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Governing Non-Potable Water-reuse to Alleviate Water Stress: The Case of Sabadell, Spain

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Abstract

The world will experience an estimated 40% freshwater supply shortage by 2030, converting water scarcity into one of the principal global challenges that modern society face. Urban water-reuse is recognized as a promising and necessary measure to alleviate the growing water stress in many regions. The transformation to widespread application of water-reuse systems requires major changes in the way water is governed, and countries such as Spain already find themselves involved in this process. Through the systematic assessment of the city of Sabadell (Spain), we aim to identify the main barriers, opportunities and transferable lessons that can enhance governance capacity to implement systems for non-potable reuse of treated wastewater in cities. It was found that continuous learning, the availability and quality of information and level of knowledge and strong agents of change are the main capacity-building priorities. On the other hand, awareness, multilevel network potential and implementing capacity are already well-established. It is concluded that in order to undertake a widespread application of water-reuse practices, criteria examining water quality according to its use need to be developed, independently of the water's origin. The development and implementation of such a legislative frame should be based on the experience of local water-reuse practices and continuous evaluation. Finally, the need for public engagement and adequate pricing mechanisms are emphasized.

Keywords: Water-reuse – Governance Capacity – Water Management – Water Scarcity

1. Introduction

Approximately four billion people experience severe water scarcity during at least one month per year, while over 500 million people face severe water scarcity with a water consumption exceeding the renewable resources by a factor of two or more [1]. The agricultural sector is responsible for 70% of the world's water consumption whereas industry and municipalities withdraw 19% and 11% respectively. However, Hoekstra *et al.*, 2012estimate that agriculture accounts for up to 92% of the global urban water footprint [2]. Large increases in freshwater demand can be expected in the next decade, particularly for industrial production in urban areas [3]. These developments are estimated to lead to a 50% increase in water demand in developing countries by 2025 [3] and a 40% freshwater supply shortage worldwide by 2030 [5]. A wide plethora of factors including, Population growth, diets shifting towards water-intensive foods such as meat, groundwater depletion, and salinization caused by unsustainable irrigation, as well as saltwater intrusion and sea level rise, further increase the pressure on freshwater resources [1-7]. The

impact of water scarcity is expected to lead to substantial unemployment. In particularity water-dependent labour in arid and semi-arid areas – 95% of which are agricultural jobs – will be affected. This type of unemployment may lead to food insecurity and social instability that could trigger large scale involuntary migration towards cities and across continents [8]. The social, economic and ecological risks of water scarcity – in particular large-scale involuntary migration, water-crisis, extreme weather events, and failure of climate change mitigation and adaptation - are also identified as the top global risks by the World Economic Forum [9]. These risks urge for water-use efficiency and water-reuse.

Wastewater is increasingly being considered, a largely untapped resource for freshwater and raw materials that can alleviate water stress [6]. At present, high-income countries treat 70% of their wastewater, upper-middle-income countries 38% and lower-middle-income countries 28%. Only 8% of the wastewater in low-income countries undergoes any kind of treatment [10]. Altogether, this means that an estimated 80% of the wastewater is released into the environment untreated [6] which leads to eutrophication, biodiversity loss and can threaten drinking water, fisheries, aquaculture and tourism [11]. Furthermore, untreated wastewater is often used for irrigation practices. Reusing treated wastewater therefore has a large potential to alleviate water stress. Moreover, since 80% of all wastewater is not treated, many Waste Water Treatment (WWT) systems have yet to be built. Thus, WWT systems and reuse systems may be a promising solution package to improve public health, reduce water pollution and alleviate water scarcity in particular in water-scarce urban regions.

The European Commission has recognized the untapped potential of treated wastewater, and has called for "closing the loop" through a circular economy approach [12]. It recognizes and enables the reuse of wastewater as a safe solution to reduce water demand. From the total reused tertiary treated water only 2.3% is for potable purposes whereas most water is reused for irrigation (52%), industry (19.3%) and non-potable urban applications (8.3%) [13].

In order to reduce water stress by a wider application of wastewater-reuse practices, major changes are required in the way the water cycle is governed at the local, regional and national level. Spain is in the middle of such a transformation process where various multi-level governance barriers and challenges emerge [14]. Current water management structures, people's expertise and investments are largely based on challenges faced in the past and typically create a path dependency, i.e., lock-in, that impedes the adoption of new approaches [15-16]. Increasingly though, well-organised structures and interdependencies amplify existing rules and routines to address narrowly defined problems [15]. However, the initial gain in efficiency is often offset by inflexible structures that prevent learning and adaptation to changing situations such as increasing water stress [16]. In order to overcome such barriers and cope with increasing water consumption in conjunction with climate adaptation [17-18-21] an adequate governance capacity is required. There are multiple definitions of governance capacity. However, a few common traits can be defined [22]. First, capacity refers to the ability of actors to jointly act in the face of collective challenges. Second, capacity is the product of actors' interaction that is influenced by the socio-institutional setting. Third, actors' values, culture and interests shape their interactions and influence collective problem-solving. Accordingly, we apply the definition of Koop et al. who defined governance capacity as '*a set of key governance conditions that should be developed to enable change that will be effective in finding dynamic solutions for water challenges in cities*' [22].

In this paper, we focus on the governance capacity of cities to alleviate water stress by applying wastewater-reuse for non-potable purposes. Through a case study in the city of Sabadell (Spain), this paper aims to identify the main barriers, opportunities and transferable lessons that can enhance the governance capacity to implement systems for non-potable reuse of treated wastewater in cities.

This paper has the following structure. Section 2 describes the applied methodology and section 3 provides the results of the case study. Section 4 provides a discussion of the results and reflects on possible transferable lessons from Sabadell for other cities in Spain, the Mediterranean and other water stressed regions. The main conclusions are provided in section 5.

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2. Methodology

Based on an extensive literature review, Koop et al. [22] developed a diagnostic framework in order to assess the most important conditions that together determine the capacity to govern water challenges. The Water Governance Capacity Framework (GCF) consists of three dimensions, nine conditions and 27 indicators [Table 1]. The "knowing" dimension relates to the need to be aware, understand, and learn about the risks and impacts of policy and strategic choices. The "wanting" dimension refers to the need for actors to commit, cooperate, act upon ambitions and use their skills to find solutions. The "enabling" dimension refers to network, resources, and instruments that actors require to realise their ambitions.

Table 1 Water Governance Capacity Framework (GCF) [22].

Dimensions	Conditions	Indicators
Knowing	1 Awareness	1.1 Community knowledge 1.2 Local sense of urgency 1.3 Behavioral internalization
	2 Useful knowledge	2.1 Information availability 2.2 Information transparency 2.3 Knowledge cohesion
	3 Continuous learning	3.1 Smart monitoring 3.2 Evaluation 3.3 Cross-stakeholder learning
Wanting	4 Stakeholder engagement process	4.1 Stakeholder inclusiveness 4.2 Protection of core values 4.3 Progress and variety of options
	5 Management ambition	5.1 Ambitious and realistic management 5.2 Discourse embedding 5.3 Management cohesion
	6 Agents of change	6.1 Entrepreneurial agents 6.2 Collaborative agents 6.3 Visionary agents
Enabling	7 Multi-level network potential	7.1 Room to manoeuvre 7.2 Clear division of responsibilities 7.3 Authority
	8 Financial viability	8.1 Affordability 8.2 Consumer willingness to pay 8.3 Financial continuation
	9 Implementing capacity	9.1 Policy instruments 9.2 Statutory compliance 9.3 Preparedness

Each indicator has its own pre-defined question and indicator-specific 5-point Likert scale, ranging from *very encouraging (++)* to *very limiting (--)* the overall governance capacity to address a water challenge. By substantiating the scores of each indicator according to a triangular approach, the findings are validated in a standardized and reproducible way. This triangular approach consists of three steps:

1. A desk study of scientific literature, official government sources, policy documents and grey literature resulting in a substantiated preliminary score of each indicator.
2. The construction of a standardized importance/influence matrix to identify stakeholders, categorize them, and specify their roles and responsibilities [19]. In this matrix, importance refers to the priority given to satisfy the needs and interests of a stakeholder. Influence refers to the power of stakeholders to enhance or impede a policy, plan or objective. The importance/influence matrix consists of four classes: 1) crowd (low importance and low influence), 2) context (low importance and high influence), 3) subjects (high importance and low influence), and 4) key players (high importance and high influence). For each class, at least one stakeholder representing the government, the market and civil society were selected (as suggested by Lange et al. [20]. A coding system is applied in this paper to refer to maintain anonymity, where [SR001], [SR002], [SR003] and so on refer to the conducted interviews.
3. Feedback on the indicator scores and their justifications by asking all interviewees to provide feedback in the form of additional information, arguments etc. Based on the incorporation of the received feedback, the final indicator scores are determined.

The selected stakeholders represented the organizations Simbiosy, the General Water Society of Barcelona (SGAB), the Consortium of Integrated Water Management of Catalunya (CONGIAC), Sabadell's wastewater treatment plant, Riusec (EDAR RIUSEC), the University of Barcelona, the Polytechnic University of Catalonia, the local water service utility, Aigues Sabadell (CASSA), the Institute of Environmental Assessment and Water Research (IDÆA), the Technical Service Consortium of the Costa Brava, Figueres City Council, Sabadell City council, Barcelona Provincial Government and the Catalan Water Agency. Experts from the identified key stakeholders were selected for semi-structured interviews in order to gather the information to score the indicators and also to receive follow-up questions for clarification or to better understand the content. People with different roles, expertise and responsibilities were selected to reduce the risk of bias and in order to unravel socially desirable responses. A coding system is applied in this paper to consistently refer to these anonymized interviews. The overall indicator scores were determined based on the separate interview scores and collection of additional information that may ratify or provides nuance to the interview findings. Altogether, 16 interviews were conducted during the period, June 6th - July 6th, 2017.

3. Case study description

At present, around 11% of total treated wastewater is reused in Spain [12]. Spain has experienced several episodes of water stress during the 1990s and the early 21st century. In particular, several acute droughts led to domestic water cuts and at times required the use of sea-going water tankers from different locations on the Mediterranean coast [14]. In order to alleviate water stress the central government and regional governments have promoted desalination plants and have devised a National Plan for Water-reuse [15]. In particular, before 2011, approximately 50 municipalities in Catalunya had approved local regulations to promote decentralized reuse systems. The actions for the use of reclaimed water in Spain, mainly consist in transporting it for specific uses, such as the watering of golf courses and public gardens, the cleaning of streets or for agriculture and industry. The implementation of a distribution network for reclaimed water, coexisting with the drinking water network, has, to date, been applied in only a few cities, such as Madrid and Sabadell. Only in Sabadell is water supplied for the use of flushing toilets.

With a population of over 208,000 people, Sabadell is the co-capital and second largest city of the County of Valles Occidental in Catalonia, Spain [16]. Situated 22km north of Barcelona, in the basins of the rivers Ripoll and Riusec, both integrated within the Besos River Basin. It is a highly commercial and

industrial city that acts as a driving force for economic and urban development. A dual network is already applied in a large part of the city that separately distributes drinking water and treated non-potable water from the EDAR Riusec treatment plant and from groundwater sources. The second WWT plant of the city, Riu Ripoll, returns treated wastewater upstream of the Ripoll river, aiming to restore the ecological flow. Together these plants treated 22,544m^3day^{-1} and 14,170m^3day^{-1} respectively in 2017 [25]. Nonetheless, the total amount of treated non-potable water supplied through the dual network is only around 274m^3 day^{-1}.

The governance of the water sector in Sabadell is composed of both private and public stakeholders. In Spain, the national and regional government mandate the normative and legislative contexts. Nonetheless, each municipality is responsible for the management of the water in its jurisdiction. Thus this role falls in the hands of the City council of Sabadell. This municipality, among others, has subcontracted the private company CASSA to do this. In addition, Water of Sabadell (CASSA) has recently become part of AGBAR (Aguas Barcelona), which in turn is predominantly owned by Suez Environment. The stakeholders with high influence and most interest were identified as the Catalan Water Agency (state), the Provincial Government of Barcelona (state), CASSA (market) and the City Council of Sabadell (state). The stakeholders with high interest but low influence are EDAR Water Treatment plant (state/market), Network of Cities & Towns for Sustainability (Civil Society), Consortium of Besos Tordera and the Catalan Association of Friends of Water (Civil Society).

A desk study of Sabadell's Integrated Water Resources Management (IWRM) – called a City Blueprint – was performed within the European POWER project[1] and indicated that the city is vulnerable to heat risk and water scarcity [Figure 1; 23]. In addition, financial pressures such as high unemployment (18.4%) and a moderate average GDP per capita (25,684 USD/year) could affect urban water management investments. Sabadell has a high drinking water quality, with 187 / 187 samples that meet the quality standards [25]. Furthermore, Sabadell's drinking water consumption of 96 litres per person per day is one of the lowest rates in Europe of domestic water consumption. The average age of the pipes of the drinking water distribution network is 38 years, so some areas require refurbishment. Non-revenue water accounts for 19.4%.

[1] https://www.power-h2020.eu/

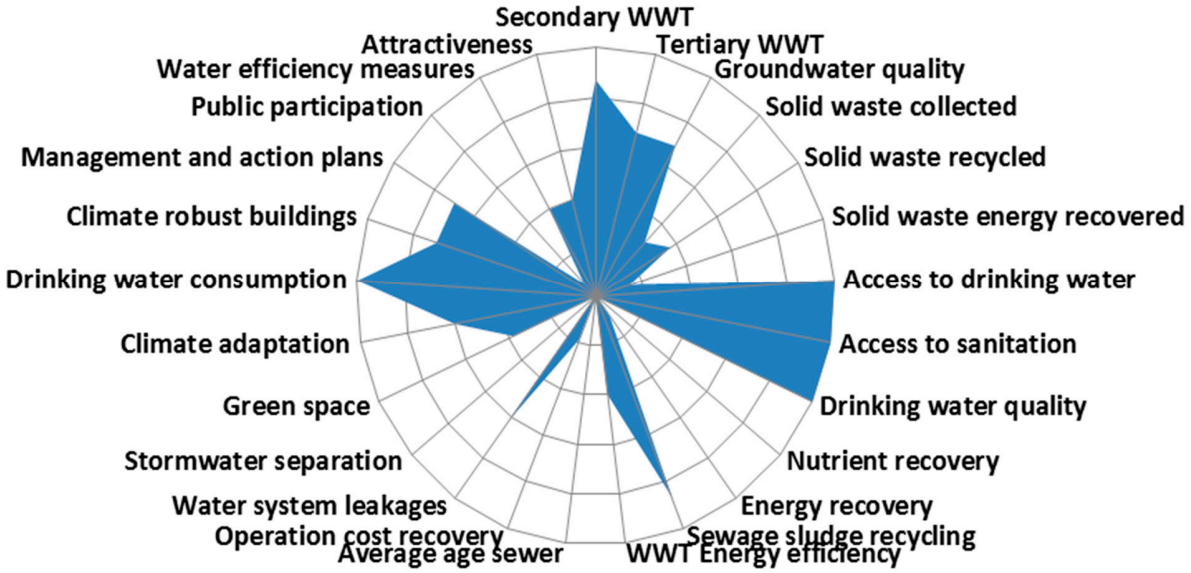

Figure 1. Spiderweb of the City Blueprint analysis of the city of Sabadell, Spain. The scores range from 0 (poor performance; centre of the circle) to 10 (high performance; periphery of the circle). The results are reported in detail in the study by Steflova [23].

4. Results

The results of the Governance Capacity Framework on site research show that the multi-level governance system of Sabadell is complex and that the reuse of treated wastewater for non-potable purposes is progressive, but not yet widely adopted in the centralized water governance system in the area of Catalonia. Figure 2 summarizes the results of Sabadell's multi-level governance capacity to alleviate water stress by wastewater-reuse schemes. The indicators are ranked from most limiting to most encouraging concerning the capacity to govern practices of water-reuse. The limiting and encouraging conditions are presented systematically in accordance with Table 1.

Condition 1: Awareness

The level of knowledge about the region's water scarcity and the amplifying impact of climate change is found to be relatively high [SR015]. However, there is little understanding with regards to how the water is used and distributed within the region, the linkages and interdependencies in relation to weather patterns, land use or environmental processes (indicator 1.1). Accordingly, the impacts on the water quality of rivers, groundwater, and the risks and uncertainties associated with the increasing water scarcity are largely

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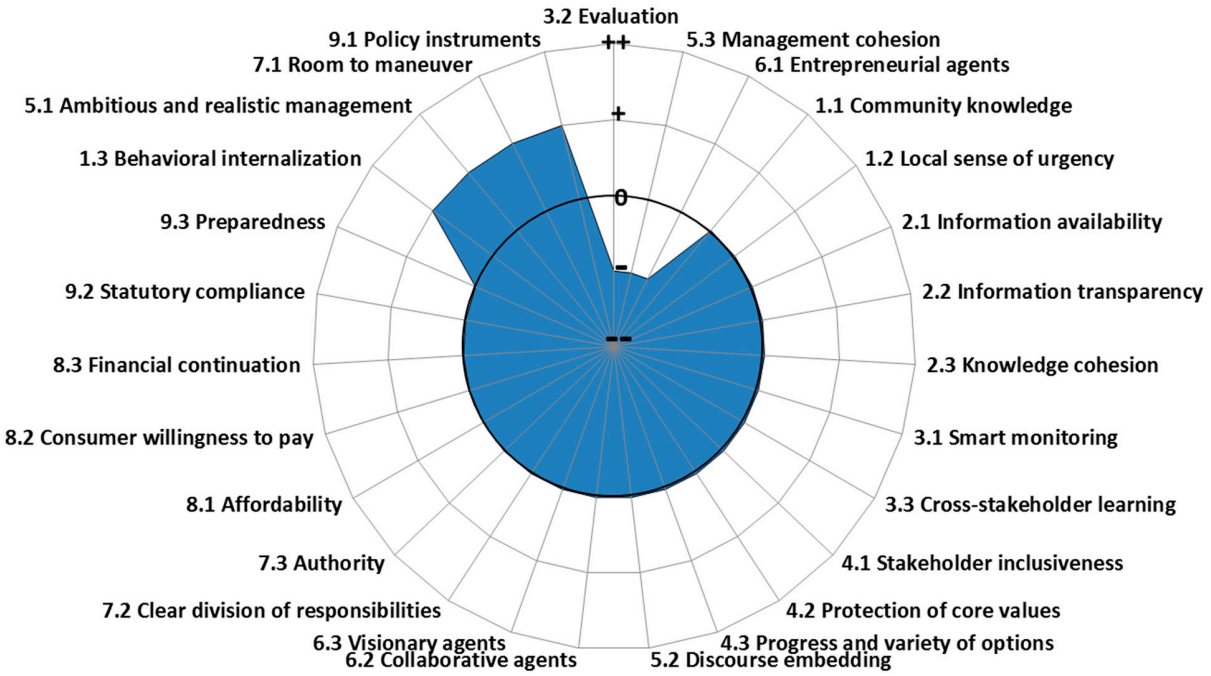

Figure 2. Results of the governance capacity to alleviate water stress by wastewater-reuse schemes in the city of Sabadell, Spain. The 27 indicators are organized clockwise around the spider web circle by most limiting (--) to most encouraging (++).

underestimated [SR002-SR011- SR013-SR015 -SR016]. The general sense of urgency of water stress is moderate amongst the citizens [SR001-SR011; indicator 1.2]. Nevertheless, water conservation strategies (indicator 1.3) such as greywater-reuse on a households level is widely applied [SR001-SR002-SR004] which is reflected in the city's low per capita water consumption of around 96L person^{-1} day^{-1} [SR006-SR011-25]. This results from that historically the region has experienced many droughts, and conservation strategies are engraved into the collective memory of the region [SR005-SR008-SR010-SR011-SR012-SR014-SR016).

Condition 2: Useful knowledge

The perception regarding the availability, transparency and cohesion of the information varied considerably between the stakeholders. It was revealed that citizens have limited access to information (indicator 2.1) and that available information is difficult to locate (indicator 2.2). The regional meteorological information and the water reservoir data published by the Catalan Water Agency (ACA) and the regional administration are available but not presented in a way that is intelligible for the general public [SR011-SR014-SR009]. Furthermore, much of the accessible information is not fully up-to-date or has a technical nature [SR004-SR007-SR010-SR012-SR014-SR016]. At the city level there have been strong attempts to improve transparency and information services such as water saving tips on the back of the water bills, education programmes and conferences for all who are interested [SR001-SR002; 23]. In general, the publicly available information is somewhat limited, which may be a by-product of limited incentives for stakeholders to communicate with citizens [SR007-SR010-SR011-SR012-SR014-SR016]. Consequently, the available knowledge about water scarcity and reuse practices is not cohesive and demonstrates the existence of different perceptions amongst stakeholders (indicator 2.3).

Condition 3: Continuous learning

The local water supplier CASSA has an advanced monitoring system (indicator 3.1) that can rapidly recognize alarming situations such as potable water contamination or leakages, and to some extent is also able to recognize long-term patterns of consumption, water flows and water quality [SR001-SR012-SR013]. Nonetheless, a more regional, national or cross-sectorial monitoring and evaluation of the water sector is largely lacking, leading to fragmented knowledge [SR011-SR014]. According to one interviewee, this is an important reason for the lack of transparency and the sharing of information between stakeholders [SR007]. Evaluation of policy (indicator 3.2) occurs on an infrequent basis [SR008], it can be non-directional and susceptible to political shifts [SR013]. The evaluation procedure is rigid, in particular with respect to the environmental laws, water distribution regulations and administrative aspects. In consequence, many norms are rather outdated and limit the application of water-reuse schemes [SR005-SR011-SR012]. For example, despite the higher quality standards of treated secondary wastewater compared to other water sources, it is still prohibited to use treated secondary wastewater for drinking water purposes [SR001]. Criteria are largely based on the origin of the water source (e.g. freshwater or recycled wastewater) instead of formulating quality standards for different use categories. Finally, it was found that learning between stakeholders (indicator 3.3) occurs on the technical level, and often with respect to narrowly defined topics. It is not very common that cross-stakeholder learning takes place on a strategic, administrative or financial level [SR005-SR012]. Many stakeholders are reluctant to share information due to the sector's competitiveness. Subsequently, cross-stakeholder learning is limited to a small alignment of stakeholders with similar interests [SR003-SR008-SR009-SR011].

Condition 4: Stakeholder engagement process

On the regional scale it is found that only a few and mostly conventional stakeholders are included in the decision-making process (indicator 4.1) which ultimately is bilateral and dominated by the national and regional government and ACA [SR002-SR004-SR005-SR007-SR010-SR011-SR012]. Most stakeholders, including academia for instance, are often only informed or consulted instead of engaged in decision making [SR005-SR012-SR013-SR015]. The decision-making process can be described as top-down with little opinion forthcoming from the local level. For example, local suggestions for more practical water quality norms for water-reuse schemes are not yet widely included in national guidelines. The water consumers or citizens have little active involvement or participation in the decision making process, which poses risks that their interests and core values can be harmed (indicator 4.2). However, citizen engagement is improving substantially (indicator 4.3) and new bottom-up initiatives as well as collaborations with grassroot organizations are appearing, such as ecological/green activist groups or basin associations (e.g. the Tordera River Basin Association and the Amics de l'Aigua civic organization).

Condition 5: Management ambition

Sabadell aims to be one of the leading cities in water-reuse practices in Europe [indicator 5.1-SR001-SR013-24]. However, the city has to deal with fragmented, sometimes contradicting policies that affect water-reuse practices. In particular, different guidelines exist originating from different government levels resulting in insufficient management cohesion (indicator 5.3). The national and regional policy ambitions regarding water conservation are moderate and most interviewees indicated that the statutory compliance to these policies is suboptimal [SR003-SR010-SR015]. Water quality and distribution norms are still determined by unilateral decisions, and a lack of sectorial, geographic and administrative alignment can be seen. Urban space construction permits have been released in the past even though they go against environmental efforts and restrictions for potential flood damage prevention [SR008]. Low water fees for agricultural purposes contradict with the efforts to lower the agricultural sector's water

consumption. Such discrepancies between national laws and the municipal administrative and geographical context can be observed and reflect a somewhat limited discourse embedding [indicator 5.2-SR007-SR009-SR014-SR016]. Ultimately, this leads to major inefficiencies and barriers in implementation of reuse schemes [condition 9-SR013].

Condition 6: Agents of change

Agents of change are found to have a limited impact on the overall governance capacity. There is little room for local entrepreneurial agents in the region's water sector (indicator 6.1). Water is ultimately publically administrated and even when subcontracted by a private company such as CASSA, the services are provided by monopolistic clusters and thus the sector is difficult to enter for entrepreneurs [SR007-SR008-SR009-SR012]. There is some sector-specific entrepreneurial space, particularly with respect to technology development [SR011-SR013-SR016]. However, in most cases entrepreneurs who enter the market would have to work with a larger, already established stakeholder [SR001]. Most expertise is accumulated in research centres [SR002] and many entrepreneurs export their goods and services abroad to areas such as Latin America [SR009]. Most collaborative agents (indicator 6.2) are active in close collaboration between a limited number of traditional stakeholders [SR003-SR014]. More recently, new and more inclusive collaborations are starting to take place. For example, public communication strategies with respect to household wastewater disposal have been established between CASSA, Sabadell City Council and ACA. This type of collaboration is often brief and established for very specific issues or events [SR001-SR016]. A frequent barrier for closer collaboration is the divergent interests of the involved stakeholders [SR016]. Finally, it is found that there does not exist a unifying long-term vision or strategy, which transcends different levels of decision-making or enables continuity beyond the political mandate of 4 years [indicator 6.3-SR013-SR014]. The leading body, ACA, is only recently recovering from a chaotic organizational period and thus their role as a visionary body has yet to be realized. At present, there is no entity that assumes the responsibility for leading the country's or region's water sector towards the implementation of water-reuse schemes or other water conserving strategies. Rather, there is a great diversity in local initiatives that aim to implement water-reuse practices.

Condition 7: Multi-level network potential

It was found that stakeholders have only limited room to manoeuvre (indicator 7.1) due to inter-organizational difficulties and the strict regulations and procedural demands of the ACA. Particularly with respect to the use or distribution of water permits, implementation is difficult [SR007-SR011]. A distinction between the private and public entities can be observed. Public management has more rigid structures and procedures whereas private management typically has more room and independence to determine strategies and to experiment [SR001-SR010-SR013]. Private companies can use this internally to remain flexible and to improve continuously [SR009-SR014-SR016]. In Sabadell, room to manoeuvre is also ensured by a long-term contract between the water supplier CASSA and the city council. The division of responsibilities (indicator 7.2) in Sabadell is mostly clear but also somewhat inflexible [SR005-SR007-SR008-SR011-SR012-SR014-SR015]. Water management is primarily the responsibility of each individual city council, with ACA and the Catalan government merely inspecting that municipalities comply with existing legislation. This leads to divergent, contradictory and overlapping approaches between different levels of decision-making [SR009-SR010-SR013-SR016]. There are also gaps identifiable, in particular with respect to financial responsibilities. It is unclear which organisations will finance the necessary infrastructural refurbishments [SR014]. ACA's authority is strong [indicator 7.3-SR008-SR011-SR015-SR016]. However, some argue that ACA's procedural demands may hinder the progress of the water sector, and procedures sometimes resonate with political shifts [SR015-SR001-SR007] due to organizational and financial uncertainty [SR014]. Partly as a result of this, the region of Catalonia lacks a

clear centralized visionary leadership to enhance water-reuse practices [SR010-SR011]. On the other hand, the role of ACA is primarily to act as an arbiter that balances and arbitrates between the interests of different stakeholders [SR008]. However, with respect to water-reuse practices, strict control of existing regulations impedes further progression. ACA is in the position to unify the many different municipal approaches to implementing water-reuse schemes. Given the many experiences and promising results it would appear to be the opportune moment to develop a coherent legislative framework for water-reuse practices in cities.

Condition 8: Financial viability

Basic water services are accessible for everyone. These services are either affordable or there are funds that support the most marginalized communities (indicator 8.1). Affordability for climate change adaptation is low because the possibility that citizens can apply to reduce the current and future impacts of climate change-induced water stress are rather limited. Although non-potable water-reuse is feasible, legislation limits its distribution and only those living in a few specific areas of the city that possess dual networks can make use of it [SR001]. The water consumer's willingness to pay (indicator 8.2) is however also restricted to basic services and willingness to pay extra for an extension of the dual networks is relatively low, with citizens indicating that these extra investments should be financially supported by the government in consultation with the service provider CASSA [SR001-SR002-SR012-SR015]. The structure that can ensure financial continuity (indicator 8.3) of water-reuse practices (indicator 8.3) was observed to be very diverse among stakeholders and governance levels. At the national, Catalan, provincial and municipal level the continuity of funding for any climate change adaptation measures - including water-reuse practices – is largely susceptible to temporary, ad hoc, short-term policies [SR005-SR012-SR014]. At present, infrastructure refurbishment requires an estimated €3 million in Sabadell [SR013]. However, CASSA nor the city council can afford to meet these costs without additional financial support.

Condition 9: Implementing capacity

Implementing capacity has been found to have both encouraging and discouraging factors. Some policy instruments (indicator 9.1), such as a progressive tax on water consumption or a connection tax for new water distributions are being used effectively to incentivize low water consumption. Statutory compliance (indicator 9.2) is adequate, the legislation is generally respected and all stakeholders comply because noncompliance is an unnecessary risk [SR005-SR007]. There is good understanding of the dynamics of reservoirs and a lot of experience from past drought events that can be employed to mitigate future drought events in the region. Water-reuse practice is increasingly being recognized as a promising and necessary climate adaptation measure. In municipalities such as Sabadell important progress has been made to implement water-reuse schemes. Sabadell has a long-term mitigation strategy and the city has demonstrated a capacity to respond efficiently to water stress in the past. However, given that it has rained in the past months and that water reservoirs are full, ensuring water supply for the region for the next two years, the issue of increased water stress has temporarily been put aside [SR005-SR014-SR004]. Hence, structural preparation (indicator 9.3) and infrastructural investments to mitigate water stress within a 30 or 50-year time frame appears to be an inevitable necessity. Some interviewees expressed their concern that the region is ill prepared for the impacts of climate change in the long run and current efforts seem to be insufficient [SR002-SR003-SR015]. Hence, the ability of Catalonia to prepare for future water stress within the next decades will be largely dependent on the willingness to learn from and enable local water-reuse practices.

5. Discussion

In order to reduce water stress by a wider application of wastewater-reuse practices, major changes are required in the way the water cycle is governed at the local, regional, national and international level. Spain is currently experiencing this transformation, with different multi-level governance barriers and challenges emerging. Governance capacity is essential to collaborate effectively and overcome these barriers. Our results demonstrate that Sabadell has gained considerable experience and has demonstrated a willingness to extend the reuse of municipal wastewater. The study has identified barriers and opportunities, revealing common factors and trends that are likely to manifest themselves in other municipalities not only in Spain, but throughout the Mediterranean and other water-scarce regions.

5.1 Coherent legislative frame required to support water-reuse

In order to establish water-reuse as an applicable solution to combat water scarcity, Europe needs to address existing discrepancies between the EU Water Framework Directive (WFD) and climatic and demographic conditions in its southern water scarce regions. In 2019, the WFD is to be fully revised and the European Commission and the European Parliament intend to redress some of the original directive's limitations for Mediterranean countries such as Spain.[2] Two of the most notable issues are the fact that Mediterranean rural municipalities are often divided into small and dispersed population hubs making the establishment of the necessary WWT plants financially unviable. Decentralised WWT can provide an alternative where effluent water might be useful for secondary purposes such as irrigation or domestic applications. Secondly, in the Mediterranean region many of the fluvial systems are ephemeral. Meaning active river systems in early spring may prove to be nothing more than a dry stony gully, three months later. As a consequence, surface water quality in these river systems is erratic and inconsistent, leading to difficulties in meeting the WFD standards. Here wastewater can provide an alternative and more reliable resource. In Europe, the lack of common water-reuse criteria, has been identified as a important factor restricting the expansion of water-reuse practices [27]. France, Cyprus, Greece, Italy, Portugal and Spain do have national policies on water-reuse that focus mainly on agricultural irrigation. However, more focus on criteria for other applications are necessary to exploit the full potential of water-reuse. Several regions in Spain already widely apply water-reuse [27]. *Royal Decree* 1620/2007 provides the legal clearance and the *Wastewater-reuse National Plan* gives orientation and proposes procedures and criteria for the following applications: (a) urban uses such as garden irrigation, street cleaning, and firefighting, as well as household applications such as toilet flushing; (b) irrigation of agricultural crops and use in aquaculture; (c) industrial uses such as in cooling towers and evaporative condensers; (d) leisure; and (e) environmental applications including aquifer recharge, forest irrigation, and wetlands maintenance [28-29]. However, overly strict legislative water quality standards together with a demanding licensing process slow down Spanish municipal efforts to reuse treated wastewater [38-30]. A reoccurring issue is that norms discriminate water, based on its source rather than on its properties, which is unfounded given the advanced treatment methods that ensure adequate water quality. In order to realise a widespread application of water-reuse practices it is necessary to develop reclaimed water quality criteria per use category independently of the water's origin [27]. The legislative framework tends to be overly precautionary, which does not reflect, nor support, the ambitions and efforts of local stakeholders aiming to implement this innovation. At present, municipal experiences with water-reuse are not fully taken into account in the evaluation of regional and national policy. Moreover, periodical shifts in political parties further impedes the development of a coherent policy that supports water-reuse schemes [SR013-SR014]. Hence, guidelines and learning experiences are divided between a heterogeneous range of stakeholders,

[2] For example: Konferenz zur EU-Wasserpolitik und Revison der Wasserrahmenrichtlinie (WRRL) 06/03/2018 European Parliament.

indicating that improved coordination through coherent regulation could boost the mainstreaming of municipal reuse of treated wastewater.

5.2 Realising public engagement for non-potable water-reuse

The public's awareness and understanding of the safety and applicability of reclaimed water is essential to the success of any water-reuse programme [31] and requires public engagement [32]. The vast majority of Spanish, European and Western societies have organized urban water systems applying a centralized approach. Such systems allow for the large-scale collection and treatment of wastewater making it cost-efficient due to their economy of scale [14]. On the other hand, alternative, decentralized systems typically give citizens the responsibility to collect, treat or dispose their water. Decentralized reuse systems are in most cases a more expensive option [33-14], in particular in urban areas where such investments in centralised water infrastructure have already been made [33]. However, there remains a persistent lack of public engagement in centralized water systems because the user, who is disconnected from water treatment, takes these services for granted, and is often not aware of the challenges and risks involved. The level of public acceptance is a key factor in the implementation of water-reuse schemes [31]. Numerous reasons why the public has a tendency to be reluctant in supporting general water-reuse, potable as well as non-potable, have been studied across the globe [35]. Common results are that potential consequences are unknown due to their (perceived) limited experience, implementation is seen as being irreversible and citizens feel that they have little control over the process [24]. The source of reused water is viewed as being unnatural and even toxic, which leads to the irrational, well recognized psychological "Yuck factor" [33-34], "naturalness" and "contagion" phenomena [36]. Ultimately, public acceptance and support for water-reuse schemes is greatly a matter of the "interplay between trust, risk perception and emotional reaction" [36]. The more the citizens are informed and the more that they trust the authorities the lower risk they perceive, and are thus more likely to support the schemes [37].

Building public support requires the construction of holistic narratives that appeal to the affective reactions as well as to the cognitive ones, changing the citizen's perception of wastewater as "dirty waste" to "resource" [36]. It is therefore a task that requires multi-level collaboration, i.e., interdepartmental efforts, stakeholder engagement and citizen participation. It might be crucial to clearly distinguish between reuse for potable and non-potable purposes. Winning trust and earning support for water-reuse for potable purposes involves overcoming many hurdles. However, the potential to reduce domestic and industrial water consumption is larger when contemplating a situation that does not require drinking water quality standards. Hence, the implementation of non-potable water-reuse is often the first choice. For example in Europe 97.7% of water-reuse is for non-potable purposes. In Sabadell the public attitude towards non-potable water-reuse was found to be quite positive. This confirms earlier research in Sabadell [38**Error! Reference source not found.**]. Due to previous experience regarding water stress, water conservation and the use of alternative sources for purposes such as flushing the toilet, washing the car or watering the garden, are already widely applied. It might explain the general positive public attitude towards water-reuse schemes at a municipal level. Hence, centralised water-reuse schemes may be more accepted by citizens if it is combined with household systems of rainwater harvesting, water conservation and greywater recycling.

5.3 Pricing Water

Pricing water services is always a tradeoff between the basic human right to affordable water and cost recovery. In fact, definitions of cost recovery can be misleading as cost can be deferred to the future or transferred to the environment, leading to environmental degradation. Hence, the question whether the price includes all operations, maintenance, and capital costs that can ensure freshwater availability in the long-term is decisive for the continuity of water services, in particular in water-stressed regions.

Examples of external factors that can be excluded are water scarcity, social and financial issues, and environmental burdens such as wastewater or wastewater effluent disposal into the environment [31]. At the same time affordability for everyone has to be ensured [14] which emphasizes the need for steering mechanisms. Reclaimed water is often priced just below the drinking water price in order to make it more attractive to consumers but this also poses issues concerning the recovery of costs [36-38]. The expansion of Sabadell's water-reuse practices is hindered because the costs would result in a higher price of reclaimed water that could not compete with drinking water. Moreover, treated wastewater is still perceived as inferior by the consumer and thus few citizens are willing to pay the same or a higher price for it compared to water from primary sources. Major policy instruments such as a progressive tax on water consumption or the inclusion of the costs of reclaiming water in the consumer price for drinking water are used effectively in Sabadell to incentivize low water consumption and ensure affordability. At the same time the existing water infrastructure requires substantial investments that may have consequences for the water price. Given the economic situation, it is a challenge to refurbish the existing water infrastructure, enhance water-reuse practices and maintain affordability of water services for everyone. In order to take up this challenge, co-financing from different stakeholders including citizens, local businesses as well as funding from regional, national or European authorities might be required to combat water stress and continue water services in the long run.

5.4 Research limitations and key priorities

The governance capacity analysis applied in Sabadell reveals a number of highly interconnected and interrelated governance processes. As a consequence, some of the framework's indicators interrelate as well. Some hypothetical "ideal" situations will not result only in very encouraging (++) indicator scores. For example, the role of entrepreneurial, collaborative, and visionary agents of change (indicators 6.1, 6.2 and 6.3) are context-dependent. Visionary agents may be more useful in times of crisis, whereas collaborative agents are more valuable in initiating new collaborations, and entrepreneurial agents operate best in flexible and open governance networks [26-22]. Hence, situations may occur in which entrepreneurial and collaborative agents of change are very encouraging (++) while, as a consequence, visionary agents are less prominently active and score lower. Another important interrelation is between indicators 5.1 *ambitious and realistic goals* and 9.2 *statutory compliance*, because it is easier to comply with goals that are not ambitious [22]. The governance capacity analysis applies a triangular approach of knowledge co-production consisting of three steps: 1) a desk study, 2) interviews and 3) feedback from interviewees. The detailed reporting and transparent research steps ensure reproducibility. However, because the number of interviewees is moderate and interviewees with different backgrounds sometimes contradict each other, the scoring justification for indicators 1.1 *community knowledge*, 1.2 *local sense of urgency* and 1.3 *behavioural internalisation* were limited due to the lack of available open source reports, documents and scientific literature. For these three indicators, a survey would provide more substantiated and accurate scores.

6. Conclusion

In line with the United Nations, we conclude that wastewater can be considered as a reliable and largely untapped resource that has much potential to alleviate water stress. In order to enable the wider application of wastewater-reuse practices, major changes are required in the way the water cycle is governed at the local, regional, national and international level. Spain is in the middle of a process of transformation wherein different multi-level governance barriers and challenges emerge. Through a case study in the city of Sabadell (Spain), this paper has aimed to identify the principal barriers, opportunities and transferable lessons that can enhance governance capacity in order to implement systems for the non-potable reuse of treated wastewater in cities. Overall, it was found that citizens in Sabadell do not fully

understand the possible risks and impacts of water stress, but have a positive attitude towards the reuse of treated wastewater for non-potable purposes. In order to overcome different operational barriers identified in the implementation of water-reuse practices, a coherent legislative framework is required that applies quality criteria per use category independently of the water's origin. Such a framework should be developed and implemented based on the local experiences of municipalities such as Sabadell through a regular evaluation process that transcends political cycles and overcomes the current fragmentation of interests, responsibilities and tasks between stakeholders. This requires the further development of governance capacity across multi-level governance layers. The results from Sabadell indicate that in particular with respect to knowledge provision, policy evaluation and learning, the development of a more coherent policy strategy for the wider application of water-reuse practices is required. These barriers and opportunities may provide learning lessons for other municipalities in Spain and throughout the Mediterranean and other water-scarce regions in the world.

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