	Enabling Features	Constraining Features
<b>Torrelele (Belgium)</b>	<ul style="list-style-type: none"> <li>• Availability of investment funds from the water supplier itself.</li> <li>• Information dissemination to promote public trust.</li> <li>• Significant time and effort invested into building trust and reaching consensus with regulators and other authorities.</li> <li>• Standards and reporting on water quality helped convince the authorities and public that the scheme is safe and environmentally favourable.</li> </ul>	<ul style="list-style-type: none"> <li>• Absence of specific regulations at the start of the project made the planning of the scheme and permitting procedure very time demanding.</li> </ul>
<b>Olympic Park (UK)</b>	<ul style="list-style-type: none"> <li>• Availability of capital financing.</li> <li>• Extensive engagement with customers throughout design and development process.</li> <li>• Existence of a Building Code, which allows for the incorporation of a non-potable water distribution system.</li> </ul>	<ul style="list-style-type: none"> <li>• Lack of regulatory clarity on the approval and governance of reuse schemes (i.e., on quality standards and roles and responsibilities of different stakeholders).</li> <li>• Relatively high cost of producing water at the plant.</li> </ul>
<b>Sabadell (Spain)</b>	<ul style="list-style-type: none"> <li>• EU funding instrumental in establishing the scheme.</li> </ul>	<ul style="list-style-type: none"> <li>• National policy and regulations hindered the development of the scheme (i.e., unrealistic frequency of monitoring and reporting, and the slow and cumbersome licensing process).</li> </ul>
<b>Capitanata (Italy)</b>	<ul style="list-style-type: none"> <li>• Research grants available to subsidise build, operation, and (in particular) monitoring.</li> </ul>	<ul style="list-style-type: none"> <li>• Water quality standards for recycling considered too strict.</li> <li>• Cost of the produced water is too high compared to alternative water sources.</li> <li>• Fragmentation, bureaucratisation, and a lack of decision-making capacity.</li> </ul>

These findings highlight the potentially damaging role that lack of regulatory clarity, overly stringent quality standards and monitoring requirements, demanding licensing process, and the high relative cost of producing water through reuse can have on the planning and implementation of water reuse schemes. They also re-emphasise the productive role which long-term stakeholder collaboration, extensive customer engagement, and providing public information can have on scheme success. Below, we discuss how constructive approaches to each of these governance dimensions could be fostered through a variety of site-specific interventions and mechanisms, which could be implemented at a range of administrative scales.





**Figure 1.** Overall governance issues map—current constraining (in red) and enabling (in green) factors in the studied schemes (NGO's = non-governmental agencies).

#### 4.1. Setting Realistic Policy Requirements

In Europe, regulatory frameworks for water reuse (where they exist) vary significantly between countries. Some EU member states have implemented regulations for water reuse largely based on water quality requirements, but mechanisms and experiences of implementation have varied significantly. It has long been argued that growth in the European water reuse sector would be better supported by clearer institutional arrangements, as well as the development of pan-European guidelines for the development and operation of reuse schemes [19]. The EU has committed itself to developing new governance arrangements for reuse. As such, the establishment of European legislated water quality criteria for reuse schemes is being considered [3]. While many argue that the lack of such criteria has been a barrier to growth in the reuse sector, it has also been recognised that legislated quality criteria can actively hinder reuse schemes if they impose overly burdensome treatment and/or monitoring requirements [20]. The challenge is to compromise between excessive precaution and insufficient safety in developing regulations [1]. The findings from Sabadell and Capitanata suggest that the development of water reuse schemes benefit from the existence of water quality standards and monitoring requirements that are based on the application of the reuse scheme (i.e., standards based on water quality judged according to its appropriateness for use and not its origin). A risk management approach could offer more flexibility than a water quality standards based approach in accommodating different reuse applications. Such a risk management based approach could be operationalized through a Water Reuse Safety Plan [21].

In the focus groups with citizens in Sabadell and with farmers and citizens in Capitanata, there was strong support for the idea that recycled water (both potable and non-potable) should have some independent certification of its quality. While there were also some concerns raised about the trustworthiness of such certification (based on similar concerns regarding the certification of 'organic' food), overall it was felt that it could help alleviate public fears around consuming food irrigated with recycled water. Whilst respondents were generally vague in suggesting who should provide such certification (e.g., 'health officials'), this nonetheless aptly illustrates the potential

importance of ‘intermediary’ actors, who provide independent review and approval, in strengthening the legitimacy of water reuse schemes, as argued by Binz et al. [22]. As one respondent stated: “*Citizens do not want to look at the quality of the water, they want to trust someone who validates it*”. Even where there are dedicated reuse policies in place and where governments have established clear targets for expanding the uptake of reuse, many schemes still struggle and reuse targets can go unmet [23]. Regulations should go hand-in-hand with a supportive institutional framework. The findings show that governance arrangements at national and regional levels are a significant concern—regulatory gaps and fragmentation of responsibilities (e.g., between environmental discharge and water abstraction regimes) present significant challenges.

#### 4.2. Ensuring Economic Viability

As the economic viability of a water reuse scheme is obviously a precondition for its operation, overly stringent standards and very demanding regulatory approval processes can quickly turn an economically viable scheme into a loss making enterprise. The data from the Olympic Park and Capitanata schemes confirm this risk. The costs of regulatory compliance are not insignificant and the monitoring processes that underpin compliance are an integral part of scheme design. Consequently, ambiguity or prevarication over standards setting (whether design or operational) will drive the costs of compliance up as operators either over-engineer monitoring procedures to compensate for uncertainty or delay investment until regulators have confirmed their requirements.

The focus groups with citizens both in Capitanata and Sabadell indicated that they would generally be unwilling to pay an equal or greater amount for reused water (whether potable or non-potable) that they perceived to be of lesser quality. In this way, water reuse can potentially suffer from an association with ‘recycling’. As one respondent pointed out, while many recycled products have a “higher ethical value”, this does not necessarily translate into a higher economic value because such products are commonly thought to be of poorer quality than non-recycled counterparts. This creates an expectation that recycled water (as well as, potentially, food products irrigated with recycled water) should be cheaper.

The economic viability of reuse schemes can be improved by facilitating access to capital financing for new schemes, and allowing for the recycled water tariffs to be competitive with other sources of water. To this end, it could be beneficial to perform proper economic analyses that take all the benefits of water reuse into account. Careful financial planning and more accurate pricing, inclusive of externalities, will help show the economic benefits of water reuse schemes.

#### 4.3. Improving Stakeholder Collaboration and Public Acceptance

Our results suggest the importance of wisely designed and facilitated interactions between the owners and operators of water reuse schemes and their regulators, their customers (particularly for non-potable schemes), and the general public. Long-term collaboration with stakeholders and customers contributes to reaching consensus with the (local) authorities and involved stakeholders, and engagement with the users of recycled water (e.g., farmers), both enabling the water reuse scheme development. In particular, the investigations reported above highlight the importance of public acceptance. In the case of Capitanata, the farmers and consumers are largely unaware of the advantages of water reuse, the quality and safety of reclaimed water, and the environmental need to search for alternative sources of water. For the citizens in the Capitanata focus group, it is clear that awareness of the problem is essential for the public to eventually accept the indirect, let alone direct, consumption of recycled water. They suggest that education campaigns and promotion activities may be needed to (re)create this awareness as well as to overcome the prejudices related to recycled water. Indeed, customer engagement and public participation is an important means to overcome this problem.

In the case of Torreele, the water company has taken great care to inform the public correctly, and public acceptance proved to be a key factor in achieving success. Public acceptance of recycled

water is influenced by several factors, including the trust in providers and policy makers, knowledge and information, previous experience with alternative water sources, impersonal and interpersonal contacts, and the control people perceive to have [6,24,25]. Improving public understanding is a key factor in the success of water reuse schemes [26,27]. The vast majority of participants in the focus group meetings underlined the importance of a comprehensive communication plan to raise public acceptance of water reuse. According to them, communication should not only focus on the solution (water reuse), but also on the underlying problem (water scarcity), and communication ought to address the perceived health risk, but also include positive messages about cost savings and environmental benefit. The use of more active public engagement methods was suggested, such as site visits to water recycling facilities and water tasting events to expose people to different water types (mineral, tap, reclaimed).

Some participants, however, felt that a high level of transparency regarding the technical aspects of a reuse scheme, such as treatment processes and/or water quality testing, was potentially counterproductive. They felt that inundating the public with large amounts of technical information could foster confusion, misinterpretation, and paranoia. Other participants felt that it was important for owners/operators of reuse schemes to be as transparent as possible, and to provide the public with as much information as possible. They felt that withholding information could create suspicion and undermine public trust. These conflicting opinions and expectations echo the pervasive uncertainty in the literature about, for instance, the role of information and knowledge in shaping public reactions [28], or the potential impact of providing factual information to different audiences [29].

In any case, a well-conceived and implemented communication campaign is needed to garner public acceptance. Effective communication with stakeholders is of crucial importance for water reuse initiatives to be successful [30]. Although, except for a few key messages that are always important, such as “water is always reused”, there is no silver bullet when it comes to the structure and content of information messages on water reuse, an understanding on the perceptions and concerns of the target audience is a precondition for an effective communication strategy, as the messages need to be tailored to each specific group of stakeholders.

It is, however, important to look beyond information provision. Simply improving the public’s knowledge of water reuse is not necessarily a key driver of acceptance. Instead, mechanisms that focus on building trust are valuable [25,31,32]. Public support for water reuse is fundamentally influenced by trust, including trust in the technical process and regulation, trust in the water reuse organisation itself, and ultimately, trust in the quality and safety of the final product, reused water.

## 5. Conclusions

The findings from this study underscore the importance of improved clarity in policy arrangements around water reuse, as well as the financial competitiveness of reuse projects compared to traditional water supply schemes. We would note that these two aspects are closely interrelated, since a highly complex regulatory approval process can significantly increase the overall cost of a scheme. It was acknowledged that legislated European water quality standards for reuse could help improve clarity, and in general such standards were viewed favourably across all four schemes. However, the risk of such standards imposing unnecessary treatment and burdensome monitoring requirements is a significant concern. In line with this, our data suggests a desire for quality standards to be developed with a very high degree of granularity between different schemes types and different applications.

Our results also show the importance of public involvement from the start of the planning of the water reuse scheme, including the provision of accurate information on system performance, benefits, and risks. Another important component in achieving public acceptance of water reuse is building trust in water service providers. Importantly, operators see effective regulation and monitoring as an influential factor in gaining public confidence in reuse schemes.

The need for constructive relationships across institutional stakeholders is the dominant theme of this study. This is not a novel finding as others have highlighted the desirability of

combined strategies for reuse scheme design and implementation. The particular emphasis placed by respondents on regulations and monitoring does, however, provide a sharper focus for this debate. These considerations can clearly trigger secondary challenges around public trust and confidence in reuse schemes and also compromise economic viability. Water reuse schemes are complicated in governance terms, as they often span the jurisdictions and responsibilities of multiple regulatory, licencing, and administrative bodies. The resulting fragmentation of authority and function makes early mapping of the governance landscape (in terms of what requirements are to be made of the scheme operator) an imperative precursor to the growth of trust and confidence.

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