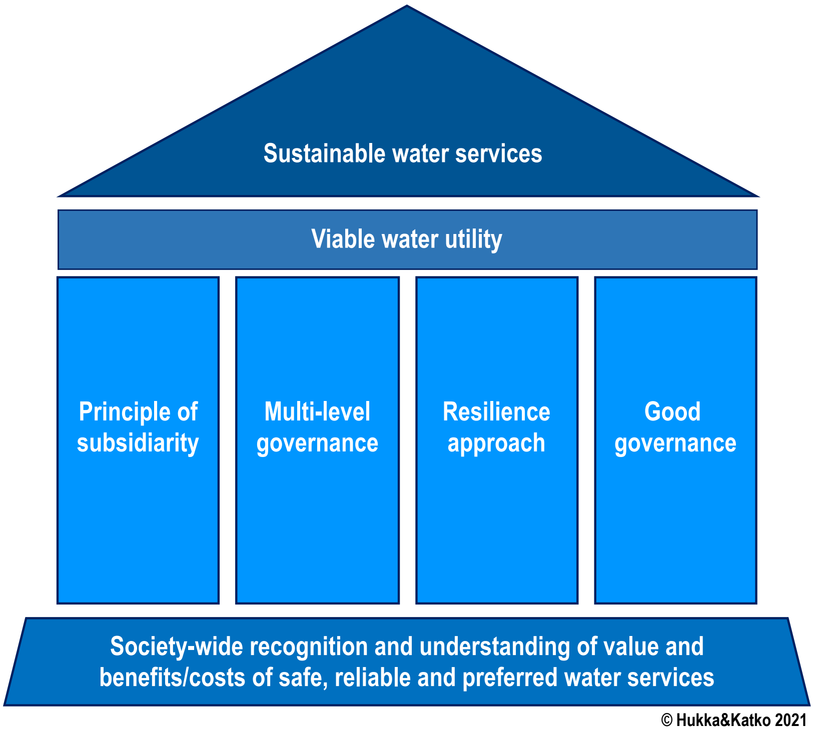
Jarmo J. Hukka and Tapio S. Katko

Towards Sustainable Water Services: Subsidiarity, Multi-level Governance and Resilience for Building Viable Water Utilities



Tampere University, Faculty of Built Environment
CADWES Publications

Tampere 2021

Tutkimuksen nimi: Kestävät vesihuoltopalvelut: Subsidiariteettiperiaate, monitasohallinto ja resilienssi toimivien vesilaitosten edellytyksenä

Towards Sustainable Water Services: Subsidiarity, Multi-level Governance and Resilience for Building Viable Water Utilities

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Abstract: Throughout the world, society depends on a set of systems that supply food, water, public health services, energy, and transport. Well-functioning water utilities play an important role in societal progress. Citizens and businesses need reliable access to high-quality and affordable drinking water and wastewater services. Producing these essential services efficiently and effectively requires viable, high-performing utilities that are also able to cope with the multi-dimensional threats. In particular, economic, social and environmental challenges are daunting because of a vast coverage gap in safely managed water services and drinking water and sanitation facilities in non-OECD countries. The aging and decaying water infrastructure exacerbates these problems and comes at a large financial cost – including a sizeable loss of economic activity also in OECD countries.

Therefore, this global challenge concerns all of us. In this study, the authors explore the applicability of the principle of subsidiarity, multi-governance and resilience approach in the development and implementation of institutional framework for regulatory governance, provision and production of sustainable water services. This study is based on an extensive literature review and on our research team's previous and on-going research.

The overall objective of this study is intensified access to and progressive sustainability of water services, and substantially improved resilience and viability of water utilities worldwide. The purpose of this study is to help and encourage designing and implementing of sound resilience of water utilities, and of appropriate multi-level governance of water services. The results of this study are the state-of-the art recommendations for: a) a definition of resilience of a water utility; b) a definition of a viable water utility; c) dialogue and compliance-restoring processes; and d) an institutional framework for regulatory governance, provision and production of sustainable water services. Our key recommendation is that in any country subsidiarity approach (based on the virtue ethicist approach), multi-level governance, and resilience approach should be studied and applied thoroughly in formulation and development of the institutional framework for water services regulatory governance, provision and production.

Keywords: Sustainable water services; viable water utilities; institutional innovations; principle of subsidiarity; virtue ethicist approach; multi-level governance; resilience; graceful extensibility; reciprocity approach

Acknowledgements

Maa- ja vesitekniikan tuki ry (no. 41250) is gratefully acknowledged.

Published in 2021 by Capacity Development in Water and Environmental Services (CADWES) Research Team, Faculty of Built Environment, Tampere University, PO Box 600, FIN-33014 Tampere, FINLAND
ISBN 978-952-03-2071-3 (pdf)
Suggested citation:
Hukka, J.J. and Katko, T.S. 2021. Towards Sustainable Water Services: Subsidiarity, Multi-level Governance and Resilience for Building Viable Water Utilities. CADWES Publications. 89 p.

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1 INTRODUCTION

"We need infrastructure that underpins our prospects for sustainable growth, by focusing on resilience and whole-of-life asset management" Infrastructure Australia (2017, 2).

1.1 Importance and Benefits of Safe Water Services

It is well recognized that water underpins most aspects of economies and sustainable development (UN 2021, 18). To formally acknowledge the importance of safe drinking water and adequate sanitation in the societal development, the United Nations Human Rights Council (HRC) adopted a consensus in September 2010 – building on the July 2010 Resolution by the United Nations General Assembly – affirming that access to water and sanitation is a human right. The HRC resolution states that *'the human right to safe drinking water and sanitation is derived from the right to an adequate standard of living and inextricably related to the right to the highest attainable standard of physical and mental health, as well as the right to life and human dignity.'* This resolution, however, fails to provide guidance on how progress is sufficiently monitored, or how the capital, operations and maintenance costs of water and sanitation services infrastructure are provided while maintaining affordable prices for the poor (WWAP 2012, 35).

The society-critical functions – which are essential to ensuring the functioning of a society and its economy – depend on infrastructure components (Skotnes 2016, 133). The disruption of crucial systems and essential services – such as water supply and wastewater assets, networks, systems and facilities – may result in substantial economic damage. These so-called *critical infrastructures* are the backbone of our modern and interconnected economies (OECD 2019, 13). The aim of defining critical infrastructure is to target sectors that are most crucial to societal and economic security and stability. Along with the definitions, lists of sectors also vary across countries (OECD 2019, 47).

Overall, six sectors are widely classified as being critical across the OECD countries: information and communication technologies, energy, finance, health, transport and water (OECD 2019, 48). According to European Union (2008, 77) 'critical infrastructure' means an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions.

The Critical Five Members (Australia, Canada, New Zealand, the United Kingdom, and the United States) propose the following definition as the starting point for a discussion about critical, nationally significant infrastructure: Critical infrastructure, also referred to as nationally significant infrastructure, can be broadly defined as the systems, assets, facilities and networks that provide essential services and are necessary for the national security, economic security, prosperity, and health and safety of their respective nations (Critical 5 2014, 2). Critical infrastructure services are vital to economic growth, so governments work to ensure that these services are as secure and resilient as possible. By ensuring that the critical infrastructure is secure and resilient, governments are able to protect and increase the strength and vitality of their respective economies (Critical 5 2014, 4).

Water is arguably *more fundamental* than any other resource – to life itself, supporting a huge array of ecosystem services – and to every economy and society. Water contributes directly and indirectly to virtually all other ecosystem services, but water and sanitation services also comprise an economic sector in itself. Furthermore, as well as being needed for all biotic and economic production processes, in most societies water also has important values such as recreational, cultural and spiritual. This *fundamental threefold value*, sustaining life, economies and cultures, creates an enormous range of competing demands on water resources but also economic opportunities (UNEP 2012, 14-15).

Consequently, it can be justifiably argued that the right to water – as well as to adequate sanitation – is *an implicit human right*. Since people cannot survive without water, the right to water can be seen either as a universal ethical and moral right or as a fundamental precondition for the enjoyment of several explicit human rights, such as the right to life, adequate standard of living and health, education, housing, work and protection against cruel, inhuman or degrading treatment or punishment. Therefore, the human right to water cannot be considered to only cover drinking water as the most crucial aspects are related to those water functions and uses that are essential for human survival and dignity such as adequate sanitation services or the preservation of healthy aquatic ecosystems in addition to the access to safe water supply (Hukka, Castro and Pietilä 2010, 241).

In addition, it is a crucial element in ensuring gender equality and eradicating discrimination. Access to safe drinking water and sanitation is most at risk for those who have been denied rights to adequate housing, education, work or social security (OHCHR 2010, 13). Ensuring access to water and sanitation as human rights means, i.a., that *access to safe water and basic sanitation* is a legal entitlement, rather than a commodity or service provided on a charitable basis. Furthermore, universal access to sanitation is "not only fundamental for human dignity and privacy but is one of the principal mechanisms for protecting the quality" of water resources (UNW-DPAC and WSSCC 2011, 1).

Failure to improve water resource management could diminish national growth rates by as much as six percent of GDP by 2050 (World Bank 2016 cited by United Nations and World Bank 2018, 26). Yet, inadequate water supply and sanitation continues to have the greatest economic consequence of all water-related risks. It also continues to be the most harmful risk to people, with diarrhoeal diseases resulting in 1.4 million premature deaths in 2010. The total global economic losses associated with inadequate water supply and sanitation have been estimated by WHO at USD 260 billion annually (Sadoff, Hall, Grey, Aerts, Ait-Kadi, Brown, Cox, Dadson, Garrick, Kelman, McCornick, Ringler, Rosegrant, Whittington and Wiberg 2015, 22). Deaths from water-related diseases are, however, inadequately monitored and reported. A wide range of estimates is available in the literature, ranging from 2 million to 12 million deaths per year. The best estimates analysed by Gleick (2002, 4) appear to fall between 2 and 5 million deaths per year.

Benefits of safe and reliable water and sanitation services are probably systematically under-estimated due to a number of non-economic benefits that are difficult to quantify but that are of high value to the concerned individuals in terms of dignity, convenience, social status, cleanliness, health and overall well-being. In addition, safe and reliable water and sanitation services appear to be a key driver for economic growth – including investments by firms that are reliant on sustainable water and sanitation services for their production processes and their workers (OECD 2011a, 16).

Further, the COVID-19 pandemic underlines the fundamental role that clean water plays in the *well-being* of communities worldwide; safe water supply and sanitation are key requirements in promoting public health services proactively, and they cannot be taken for granted anywhere (Katko and Hukka 2021, 68).

Whittington (2015, 10) points out that there can be *a wide range of cost-benefit outcomes* depending on local conditions. Therefore, according to him, global averages of benefit-cost ratios will offer little useful information about the attractiveness of water, sanitation and hygiene (WASH) investments in local settings. Yet, it has been estimated that achieving universal access to safe drinking water, sanitation and hygiene (Sustainable Development Goals/SDG Targets 6.1 and 6.2) in 140 low- and middle-income countries would cost approximately USD 1.7 trillion from 2016 to 2030 (Hutton and Varughese 2016, xi). The benefit-cost ratio (BCR) of such investments has been shown to provide a significant positive return in most regions (WHO 2012a, 47; Hutton 2018). An analysis by Hutton (2018 cited by UN 2021, 56-57), based on disaggregated data between rural and urban areas suggest that current BCRs favour drinking water supply (with BCRs of 3.4 and 6.8 for urban and rural areas respectively) over sanitation (with 2.5 and 5.2 for urban and rural areas respectively).

The American Society of Civil Engineers (ASCE) partnered with the Value of Water Campaign to commission a study on the economic benefits of investing in water and wastewater infrastructure in the United States, out of which four key findings emerged (Value of Water Campaign and ASCE 2020, 19):

1) Service disruptions would cost water-reliant businesses USD 250 billion by 2039;
2) Underinvestment would lead to a cumulative USD 2.9 trillion decline in the gross domestic product by 2039;
3) Costs incurred by US households due to water and wastewater failures would be seven times higher in 20 years than they are today; and
4) Failing water infrastructure would result in USD 7.7 billion in cumulative healthcare costs to households over the next 20 years.

In assessing the benefits of closing the water infrastructure investment gap, three key findings were identified: i) Business sales would increase, and the US GDP would grow by USD 4.5 trillion; ii) The US trade balance would dramatically improve, making exports more competitive; and iii) Investment would create 800,000 jobs, and disposable income would rise by over USD 2,000 per household by 2039 (Value of Water Campaign and ASCE 2020, 27). The report concludes that failing to act now will lead the country into a prolonged era of economic and public health vulnerability (Value of Water Campaign and ASCE 2020, 33).

1.2 Definition and the Scope of Water Services

The European Union (EU) Services Directive classifies water distribution and supply services as well as wastewater services as *the services of general economic interests* (SGEI) (European Union 2006, 58 cited by Delimatsis 2015, 21). *The definition of water services* considerably varies between countries: the narrow definition of water services is limited to traditional drinking water and sewage services (European Environment Agency 2013, 25). In Finland, for example, the Water Services Act (119/2001, the amendment 681/2014; Finlex 2016) stipulates that the water services cover conveyance, treatment and distribution of potable water for the community’s use as well as the collection, treatment and disposal of wastewater (Beilinskij 2015, 8).

The scope of water services – as the authors understand – encompasses abstraction, conveyance, impoundment, storage and processing of raw water (surface water or groundwater), the distribution and supply of purified water for community use, and also the collection and conveyance of community wastewater, treatment of wastewater, and discharging the treated wastewater into surface water. The protection of raw water sources and the environment vis-à-vis the aforesaid activities are also included in water services production.

Water services are generally *delivered by private or public water utilities* that are under a formal or statutory duty to distribute safe water to consumers within a specified area and that are often, but not always, responsible for the removal and treatment of wastewater. A person who holds property located within the service area of a utility typically has a right to a connection to the water and wastewater networks and to the water services produced by that utility. This too is a kind of relationship with water. It is, however, a right to a service and not a right to a share of a specific water resource (Hodgson 2016, 12).

Where domestic water is supplied through a piped water conveyance network, these networks typically also supply important municipal users and uses, for example, schools, hospitals, civic offices or meeting halls, parks, and a range of business activities, including offices, restaurants, shops, workshops and light industry. In theory, wastewater resulting from these uses is treated in wastewater treatment plants and discharged to rivers and other surface water bodies. From a policy perspective, the water supply sector constitutes a use of water that demands the utmost tenure security. Where a 'modern' formal water rights system has been introduced, the abstraction of water for a water supply network will invariably take place on the basis of a 'modern' formal water right (Hodgson 2016, 36).

Within the European Union, *the water services are regulated* at EU and national levels. The Water Framework Directive (WFD) and the 'water industry' Directives (the Drinking Water Directive (DWD), the Urban Waste Water Treatment (UWWTD) and the Bathing Water Directive (BWD) govern the environmental and health standards at EU level and are implemented in national legislation. The organization of water services (the choice of the management model) is subject to subsidiarity (Protocol 26 to the Treaty on the Functioning of the European Union) and it is a competence of the Member States. The EU institutions are neutral in regard to the choice of management models (European Federation of National Association of Water Services 2020, 6).

Worldwide, predominantly **a public utility** is responsible for the development and operational management of community water infrastructure. In Finland, for example, there are about 1,100 water utilities operating under the Water Services Act. Out of them, approximately 400 water utilities are owned by municipalities and approximately 700 utilities are owned by local water cooperatives. In addition, there are some 300 community water systems – mainly owned by the water cooperatives – which do not operate under the Water Services Act (Kuulas, Renko and Kuivamäki 2020, 11). According to Luukkonen (2013, 18), the water cooperative utilities supply 10 percent of the drinking water, and they serve approximately 13 percent of the population in Finland.

A public water utility within its designated service area can also be defined as *a typical natural monopoly,* i.e., an economic activity that is most efficiently carried out by a single producer (Gustafsson 2020, 44; World Bank 1994). Society can benefit from having a utility as a natural monopoly. Multiple utilities are not economically feasible since there would be a need to have multiple treatment plants and distribution networks such as sewers and water pipes for each overlapping utility. The public monopoly utility, however, should be and usually is heavily regulated to ensure that citizens and businesses get fair pricing and safe, reliable and sufficient services, and both the natural and the built environment are properly protected.

1.3 Sustainability and Resilience

The concepts of **sustainability and resilience** have become topical and popular over the past decades. They dominate research trends and practical interests also in the field of civil infrastructure. Sustainability and resilience are *complementary* and should be used in an integrated perspective. While sustainability aims at reducing impacts and resources and, more generally, at satisfying the needs of today's generation without living at the expense of future generations, resilience aims at achieving the robustness and rapid recovery of systems. Resilience thinking is an integrative approach for dealing with the sustainability challenge. When dealing with civil engineering, resilience is *a property of communities* rather than structures or infrastructure. Resilience is not only about being able to withstand a certain disturbance, but also about having resources and means for a prompt, efficient, and effective recovery (Bocchini, Frangopol, Ummenhofer and Zinke 2014, 4; Folke 2016, 13).

Since the mid-2000s, governments have designed and implemented public policies to support the protection of critical infrastructure against natural hazards and malicious attacks.

Most OECD countries have defined critical infrastructure sectors, established an inventory of assets, and put in place regulations, national programs or incentive mechanisms to strengthen the resilience of critical infrastructure to shock events. Today's critical infrastructure resilience policies have to address diverse and complex shock events, more interdependent systems and countries, and the fast pace of innovation in infrastructure sectors. *Aging infrastructures* also present a growing policy challenge. At the same time, the global increase in infrastructure investment and the digital transformation of infrastructure services provide opportunities to rethink critical infrastructure resilience (OECD 2019, 3).

In many OECD countries, aging infrastructure requires investments and innovation provides opportunities to make these investments contribute to increased productivity. Getting such infrastructure investments not only right but also resilient requires revisiting the overarching governance models for infrastructure delivery (Critical 5 2014 cited by OECD 2019, 24). Grigg (2006, 246) points out that aging infrastructure is a "creeping crisis". While the problem of aging and deteriorating infrastructure does not occur suddenly, it nonetheless constitutes a crisis for water undertakings. Just as water suppliers may suffer failures from accidents, attacks, other malevolent acts, and natural disasters, they also are vulnerable to failures within their systems.

To function properly and sustainably, all aspects of water resources management and water supply-related services must be fully funded. This not only includes the creation and maintenance of physical infrastructure, but also water resource management, environmental protection and pollution abatement measures, and less visible functions such as policy development, research, monitoring, administration, legislation enforcement, provision of public information, control of corruption and of conflicts of interest, and the involvement of public stakeholders (WWAP 2012, 313).

Supplying water and providing sanitation services has an inherent financial cost not only with regards to capital investments but also during the operations and maintenance, renovation and expansion phases. These financial costs are reasonably straightforward to identify and potentially match in order to recover costs (Cardone and Fonseca 2003, 25). The United Nations World Water Development Report (UN 2021, 10) observes that unlike most other natural resources, water's 'true' value is being recognized extremely difficult to determine. Therefore, the overall importance of this vital resource is not appropriately reflected in political attention and investments. This not only leads to inequalities in access to water resources and water-related services, but also to inefficient and unsustainable use and degradation of water supplies themselves, affecting the fulfilment of nearly all the SDGs, as well as basic human rights.

1.4 Multi-level Governance and Subsidiarity

A public service industry, or a local public economy, should have **three components**. These components are jurisdictions and organizations that ***provide*** *a good or service*, jurisdictions and organizations that ***produce*** *or supply a service or good*, and jurisdictions and organizations that legislate and administer rules ***governing*** *provision and production* (Oakerson 1999; Ostrom, V. and Ostrom, E. 1991; ACIR 1991 cited by Heikkila 2004, 102). Heikkila (2004, 102) reveals that in contrast to common-pool resources (CPRs) theory, public service industry literature *does not emphasize the physical boundaries* of a resource or good as a criterion for identifying the appropriate scale of jurisdictions that provide or produce a service such as conjunctive management. When provision, production, and governance are separated, jurisdictions have opportunities to address a shared problem related to the management or use of a resource by coordinating service production. Therefore, interjurisdictional coordination can allow small-scale jurisdictions to engage in conjunctive water management in a way that eliminates the need for a large and centralized authority.

Hooghe and Marks (2002, 8) acknowledge that beyond the bedrock agreement that efficient governance must be **multi-level**, there is no consensus about how multi-level governance should be structured. The planning of the multi-level governance can be done, however, in accordance with **the principle of subsidiary** (Papunen 1986, 52 cited by Haapalainen 1990, 9). Haapalainen (1990, 9) argues that in accordance with the subsidiarity approach the matters have to be decided on where they are known best, therefore, ultimately *as close as possible to the citizens*. Further, Haapalainen (1990, 9) points out that the principle of subsidiarity has two main dimensions: centralization and decentralization. The focus of the multi-level planning is on the system having multi-levels and multiple objectives. The principle of the multi-level planning is based on two-way communication between the planning levels and also on the expression of their own development interests and objectives. The principle of the multi-level planning can thus be applied, as well as the principle of the subsidiarity, to the policy planning of societal systems to either promote centralization or to promote decentralization.

The general aim of the principle of subsidiarity is, however, *to guarantee a degree of independence for a lower authority* in relation to a higher body or for a local authority in relation to central government. It therefore involves the sharing of powers between several levels of authority (European Parliament 2020). Vischer (2001, 142) points out that fundamentally subsidiarity envisions a society in which problems are simply solved and decisions made from the bottom up. As a model of governance, subsidiarity offers no shelter to those who seek the unbridled expansion of centralized government, nor to those who disregard the need for a vital government role in making an empowered and connected citizenry a reality.

Stoa (2014, 31) emphasizes that the aim of the principle is *to promote efficiency and local ownership* over policies and regulation, while placing a check on centralized governance and consolidation of authority at the highest levels of government. The principle of subsidiarity may not yet be characterized as a customary principle of international law, but it is gaining increased recognition as an integral component of effective governance frameworks. According to Stoa (2014, 35) the rise of subsidiarity in international agreements and policy statements has been manifested in the adoption of *Integrated Water Resources Management* (IWRM). For example, the 1992 Dublin Statement on Water and Sustainable Development establishes stakeholder participation as one of the four pillars of IWRM (ICWE Secretariat 1992, 4). Further, the World Bank (2004, 1) acknowledges Principle 2 as ***the institutional principle***, which stipulates that resource management should respect the principle of subsidiarity, with actions taken at the lowest appropriate level.

Over time, Global Water Partnership (GWP 2017) has adopted and developed its universal guiding principles for the equitable and efficient management and sustainable use of water based on the Dublin and Rio statements in 1992, on the outcomes of the Millennium Assembly in 2000, which fostered the formulation of the Millennium Development Goals, and on the outcomes of the World Summit on Sustainable Development Plan of Action in 2002, which set a target for the preparation of IWRM and Water Efficiency plans. The GWP guiding principles with regard to water services can be elaborated as follows: ***Principle 2*** *– Water development and management should be based on a participatory approach, involving users, planners, and policymakers at all levels* and ***Principle 4*** *– Water is a public good and has a social and economic value in all its competing uses.*

The Dublin Statement on Water and Sustainable Development (ICWE Secretariat 1992, 4) recognizes that within Principle 2, the participatory approach involves raising awareness of the importance of water among policymakers and the general public. It means that decisions are taken at the lowest appropriate level, with full public consultation and involvement of users in the planning and implementation of water projects. Within Principle

4, it is vital to first recognize *the basic right of all human beings to have access to clean water and sanitation at an affordable price*. Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.

Article 4 of the Berlin Rules stipulates that the states shall take steps to assure that persons likely to be affected are able to participate in the processes whereby decisions are made concerning the water management (International Law Association 2004, 12). “Management of waters” and “to manage waters” includes the development, use, protection, allocation, regulation, and control of waters (International Law Association 2004, 10). Further, in accordance with Article 18, states should assure that persons likely to be affected by water management decisions are able to participate in decision-making processes and have a reasonable opportunity to express their views on programs, plans, projects, or activities relating to waters. *The right to participate in governance* is expressed in numerous international human rights instruments, e.g., in the Universal Declaration of Human Rights and the International Covenant on Civil and Political Rights. The formulation of the right of participation, however, is up to each state as far as the arrangements assure genuine and serious consideration of the views of the citizens. In addition, Article 18 also introduces *access to information* as a prerequisite to participation in decision-making and to monitoring governmental and private activities. Access to obtain information is necessary for meaningful participation in water governance (International Law Association 2004, 24-25).

In accordance with the Berlin Rules (Article 20), the states should also take all appropriate steps to protect the rights, interests, and special needs of communities and of indigenous peoples or other particularly vulnerable groups likely to be affected by the management of waters. This should concern development of the waters both for the benefit of the entire state and of a group of states (International Law Association 2004, 26).

1.5 Structure, Overall Objective, Purpose and Results of the Study

In this study, we will explore the applicability of ***the principle of subsidiarity, multi-governance and resilience approach*** in the development and implementation of *institutional framework for regulatory governance, provision and production* of sustainable water services. The study is based on an extensive literature review and on our research team’s previous and on-going research.

The selected theoretical framework will cover institutions and institutional framework, subsidiarity principle, multi-level governance structures, sustainable development and green economy, and resilience. We will also carry out a short review on the state of water infrastructure in various countries. We will also make diagnoses of sustainable water services and viable water utilities. These diagnoses will be followed by a discussion part as well as by our conclusions and recommendations.

The overall objective of this study is intensified access to and progressive sustainability of water services, and substantially improved resilience and viability of water utilities worldwide.

The purpose of this study is to help and encourage designing and implementing of sound resilience of water utilities, and appropriate multi-level governance of water services.

The results of this study are our recommendations for: a) a definition of resilience of a water utility; b) a definition of a viable water utility; c) dialogue and compliance-restoring processes; and d) an institutional framework for regulatory governance, provision and production of sustainable water services.

2 THEORETICAL FRAMEWORK

2.1 Institutions, Institutional Arrangements and Institutional Framework

Berg (2013, 7) points out that numerous studies have addressed water utility performance both in developed and developing nations. The studies point out *the importance of the institutional factors* affecting those managing water utilities and those providing regulatory oversight: social structures (the political and cultural context), formal organizations (government ministries and regulatory authorities), and support systems (including political patronage and civil service). These external factors affect how conflicts are resolved regarding resource allocation, pricing, and access to water services. Obviously, these issues influence the internal governance of the water utilities.

The most popular definitions of an institution have at their core social factors that influence, to some extent, human behaviour (Davis 2009, 3). According to North (1991, 97) **institutions are the humanly devised constraints** that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and self-imposed codes of conduct), and formal rules (constitutions, laws, property rights). Together with the standard constraints of economics they define the choice set and therefore determine transaction and production costs. They evolve incrementally, connecting the pasts with the presents and the futures.[1]

Kemper (1996) points out that, in colloquial language, the expression "institution" also applies to organizations. For more clarity, she uses the term "institutional arrangement", which indicates the structural nature of institutions. According to her, *institutional arrangements and actors*, i.e., individuals, agencies and organizations, compose **the institutional framework**. According to Heikkila (2004, 97) the institutional arrangements can include enforced formal laws governing individual behavior, public and private organizational arrangements, as well as informal norms and standards shared among communities.

Because of the aforesaid *cognitive path dependence*, the scaffolding of the human landscape (i.e., the formation of institutions) also takes place in a path-dependent way. Once all of the players have formed the same mental models, the institutional mix may start solving a variety of social problems in a particular way. One can speak of the "increasing returns of an institutional framework" in the sense that once the problem solutions are learned by agents, they are unconsciously applied each time similar problems arise. This institutional path dependence may structure the economic game in a standardized way through time and lead societies to play a game that results in undesirable consequences (North 2000; Pierson 2000 cited by Mantzavinos, North and Shariq 2004, 81).

Andrews (2013, 82) uses the *iceberg metaphor* for reminding that "a large part of institutional logic is unseen or below the water line because it is informal". He further points out that institutional reforms can only work if they are tailored to the local context and therefore the so-called best-practice reforms tend to fail. North's definition implies that institutions are conceptually distinct from the behaviour they influence – the rules of the game are distinct from the way the game is played (Davis 2009, 4). Additionally, because the institutions make up the incentive structure of a society, they define the way the game is played through time.

In other words, policies consist of changes in formal institutions, but outcomes are a result of changes in both formal and informal rules as well as enforcement characteristics (Mantzavinos et al 2004, 77). Hence, according to Andrews (2013, 82), new institutions can be created that resemble iceberg tips with no foundation (Figure 1).

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[1] plural form used intentionally

The tip seems to be intact above the waterline, but because of lack of norms and cultural-cognitive fundamentals, it is only a matter of time until it sinks (Andrews 2013, 82). We should also recognize that informal institutions are produced internally – i.e., they are endogenous to a community (Lipford and Yandle 1997 cited by Mantzavinos et al. 2004, 79). Formal institutions, however, are imposed externally onto the community as the exogenous product of the evolution of relationships among rulers (Mantzavinos et al. 2004, 79).

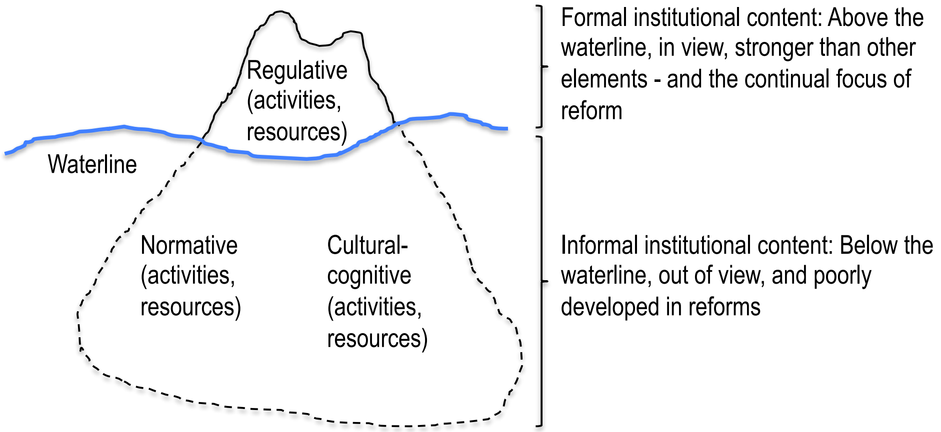


Figure 1. Reforms foster new institutions as foundation-less iceberg – the sinking kind (Andrews 2013, 82).

2.2 Principle of Subsidiarity

The general aim of **the principle of subsidiarity** is to guarantee a degree of independence for a lower authority in relation to a higher body or for a local authority in relation to central government. It therefore involves the sharing of powers between several levels of authority (European Parliament 2020).

According to Delchamp (1994, 7) "subsidiarity" is a fashionable idea today, although its meaning remains unclear. Merriam-Webster Dictionary (2021a) defines subsidiarity as follows: "*Subsidiarity, in [Wilhelm] Röpke's understanding, refers to the absolute right of local communities to take decisions for themselves, including the decision to surrender the matter to a larger forum. Subsidiarity places an absolute brake upon centralizing powers by permitting their involvement only when requested.*"

Subsidiarity was particularly asserted *as a central principle of social theory in the Catholic Church* by Pope Pius XI on 15 May 1931. He advocated for a social hierarchy starting with the individual, and progressing upwards to the community, to organizations and corporations, and finally the State. He recommended action at an individual or lower level, wherever possible, as being preferable to action at a higher level, such as at a community or corporate level (Evans 2013, 45).

The principle of subsidiarity can be defined as a principle by which *the smallest possible social or political entities should have all the rights and powers they need to regulate their own affairs freely and effectively* (Alen 2002 cited by Brouillet 2011, 605). Delchamp (1994, 8) emphasizes that the basic idea underlying the principle of subsidiarity is that political power should intervene only to the extent that society and its constituent parts, ranging from the individual to the family, the local community and various larger groupings, have not been able to satisfy the various needs.

Haapalainen (1990, 9) argues that in accordance with the subsidiarity approach the matters have to be decided on where they are known best. According to him, the principle of subsidiarity has mainly two dimensions. One dimension is the principle of centralization and the other dimension is the principle of decentralization, i.e., the matters should be resolved at the lowest possible level. Therefore, ultimately *as close as possible to the citizens*. Also Gernat (2013, 222) points out that the rationale behind subsidiarity is that actions are taken at the lowest level possible in order to ensure closeness to the people.

Yet, Jachtenfuchs and Krisch (2016, 18) reveal that subsidiarity has long had a variety of meanings, and the resulting vagueness has only contributed to the appeal of the concept. Different interpretations of subsidiarity have remarkably different institutional implications regarding the objectives of the polity, the domain and role of subunits, and the allocation of authority to apply the principle of subsidiarity itself (Follesdal 2011, 4). The effects of subsidiarity will largely depend, therefore, on the organizations that interpret the principle and give it meaning (Jachtenfuchs and Krisch 2016, 18). According to them subsidiarity is likely to have stronger decentralizing effects if lower-level actors play a significant role in its interpretation and policing.

According to Follesdal (2011, 8-9), there are several versions of subsidiarity, with very different implications for the allocation of authority. They differ as to the objectives of the member units and the central authorities, the domain and roles of member units such as states, how they allocate the authority to apply the principle of subsidiarity itself, and how they conceive of the relationship between different levels of political authority. He mentions some central variations: a) does the conception of subsidiarity stress the immunity of member units, or instead insist on the obligations of larger units to assist as they – or the member units - see fit? b) what are the fundamental units of normative concern? States – or individuals? c) who should have authority to specify the objectives and interests to be protected and promoted – and to determine whether more centralized action is required: the member units or central authorities?

Brouillet (2011, 605) argues that the responsibilities of the larger social and political entities should be *limited to the things that the smaller entities cannot accomplish alone*. It thus has a dual aspect: negative subsidiarity requires that a larger entity should not intervene in what a smaller one can do for itself; while positive subsidiarity requires that it must intervene to provide assistance when needed. Further, Delchamp (1994, 10-11) stipulates that the first meaning of the word "subsidiary" evokes *the idea of substitution*, hence something of secondary, lesser, importance. This means that the higher authority could intervene only to the extent to which the lower authority has shown or proved its incapacity. The second meaning evokes, however, *the idea of help* (subsidium) and has the idea of intervention. Therefore, a question of assessing arises, not if the authority has the right to intervene, but if it has the duty to intervene. This type of help enhances and authorizes the autonomy of the lower authority.

According to Burbridge (2017, 144), desire for devolution is a political preference about the way the state's authority should be distributed; it cannot be universalized as a principle and fails to recognize that inappropriate or inefficient decentralizations can in fact go against the principle of subsidiarity. Chaplin (2014, 72 cited by Burbridge 2017, 144) argues that subsidiarity is better understood as apolitical with respect to how the state should be structured: *"Subsidiarity is a call for social functions to be fulfilled, not at the lowest possible level but rather at the right level."* Chaplin (2014, 76 cited by Burbridge 2017, 144) points out further that all communities have a responsibility towards all other communities (and to persons) to offer them various kinds of help or service. The principle has not only a vertical but also a horizontal relevance. Therefore, subsidiarity is not a principle of decentralization, but rather, a principle of 'non-absorption'.

Follesdal (2014) describes that the paramount attribute of the principle of subsidiarity holds *that authority should rest with the member units unless allocating them to a central unit would ensure higher comparative efficiency or effectiveness in achieving certain goals*. According to him, however, this principle can be defined in several ways, for instance concerning which units are included, which goals are to be achieved, and who has the authority to apply it.

Barber and Ekins (2016, 9 cited by Burbridge 2017, 155) give a crucial notion about the relationship between subsidiarity and efficiency:

> *"Subsidiarity, by insisting on the worth of smaller associations, protects people's capacity to choose and pursue valuable activities within groups: individuals are more likely to be able to exercise control within smaller units than larger ones, and this capacity for control is morally valuable. Indeed, this benefit is such that it justifies a certain amount of inefficiency. Even if the activity would have been more effectively run by a state body, it will often be unjust to wrest control from the association's members. Subsidiarity is not reducible to a simple test of comparative efficiency because the exercise of local self-government is, in itself, sufficiently valuable to justify tolerance of some inefficiency."*

According to Evans (2013, 47), subsidiarity advocates a social order for the more efficient functioning of society. When individuals or subsidiary organizations are allowed to resolve the matters closest to them, larger organizations, such as the state, are exempted to carry out better the functions specifically allocated to them. The aim is that individuals are empowered and responsible for problems affecting them and close to them. At the same time, the state and its organizations can function more effectively, without overlap, and are able to more efficiently resolve matters pertinent to their respective spheres.

Evans (2013, 60) summarizes that the principle of subsidiarity can be used in a political context, although is best characterized as *a social and moral principle*. Subsidiarity advocates for greater participation of the individual in society. Therefore, the principle can be applied to enhance democracy and human rights by promoting the participation and dignity of the individual. The efficiency of the political system can be improved through decentralization and by ensuring that the most appropriate entities resolve problems closest to the problem autonomously and without interference or duplication from other entities.

Burbridge (2017, 159-160) also emphasizes that there are many ways to practice the principle of subsidiarity. He offers five distinct approaches to illustrate the diversity of possible approaches to practicing subsidiarity: *liberal, republican, utilitarian, relativist and virtue ethicist* (Table 1).

Table 1. Five possible approaches to practicing the principle of subsidiarity (Burbridge 2017, 162).

Approach to subsidiarity	**State-society relationship**
Liberal	State sets the terms for stable societal authorities
Republican	Society sets the terms for stable state authority
Utilitarian	All state and societal goals are commensurable through a principle of efficiency
Relativist	There is no possible commensurability between state and societal goals
Virtue ethicist	Commensurability between state and societal goals can be obtained through the practice of solving similar problems

Burbridge (2017, 161-162) believes that ***a virtue ethicist approach*** meets the demands of many points, if not all of points, raised in discussions regarding the subsidiarity. A virtue ethicist approach takes the practice of solving social problems as generative of *greater awareness of human needs, demands and capacities*. Consequently, this should create spheres of debate on what level of authority would best realize particular goods in tandem with debate on the meta-explanation of the aim of human society. The stance does not affirm incommensurability between community and state values, for it believes that communication about ends is part of the practice of human coordination. At the same time, a virtue ethicist refuses to place all activities on a single spectrum of efficiency, for associations can act towards diverse ends, each of which can be considered good in itself. The comparative mechanism is, therefore, irreducibly binary, for it asks if one aim will be better established by one actor or by the other, *or* asks which aim of two possible aims is best. It does not assume either the state or the associational group is better at decision-making in general. Regular dialogue on aims and means is part of *a generative practice* of human coordination, which in turn facilitates two-directional changes in authority structures, depending on what the common good requires. Primary group and subsidiary get to know each other not through legal codification but through *sharing the practice of solving social problems*. Box 1 shows the characteristics of a virtue ethicist approach.

In addition, a virtue ethicist approach provides a basis for acknowledging diverse group ends that are nevertheless in communication through the practice of deciding who decides (Burbridge 2017, 163-164).

Box 1. The characteristics of a virtue ethicist approach.

a) It does not affirm incommensurability between community and state values.
b) It refuses to place all activities on a single spectrum of efficiency.
c) It asks if one aim will be better established by one actor or by the other or asks which aim of two possible aims is best.
d) It does not assume either the state or the associational group is better at decision-making in general.
e) Any movement from one realm of authority to another must satisfy the method of binary evaluation.
f) One cannot excuse usurpation on the grounds of one authority type being in general more effective.
g) A declaration of incommensurability is insufficient grounds for usurpation of authority.
h) Regular dialogue on aims and means facilitates two-directional changes in authority structures, depending on what the common good requires.
i) Primary group and subsidiary get to know each other not through legal codification – which may, nevertheless, be a complementary by-product – but through sharing the practice of solving social problems.

Source: Burbridge 2017, 162.

Vischer (2001, 142) points out that subsidiarity, at its core, simply envisions a society in which *problems are solved and decisions made from the bottom up*. As a model of governance, subsidiarity offers no shelter to those who seek the unbridled expansion of centralized government, nor to those who disregard the need for a vital government role in making an empowered and connected citizenry a reality. Stripped of its partisan baggage, subsidiarity offers a model that – rooted in a social justice tradition that stresses both individual liberty and communitarian values – rejects the alienations of both the market and centralized government, embracing instead individuals and the mediating structures to which they belong.

2.3 Multi-level Governance Structures

Decentralization

According to Böckenförde (2001, III) one of the core functions of any constitution is to frame the institutions of government and to determine who exercises the power and authority of the state, how they do so and for what purpose. The constitutions, however, neither fall from the sky nor grow naturally on the vine. Instead, they are *human creations and products* shaped by convention, historical context, choice, and political struggle.

Decentralization is a political and technical process that is closely tied to national histories, priorities and capacities. A general description of decentralization is that it involves shifting a combination of political, fiscal and administrative responsibilities from central to sub-national governments, and also sometimes to civil society and the private sector. Decentralization is often described as part of democratic governance. It should enhance the roles that decentralized authorities play in local development and be conceptualized in terms of its impacts on the capabilities, accountability and responsiveness of *local governance* (UNDP 2009, 5).

Faguet (2011, I) explains that the most important theoretical argument concerning decentralization is that it can improve governance by making government more accountable and responsive to the governed. While the motivation for decentralization will often vary from state to state, the following two sets of objectives are the most prevalent (Böckenförde 2011, 4):

- to design efficient service delivery based on the principle of subsidiarity: services that can be effectively provided by lower levels of government should fall in their responsibility; to distribute public power broadly so as to achieve more effective and responsive government; to broaden access to government services and economic resources; and to encourage greater public participation in government; and
- to construct a government structure in which diverse groups can live together peacefully; and to allow stakeholders representing a minority or marginalized regions to identify their space in the system, thereby underpinning the stability of the state by persuading them to remain loyal.

Van Vliet, Chappels and Shove (2005 cited by Bell 2015, 6) analyze the role of infrastructure in shaping patterns of consumption, and the potential for alternative configurations of both technologies and organizations. They study various arrangements which cut through the conventional contradiction between centralized and decentralized systems. They reveal a move from centralized infrastructure provision and explore the potential for differentiation in infrastructure provision to lead to more sustainable modes of provision. They argue that the scale of management does not need, however, match the scale of technologies and service networks. Rather, it is possible for small scale technologies to be managed by large scale organizations, and small-scale organizations can act as providers and brokers for larger networks of provision.

According to Böckenförde (2011, 39) decentralization includes a formal and a substantive element. Whereas the formal element addresses the structural configuration of government, the substantive element concerns the actual depth of decentralization, perhaps best measured in terms of administrative, political and fiscal decentralization. The binary concept of a ‘federal’ or ‘unitary’ government does not indicate the strength of decentralization in a country; rather, it describes the legal relationship between the various levels of government. Federal systems often require legal safeguards to implement and protect self-rule and shared rule.

Omolo (2010, 16) defines these three fundamental dimensions of decentralization, i.e., administrative, political and fiscal decentralization as follows:

1. *Administrative decentralization* is the transfer of responsibility for the planning, financing and management of certain public functions from the central government and its agencies to field units of government agencies, subordinate units or levels of government, semi-autonomous public authorities or corporations or regional or functional authorities (Oloo 2006).
2. *Political decentralization* entails a movement away from a monocentric to a polycentric structure of political power and takes two forms, horizontal, where organizations that promote separation of powers and accountability of the Executive for its actions such as legislature, and the courts are strengthened. Vertical decentralization involves assigning powers to local government structures (Muia 2008, Oloo 2006).
3. *Fiscal decentralization* involves the transfer of financial resources from the central government to autonomous local agencies. It may be done directly through assignment of tax powers to facilitate the decentralized authorities to implement their responsibilities. Alternatively, it may be done indirectly through financial deregulation where regulation of financial organizations is shifted away from the major capitals (Oloo 2006).

There are also three main types of decentralization, namely: *de-concentration, delegation and devolution* (Rondinelli, Nellis and Cheema 1984). According to Omolo (2010, 16) these three types derive their identity from the three dimensions above, i.e., political, administrative and fiscal decentralization.

1) *De-concentration* is defined as administrative decentralization where the central government distributes responsibilities for certain functions to regional branch offices that implement decisions made at the centre. It also involves delegation of authority by the central government to subordinate levels of the government to make administrative decisions on behalf of the central government. The officers can be responsible in varying degrees for government policy within their territories (CKRC 2002; Oloo 2006 cited by Omolo 2010, 17).
2) *Delegation* means that the central government is passing the responsibility of decision-making and service delivery to semi-autonomous organizations, which are not completely owned by the government. The organizations can include local government, parastatals, the private sector and non-governmental organizations (NGOs) (Muia 2008 cited by Omolo 2010, 17).
3) *Devolution* is defined as a process where political, administrative and fiscal powers are distributed to semi-autonomous territorial or sub-national units (Muia 2008 cited by Omolo 2010, 17). Devolution is therefore broader than de-concentration since it encompasses more than just transfer of administrative powers. The authority to make public policy decisions in the political, administrative and fiscal spheres is conferred on the sub-national entities by law. The powers are usually determined by legislation rather that vested in the Constitution (CKRC 2002 cited by Omolo 2010,17).

Therefore, while de-concentration represents low autonomy and central accountability, devolution is based on high autonomy and downward accountability (Oloo 2006 cited by Omolo 2010, 17). In devolution, the sub-national entities are not directly accountable to central government although they have to perform their activities within statutes and rules set by it (Muia 2008 cited by Omolo 2010, 17). Yet, it also involves some degree of cooperation between different levels of the government (Mwenda 2010).

Federalism is formally stipulated decentralized governance within a nation's constitution (Barrett, Mude and Omiti 2007 cited by Omolo 2010, 17). The linkage between decentralization and federalism is from defining to what extent and type of services for which central government should transfer responsibility and resources to local levels. Both federalism and decentralization are based on *the principle of subsidiarity*, i.e., an idea that a central authority should have a subsidiary function, performing only those tasks which cannot be performed effectively at a more immediate or local level.

Multi-level governance

Hooghe and Marks (2002, 8) consider that beyond the adamant agreement that *efficient governance must be multi-level*, there is no consensus about how multi-level governance should be structured. The following concerns can thus be expressed:

a) Should jurisdictions be designed around particular communities, or should they be designed around particular policy problems?
b) Should jurisdictions bundle competencies, or should they be functionally specific?
c) Should jurisdictions be limited in number, or should they proliferate?
d) Should jurisdictions be designed to last, or should they be fluid?

Heikkila argues, however, that a public service industry, or a local public economy, should have **three components**. They are jurisdictions and organizations that ***provide*** a good or service, jurisdictions and organizations that ***produce*** or supply a service or good, and jurisdictions and organizations that *legislate and administer rules* ***governing*** provision and production (Oakerson 1999; Ostrom, V. and Ostrom, E. 1991; ACIR 1991 cited by Heikkila 2004, 102). According to Parks and Oakerson (2000, 170) local public economies research makes an important conceptual and practical distinction between provision of goods and services and their production. This distinction between service provision and production is given in Box 2.

Box 2. Provision and production.

Provision - Decisions made through collective-choice mechanisms:

1) The kind of goods and services to be provided by a designated group of people;
2) The quantity and quality of the goods and services to be provided;
3) The degree to which private activities related to these goods and services are to be regulated;
4) How the production of these goods and services is to be arranged;
5) How the provision and production of these goods and services is to be financed; and
6) How the performance of those who produce these goods and services is to be monitored.

Production - Production refers to the actual process of producing and delivering the services on which provision authority has decided:

1) The more technical process of transforming inputs to outputs − making a product, or in many cases, rendering a service.

Source: ACIR 1987 cited by Ostrom, Schroeder and Wynne 1993.

The planning of the multi-level governance can be done in accordance with *the principle of subsidiary* (Papunen 1986, 52 cited by Haapalainen 1990, 9). Haapalainen (1990, 9) points out that the principle of subsidiarity has two main dimensions: centralization and decentralization. The focus of the multi-level planning is on the system having multi-levels and multiple objectives. The principle of the multi-level planning is based on a two-way communication between the planning levels and also on the expression of their own development interests and objectives. The principle of the multi-level planning can thus be applied, as well as the principle of the subsidiarity, to the policy planning of societal systems to either promote centralization or to promote decentralization.

Heikkila (2004, 102-103) reveals that in contrast to *common-pool resources (CPRs) theory*, public service industry literature does not emphasize the physical boundaries of a resource or good as a criterion for identifying the appropriate scale of jurisdictions that provide or produce a service such as conjunctive management. When provision, production, and governance are separated, jurisdictions have opportunities to address a shared problem related to the management or use of a resource by coordinating service production. Therefore, interjurisdictional coordination can allow small-scale jurisdictions to engage in conjunctive water management in a way that eliminates the need for a large, centralized authority to encompass a large watershed.

According to Heikkila (2004, 111) *local public economy (or public service industry) theory* conceptualizes institutional boundaries as being formed around local problems that affect a group of individuals, rather than around a physical resource or good. Low, Ostrom, Simon and Wilson (2003, 108) argue that the presence of larger, overlapping jurisdictions is an important complement to the work undertaken by parallel, smaller-scale units. Larger units can back up the smaller units in several ways: 1) providing support at times of natural disasters; 2) addressing corruption or gross inefficiency; 3) providing scientific and technical skills to complement the local knowledge; 4) providing conflict resolution arenas for conflicts among parallel units; and 5) taking on functions that are generally more efficiently undertaken by larger units.

Hooghe and Marks (2002, 7) raise a criticism of large-scale government: *it cannot accommodate diverse citizen preferences*. Preferences of citizens may differ widely, and if one takes this heterogeneity of preferences into account, the optimal level of authority may be lower than economies of scale dictate. Therefore, they argue that multi-level governance allows decision-makers to adjust the scale of governance to reflect heterogeneity of citizen preferences.

Local systems may in general be *best able to verify local information, address locally specific conditions, and respond rapidly*. The checks and balances on local interests, however, may work best at greater-than-local levels. The fact that “redundant” local variations exist may mean that system-level responses may be more potent and rapid than otherwise, and/or that local variations may be able to meet unforeseen contingencies. Individuals who interact with others more frequently on a face-to-face basis, and know that future interactions are likely repeated, are more suitable to build trust and adopt forms of *reciprocity* than when interactions are more antonymous and infrequent. More experimentation can also occur when local units have some autonomy to create their own rules and policies. Some experiments may fail, but others can learn both from bad and good experiences (Low et al. 2003, 106-107).

Local government also provides an important *source of stability, equity, and voice*. The concerns with democracy, community, and equity should not, therefore, be destroyed by a singular focus on efficiency (Warner and Hefetz 2002, 86). Although efficiency is important, public service provision is also about equity, democracy, and community building (Frug 1999 cited by Warner and Hefetz 2002, 71). In addition, sustainable development of water systems needs to be examined as part of the public services and public good. Public good is not defined by the experts alone, but necessitates dialogue and community involvement (Takala 2017, 503).

Warner and Hefetz (2002, 71) give two major forms of market-based public service delivery in US metropolitan regions: 1) privatization, where local governments contract with private market suppliers to deliver public services, and 2) intermunicipal cooperation, where local governments contract with each other, creating a public market, to gain scale in service delivery. *Ensuring citizens equitable access and voice in public decision-making* is an important part of the public service. Market solutions to service delivery – private or public – must be assessed for their performance with respect to all three governance goals: efficiency, equity, and voice.

Warner and Hefetz (2002, 85-86) *caution against overreliance on markets* to organize regional service delivery and governance. One should notice that consumer voice and citizen voice are not the same. Market solutions rest on the logic of individual community self-interest, and this constrains their ability to address the broader collective well-being of the region. Consumers are price-takers in the marketplace, but citizens, through their governments, need to create the choices that build community. Local government provides an important source of *stability, equity, and voice*. The concerns with democracy, community, and equity should not, therefore, be destroyed by a singular focus on efficiency.

According to Tsanga Tabi (2016, 168) the achievement of public values hands over legitimacy to a public water utility having the responsibility for the production of vital services. These public values appear as a collective construction bringing together all the stakeholders in the management and the governance of the service and highlighting unchanging values that the society widely shares. Tsanga Tabi also points out that the difference between public and private management lies in the capacity of the actors *to encompass public values*. Further, her study shows that in a policy context where pursuing private economic interests conflicts with public goals, public values take precedence for the management and the regulation of the water service.

Regulatory governance

The basic terms concerning *governance, regulation and regulatory governance* are formulated in Box 3. The goal of good regulatory governance is to ensure that regulations *efficiently produce economic, social and environmental benefits*. This means in practice that widely defined benefits should justify widely defined costs, costs should be the minimum needed to produce any level of benefits, and resources should be allocated to their highest values. The most common objectives of good regulatory governance are identified as follows (Jacobs and Ladegaard 2010, 7):

1. *Effective:* The relationship between the goals of public policy and the results of the regulation. The closer the results of the regulation to clear goals, the more effective is the regulation.
2. *Efficient:* A scale representing the relationship between benefits and costs at any moment in time. Regulation that is efficient one day can be inefficient the next, as effectiveness, valuation of benefits, and opportunity costs change. Any reform that increases benefits while holding costs constant, or that reduces costs while holding benefits constant, increases efficiency.
3. *Transparent and accessible:* The capacity of stakeholders to understand the entire cycle of regulation through problem and goal definition, development, adoption, implementation and adjudication. The more easily and thoroughly a stakeholder can get information about the regulatory activities of a government, the more transparent are those activities. Among the transparency tools are consultation/engagement

methods that provide opportunities for stakeholders to participate in the development, monitoring, and revision of regulations. Opportunities should be "meaningful", that is, the information and views of stakeholders should be obtained in a way that is relevant, timely, and responsive to policy development.

Box 3. Defining Basic Terms in Regulatory Governance.

Governance: Rules, processes and behaviour that affect – through the process of decision-making and the structures and consultation systems that accompany such decision-making – how powers are shared and exercised in a state, particularly as regards openness, participation, accountability, effectiveness and coherence (EU 2001, C287/5; Ferris 2001, 3; Momen and Begum 2019 cited by Momen 2021, 1; Momen 2019 cited by Momen 2021, 1).

Regulation: The diverse authoritative set of instruments by which governments establish requirements on businesses, citizens and the public sector to intervene and shape the people's behaviour to bring desired behavior or outcomes in economy and society. Regulations include laws, formal and informal orders and subordinate rules issued by all levels of government, and rules issued by non-governmental or self-regulatory bodies to whom governments have delegated regulatory powers. The promulgation of an authoritative set of laws, predefined standards, tools, measures, orders and rules has to be accompanied by some mechanism for monitoring and promoting compliance with those rules (Jacobs and Ladegaard 2010, 6; Lodge and Wegrich 2012 cited by Momen 2021, 4; Levi-Faur 2011, 103 cited by Kjaer and Vetterlein 2018, 499; Momen 2019 cited by Momen 2021, 1).

Regulatory quality: A regulatory framework in which government agencies seek to develop and implement regulations and regulatory regimes that are efficient in both a static and dynamic sense in terms of using economic, social, and environmental resources to their greatest value; effective in terms of achieving a clear public policy purpose; transparent; and accountable for results. Flexibility is added to these quality standards, since regulatory rigidities in the face of changing context and needs are common and among the main contributors to regulatory failures (Jacobs and Ladegaard 2010, 6; OECD 2008).

Regulatory governance: A holistic term that refers: a) to the application of binding rules – including standard-setting, monitoring and sanctioning – by which governments can intervene in the activities of specific categories of economic, political or social actors in order to effectively regulate society and economy; and b) to the systematic implementation and operation of government-wide policies on how to use regulatory powers to produce quality regulation within the procedural values of the governing system (such as democratic processes). Good regulatory governance is grounded in the view that ensuring the quality of regulation is a permanent and essential role of government, not a one-off set of improvements, and that institutional capacities should be designed around a clear view of the appropriate use of regulation in society (Jacobs and Ladegaard 2010, 6; Kjaer and Vetterlein 2018 cited by Momen 2021, 3; ECPR 2021).

The Good Regulatory Practices (GRPs) generally refer to the *"systematic application of tools, institutions and procedures which governments can mobilize to ensure that regulatory outcomes are effective, transparent, inclusive and sustained."* According to Jacobs and Ladegaard (2010 cited by World Bank Group 2019, 12), GRP consists of four distinctive core elements:

Regulatory policy – an overarching political statement about how a government uses its regulatory powers. Modern policies include statements about the quality of regulations and regulatory procedures.

Regulatory institutions – the administrative and political bodies through which regulations are made, implemented, and adjudicated.

Regulatory quality tools and processes – the administrative and political procedures through which regulations are developed, adopted, implemented, monitored, and reviewed. Such procedures include use of regulatory impact analysis (RIA), public consultation mechanisms, and benchmarking and review tools such as the Standard Cost Model and "guillotine" reviews (a large number of regulatory instruments are reviewed against certain criteria, such as legality, necessity, and efficiency – World Bank Group 2019, 36).

Regulatory policy instruments and outputs – the legal instruments through which regulatory policy objectives are reached. They are found in the stock of existing regulations and the flow of new regulations adopted each year, and can include regulatory as well as alternative, nonregulatory policy instruments used to reach regulatory policy objectives. The policy instruments are outputs of the policies, institutions, and procedures.

Multi-level governance of water services in Finland

In Finland, the tasks and responsibilities with regard to water services have been allocated judicially to three levels of governance: *national, regional and municipal* (Ministry of Agriculture and Forestry 2020). Figure 2 conceptualizes the Finnish organizational framework for multi-level water services governance (regulatory governance, provision and production). This framework only covers those water utilities which are operating *under the Water Services Act (681/2014)*. In conformity with law, *the regulatory governance* activities have to be implemented at national, regional and municipal levels. *The provision* activities have to be carried out by the municipality. Therefore, in Finland, the regulatory governance of water services is carried out *de jure* at three levels of governance and the provision is implemented *de jure* at the lowest possible governance level. The current Water Services Act stipulates only that *production* activities have to be carried out by a water utility, and thus the utility can operate *de jure* and *de facto* at any governance level.

At the national level, *the Ministry of Agriculture and Forestry* is responsible for drafting the legislation. The jurisdiction of *the Ministry of the Environment* is to control the management of the environmental pollution and the quality of the environment. *The Ministry of Social Affairs and Health* is in charge of securing the quality of drinking water (Ministry of Agriculture and Forestry 2020).

The Ministry of Agriculture and Forestry is responsible for overall guidance and monitoring of the compliance and enforcement of the Water Services Act. The guidance of the ministry is administrative and predominantly focused on *the Centres for Economic Development, Transport and the Environment (ELY Centres)* at the regional level. Therefore, principally the oversight and execution of enforcement, inspection for complying rules and requirements, and guidance of the municipalities are implemented by ELY Centres (Beilinskij 2015, 38).

ELY Centres are responsible for the regional implementation and development tasks of the central government in Finland. ELY Centres are under the administrative branch of the Ministry of Employment and the Economy. They also deal with tasks coming under the administrative branches of the Ministry of the Environment, the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry, the Ministry of Education and Culture, and the Ministry of the Interior (ELY Centre 2020a). The Regional State Administrative Agencies (AVIs) are state authorities that handle permits under the Environmental Protection Act and the Water Act for activities with major environmental impacts or impacts on water resources (The European Federation of National Association of Water Services 2020, 29; Regional State Administrative Agency 2020).

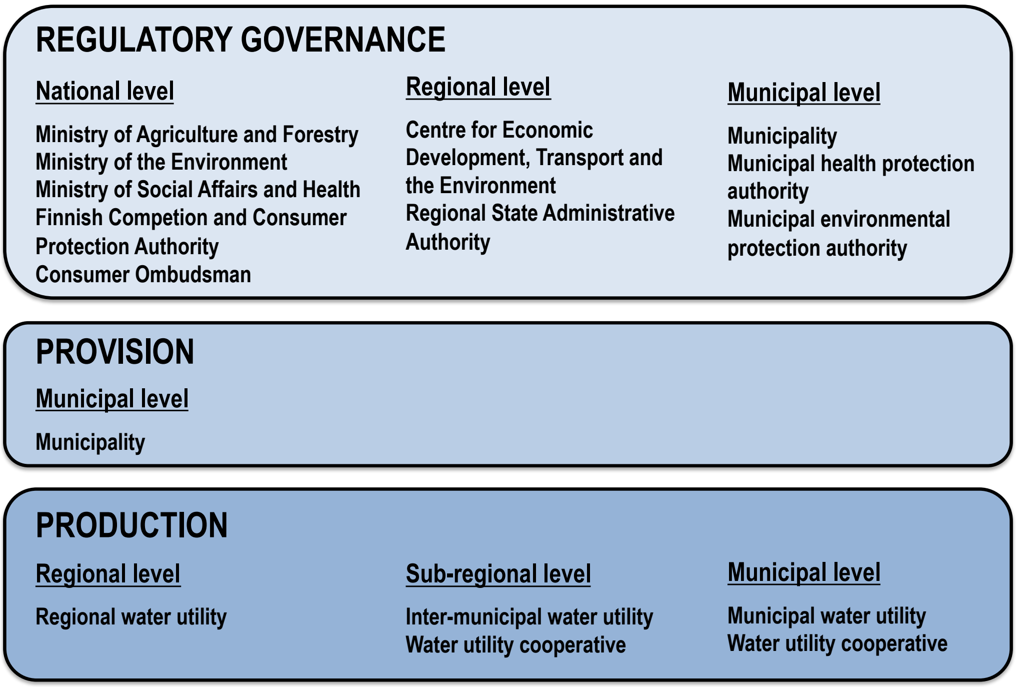


Figure 2. The conceptual organizational framework for multi-level water services governance (regulatory governance, provision and production) at national, regional, sub-regional and municipal levels in Finland.

ELY Centre is *a regulatory governance authority* within its territory concerning water services. ELY Centre is responsible for the execution of enforcement and inspection for complying rules and requirements with regard the municipalities and the water utilities. The Water Services Act does not define in detail the responsibilities of ELY Centre. Therefore, the regulatory responsibilities are based on the jurisdiction of ELY Centre (Beilinskij 2015, 38). In addition, the Act on Centres for Economic Development, Transport and the Environment stipulates that ELY Centres are, i.a., responsible for the tasks related to water resources management that are specifically allocated to them and *for overseeing the public interests* with regard to the environmental and water issues (Finlex 2009). In practical terms, ELY Centres are responsible for monitoring water services, for guidance of planning and targeting of financial support within their territories (Centre for Economic Development, Transport and the Environment 2013). In addition to overall promotion of environmental protection, ELY Centres also have permit and supervisory duties under the Environmental Protection Act, the Water Act and the Waste Act (ELY Centre 2020 b).

Other regulatory governance authorities in accordance with the Water Services Act are *the municipal health protection authority* and *the municipal environmental protection authority*. *The Finnish Competition and Consumer Authority* (FCCA) is not mentioned in the Water Services Act, but the jurisdiction of FCCA is to secure neutral competitive conditions and to safeguard water utilities' customers against utilities' abuse of a dominant position as it is prohibited in accordance with the Competition Act (948/2011). In accordance with the Water Services Act, also *the Consumer Ombudsman* is a specific supervisory authority, who oversees that the contractual terms concerning the water services conform to the Consumer Protection Act and other laws enacted to protect the consumers (Beilinskij 2015, 38).

The Water Services Act does not define the responsibilities of these authorities in detail, and in general their regulatory governance responsibilities are based on their specified jurisdictions. All regulatory governance authorities *oversee both the municipalities and the water utilities within their jurisdictions*. All these authorities can also impose coercive measures on water utilities, property owners and occupants, but only ELY Centre can impose a prohibition or an order on the municipality (Beilinskij 2015, 38).

The municipality is responsible for provision and overall development of water services (drinking water and wastewater) within its territory in accordance with the Water Services Act. The water services development has to cope with the urban and community development, and health and environmental protection requirements within the municipal territory. Therefore, the municipality has to provide appropriate measures for establishing a water utility competent to cope with the needs, for extending a water utility service area or for securing availability of other viable means for water supply and wastewater disposal (Beilinskij 2015, 41).

The municipality is also responsible for formulation, specifying and designation of *the water services area*. The water services area has to be viable both for the water utility and the property owners and occupants. In addition, the designated responsible water utility should be able to produce the services cost-effectively and adequately, and the water services charges should be *affordable, fair and equal* (Beilinskij 2015, 13). Also, the rationale for charges and cost recovery has to be *transparent*. In the long term, however, the water services and stormwater charges have to cover all new, repair, renovation and renewal/replacement investments of a water utility, as well as operating costs. In accordance with *the cost recovery principle*, the charges have to correspond as far as possible to the actual costs of the water services. Cost recovery ensures that the water utility has economic and financial capability to fulfill its tasks through sufficient revenue generation. Therefore, not more than a reasonable rate of return may be included in the charges. The most essential aspect regarding cost recovery is that the rate of return should not compromise sufficiency of the repair, renovation and renewal/replacement investments (Beilinskij 2015, 34).

In addition, Beilinskij (2015, 34-35) insists that all investments in new infrastructure and in repair, renovation and renewal/replacement of existing infrastructure as well as the operating costs stipulated in the Act have to be understood comprehensively. For example, the capital expenditures in construction and extension of the networks or in the acquisition of equipment are considered new investments. All the utility's investments in the maintenance, such as major renovation investments in the network are considered as repair investments. The costs shall include all expenditures directly related to the operations of the utility. They include both operating expenditure and capital costs. In addition to the financial cost, also environmental and resource costs can be included in accordance with Article 9 of the European Union's Water Framework Directive. Notwithstanding the cost recovery principle, the Act permits *the financial support* for the water services from the funds of the municipality, the State and the European Community.

The municipality has to *collaborate* with all water utilities within its territory, with the bulk water suppliers delivering water to the utilities, with the plant operators treating wastewaters from these water utilities and with other municipalities. The municipality also has to *participate* in the general planning for supramunicipal water services development that can cover inter-municipal, or other defined sub-regional and regional area. The municipality has the statutory duty to designate and authorize the utility service area. The roles and responsibilities of the municipality and the water utility are *independent and separated* irrespective of whether the municipality owns the utility (Beilinskij 2015, 10-18). The municipalities are also responsible for supervision of the water utilities (Ministry of Agriculture and Forestry 2020).

The water utility is responsible for taking care of water services infrastructure, service production and delivery, i.e., that water services infrastructure is constructed, operated and maintained cost-effectively and with due diligence within the utility's designated service area. The property owners or the occupants of properties have an overall responsibility for taking care of the properties' water and wastewater systems and appliances. This rule is important from the point of responsibility to maintain the house connections in good condition (the authors' note). As a general rule, the property inside the service area has to be connected into the utility's water and sewer networks. When the property is located outside the service area, the property's obligations to take care of water supply and wastewater treatment/disposal are not stipulated in the Water Services Act but in other legislation (Beilinskij 2015, 10-18).

In accordance with the Water Act, a water utility is an entity which takes care of the community water services (water and/or wastewater) and has a service area designated by the municipality. The Water Act is applied to all these water utilities regardless of their ownership or the organizational model (Beilinskij 2015, 8). Although the Water Act is not applied to a water utility responsible for water services but operating without a designated service area, there are several other laws applicable for utility's operations, for example, the Water Act, the Health Care Act, the Environmental Protection Act, the Competition Act and the Consumer Protection Act (Beilinskij 2015, 9).

The water utility has to identify and be aware of the risks associated with *the raw water quantity and quality* as well as of *the condition of the capital assets*. Therefore, the utility has to monitor the quantity and quality of the raw water, the condition of the assets, and the quantity of leakages and inflows in water distribution and sewer networks. The maps of the network locations have to be in digital form. During emergencies and disruptions, the water utility is responsible for maintaining water services of the properties connected to the utility networks. In order to secure the availability of the services, the utility has to *collaborate* with other water utilities connected into the common network, and with the municipality, the municipal regulatory authorities, the rescue authorities, the contractual partners and the customers. The water utility has to prepare an emergency response plan and start implementing the necessary response measures and actions in accordance with this plan (Beilinskij 2015, 18).

2.4 Sustainable Development and the Green Economy

Sustainable development

The Brundtland Report (BR) introduced the concept of *sustainable development* to the international community in 1987 as a new paradigm for economic growth, social equality and environmental sustainability. The BR argued that sustainable development can be achieved by an integrated policy framework embracing all three of those pillars. Sustainable development is not a destination, but *a dynamic process* of adaptation, learning and action. It is about recognizing, understanding and acting on interconnections – above all those between the economy, society and the natural environment. (United Nations Secretary-General's High-level Panel on Global Sustainability 2012, 6)

The BR specified that sustainable development is development that *meets the needs of the present without compromising the ability of future generations to meet their own needs*. It comprises two key concepts: the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs (WCED 1987a, 41).

According to Elkington (2004 cited by Rodriguez-Nikl, Comber, Foo, Gimbert-Carter, Koklanos, Lemay, Maclise, VanGeem and Webster 2015, 6) two definitions are commonly offered for sustainability within the civil engineering profession. First, the Report of the

World Commission on Environment and Development, Our Common Future (the BR) defines sustainability as shown in the previous paragraph (WCED 1987b). Second, the Triple Bottom Line (Figure 3) views sustainability as satisfying three objectives: not only economic but social and environmental as well. This is also referred to as People-Planet-Profit or the Three Pillars of Sustainability.

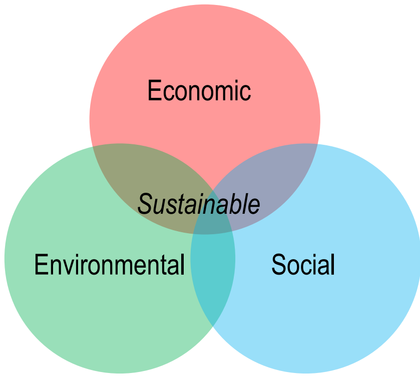


Figure 3. Triple Bottom Line (Elkington 2004).

According to Turner II (2010, 572) sustainability addresses threats to provisioning society and to maintaining life support systems, and decision-makers want to know these threats and their implications, including the capacity (or adaptive capacity) of the system, foremost the human subsystem, to withstand and adjust to them.

A single blueprint of sustainability cannot be found, as economic and social systems and ecological conditions differ widely among countries. Each nation will have to work out its own concrete policy implications. Yet irrespective of these differences, sustainable development should be seen as a global objective (WCED 1987c, 39). The overall objective of integrating environment and development at the policy, planning and management levels in Agenda 21 is to improve or restructure the decision-making process so that consideration of socio-economic and environmental issues is fully integrated, and a broader range of public participation assured (UNCED 1992, 64). The linked basic needs of housing, water supply, sanitation, and health care are also environmentally important (WCED 1987a, 50).

The Green Economy

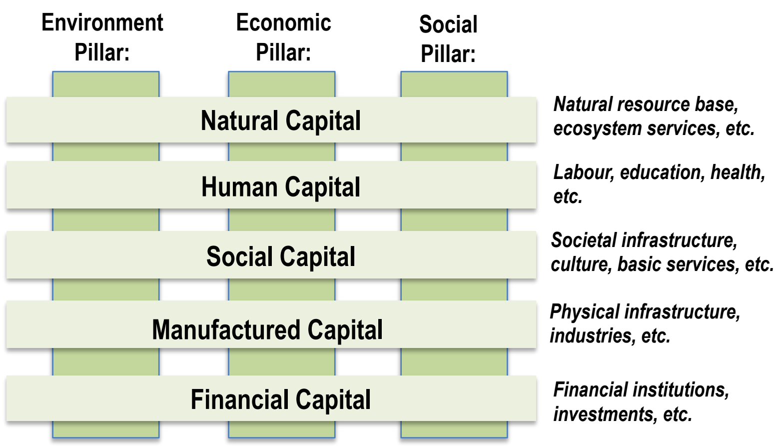
The United Nations Conference on Sustainable Development (UNCSD) took place in Brazil in 2012 to mark the 20th anniversary of the 1992 United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, and also the 10th anniversary of the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg. The aim was to define pathways to a safer, more equitable, cleaner, greener and more prosperous world for all, in particular with the help of one important tool available in the context of sustainable development and poverty eradication – *the green economy*. The outcome document "The Future We Want" recognized that water is at the core of sustainable development as it is closely linked to a number of key global challenges. In particular, the report underlined the critical importance of water and sanitation within the three dimensions of sustainable development (United Nations 2012, 32).

Infrastructure is a cornerstone of the economy and the most basic infrastructure is that for water services. Clean, safe water – whether for drinking and cooking or for industrial and manufacturing purposes – is needed by every citizen and business (North Carolina State

Water Infrastructure Authority 2017, 1). Therefore, access to reliable, clean water and adequate sanitation services for all is *a foundation of a green economy* (UNEP 2011a, 116). Water is fundamental to the green economy because it is interwoven with so many sustainable development issues, such as health, food security, and poverty. The multiple benefits of providing access to water and sanitation in terms of health, life expectancy, and the freeing of time for education and economic activities, are well known (UN-Water 2012a, 5).

Direct benefits to society can be expected to flow both from increased investment in the water and sanitation services sector, including investment in the conservation of ecosystems critical for water. Research shows that by investing in green sectors, including the water sector, more jobs and greater prosperity can be created. These opportunities are likely strongest in the communities where people still lack access to improved water and sanitation services. Early investments in these services appear to be a precondition for progress. Once these investments are made, the rate of progress will be faster and more sustainable, thus making transition to a green economy possible. The costs of achieving a transition will be much less if the increased investment is accompanied by improvements in governance arrangements, the reform of water policies and the development of partnerships with the private sector. The opportunity to improve governance arrangements is one of the biggest opportunities to speed transition to a greener economy (UNEP 2011a, 146).

Seeking to improve the effectiveness and scale up the impact of activities for sustainable development, green economy focuses on enablers that cut across the three pillars of environment, economic and social development. These enablers refer to resources or different types of capital that are employed to advance implementation of sustainable development and deliver results in its three pillars or domains. This more integrated approach does not require any change to the established definition of sustainable development, nor does it seek to substitute the three pillars. It focuses on environment as a driver for economic growth, and ecosystem services that can be valued in economic terms. Using the idea of five capital types as enablers that cut across the three pillars of sustainable development, the approach can be presented schematically as shown in Figure 4 (United Nations 2011, 41).



Note: Five "enablers" that cut across the three pillars of sustainable development to deliver "results" in each of the environmental, economic and social domains.

Figure 4. Drivers for green growth (United Nations 2011, 41).

Sustainable development provides important context for *green growth*. Green growth is not a replacement for sustainable development but should rather be considered a subset of it

(OECD 2011b, 5). According to Rotmans, the green economy not only deals with the new technological solutions, but it also requires *sustainable ways of living, new institutions, and cultural changes* (Rotmans 2012 cited by Hatakka 2013, 5). The concept of a green economy is not a replacement for that of sustainable development, but rather a way of conceiving the contribution of economic activities to sustainable development. If sustainable development is the *"what,"* a green economy is the *"how"* (Federation of Canadian Municipalities 2011, 10).

There is, however, no internationally agreed definition or universal principles for green economy and, therefore, interrelated but different terminology and concepts have emerged over recent years. Allen and Clouth (2012, 63-64) gave several definitions developed by different organizations for the green growth and the green economy. Based on the review of emerging literature using a green economy policy typology, policies that were proposed in most of the publications included public investment in infrastructure (such as sustainable energy, water, transport and waste) as well as public investment in innovation (through measures such as funding for R&D and deployment) (Allen 2012, 40).

At the operational level, green economy is seen as one whose growth in income and employment is driven by investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. These include investments in human and social capital. The central position of human well-being and social equity as core goals are also recognized. By definition, green economic objectives need to be aligned with the sustainable development agenda. Affirming sustainable development as overall goal, green economy also represents an attempt to mobilize more action-oriented, mainstream and bottom-up pathways to sustainable development (United Nations 2011, 31).

The transition to green economy presents, however, a triple challenge (Figure 5, UNEP 2012, 15). First, there is a need to focus on the economy, finding ways to increase prosperity without increasing resource use and environmental impacts, i.e., being more resource-efficient. Resource efficiency cannot guarantee steady or declining resource use or sustainability: the world could become more efficient but still put excessive demands on the environment. Therefore, the second challenge, to achieve sustainability, is the need to maintain ecosystem resilience, which is governed by the status, trends and limits of natural systems. The third element is human well-being, including health, employment, job satisfaction, social capital and equity. This also includes a fair distribution of the benefits and costs of the transition to the green economy. In balancing environmental, economic and social elements, the green economy concept evidently has much in common with some models of sustainable development, which sees the triple challenge of economic efficiency, ecological sustainability and social equity (UNEP 2012, 15).

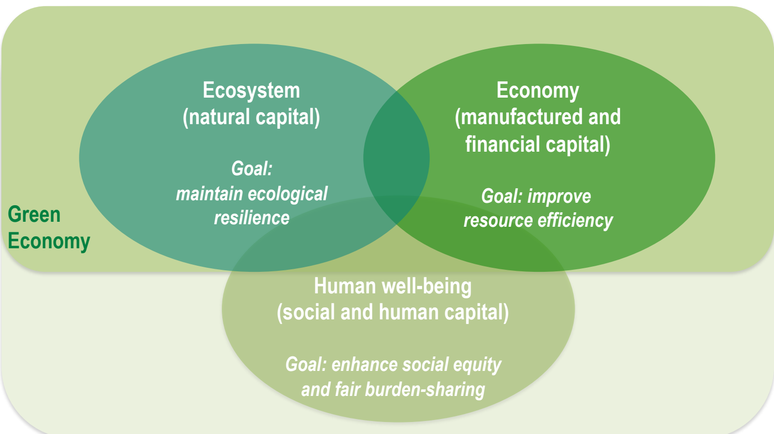


Figure 5. Creating a green economy: a triple challenge (UNEP 2012, 15).

Innovation

According to OECD (2011b, 4) green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies. To do this it must catalyze investment and innovation which will underpin sustained growth and give rise to new economic opportunities. OECD (2011b, 10) emphasizes that societies become dependent on institutions and technologies with which they are familiar. Social and economic inertia can be so strong that even a change that could provide a large benefit will not change behaviour. Therefore, ***innovation*** plays a key role in a green growth strategy by breaking dependence on established ways of doing things.

Schumpeter (1934 cited by OECD and Eurostat, 2005, 29) has introduced the modern basis for theories of innovation. He argued that economic development is driven by innovation through a dynamic process in which new technologies replace the old, a process he labelled "creative destruction". He pointed out that "radical" innovations create major disruptive changes, whereas "incremental" innovations continuously advance the process of change.

In the Oslo Manual, eco-innovation is defined as *"the creation or implementation of new, or significantly improved, products (goods and services), processes, marketing methods, organizational structures and institutional arrangements which – with or without intent – lead to environmental improvements compared to relevant alternatives"* (OECD and Eurostat 2005, 46). Eco-innovation can be understood and analyzed in terms of an innovation's 1) target, 2) mechanism, and 3) impact. Figure 6 presents an overview of eco-innovation and its typology (OECD 2009b, 13).

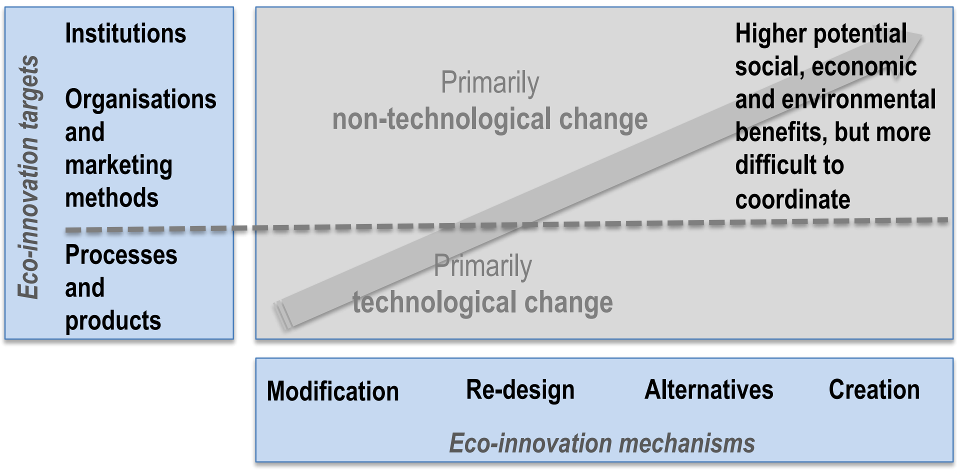


Figure 6. The typology of eco-innovation (OECD 2009b, 13 modified by Hukka, Nyanchaga and Katko 2016, 267).

In this definition, eco-innovation is not limited to environmentally motivated innovations but includes "unintended environmental innovations". Institutional eco-innovations such as changes in values, beliefs, knowledge, norms, and administrative acts are included, along with changes in management, organization, laws and governance systems that reduce environmental impacts (UNEP 2011b, 36). Innovation, therefore, is *not simply about technological solutions* ('techno-fix' approach). Rather, innovation is a process that has three different forms with different outcomes (UNEP 2011b, 38):

1) *Technological innovations* providing specific techniques for managing/processing materials and energy;
2) *Institutional innovations* for managing on a society-wide basis – or even globally – incentives, transaction costs, rents, benefit distribution, dispersal, contractual obligations, precautions, and individual obligations; and
3) *Relational innovations* for managing cooperation, social cohesion, solidarity, social learning and benefit sharing.

2.5 Resilience Approach and Thinking

Governments began in the beginning of 21st century to shift the focus from critical infrastructure protection to **critical infrastructure resilience** in order to adjust these policies to this changing risk landscape (OECD 2019, 36). The resilience focus does not preclude protection, or security considerations. It rather *broadens the lens of critical infrastructure frameworks* by integrating concepts such as adaptability, flexibility and robustness (Flynn 2008; Barami 2013 cited by OECD 2019, 36). Woods uses the term *robustness* to refer to systems that are designed to effectively handle known failure modes (Resilience Engineering Association 2021).

While the common definition of sustainability focuses on future developments in regular conditions, resilience refers to *the capabilities of a community reacting to an abnormal impact*. Both concepts address a holistic view and deal with the assessment of an infrastructure system. On the other hand, sustainability is more related to an environmental orientation and the reduction of impacts on the environment, while resilience deals with extreme events and disaster management. While sustainability aims to reduce impacts and resources and, more generally, to satisfy the needs of today's generation without living at the expense of future generations, resilience aims to achieve the robustness and rapid recovery of systems. Therefore, Bocchini, Frangopol, Ummenhofer and Zinke (2014, 1) suggest that *resilience and sustainability are complementary* and should be used in an integrated perspective.

Folke (2016, 13) stipulates that resilience thinking is *an integrative approach for dealing with the sustainability challenge*. Biggs, Schlüter and Schoon (2015 cited by Folke 2016, 8) see resilience as *the capacity of a social-ecological system to sustain human well-being in the face of change, by persisting and adapting or transforming in response to change*. A central challenge in this context is the capacity of social-ecological systems to continue providing key ecosystem services that underpin human well-being in the face of unexpected shocks as well as gradual, ongoing change. According to Folke (2016, 8), resilience as a system property should not be reduced to a simple metric, but different types of metrics and indicators need to be used and combined to capture facets of resilience and help guide management and governance.

According to Bocchini et al. (2014, 4) resilience is *the ability of human communities to withstand external shocks or perturbations to their infrastructure and to recover from such perturbations*. This definition introduces two paramount aspects. First, when dealing with civil engineering, resilience is *a property of communities* rather than structures or infrastructures. Second, resilience is not only about being able to withstand a certain disturbance, but also about having resources and means for a prompt, efficient, and effective recovery.

Researchers in different fields, including psychology, economics, ecology, and highly complex engineering systems have sought to apply the resilience concept to the systems they study. There are almost as many definitions of resilience as there are people defining it (Moteff 2012, 2). We will introduce some of these definitions below.

Based on the three pillars of sustainability and extending from the physical infrastructures to include the socio-economic and environmental, the UNISDR broadened the definition of resilience as: *"the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions."* Resilience means the ability to "resile from" or "spring back from" a shock. The resilience of a community in respect to any hazard or event is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need (UNISDR 2009, 24 cited by DESURBS 2014, 4)

The United Nations Office for Disaster Risk Reduction (UNDRR 2021) defines resilience as follows: *The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management.*

The Critical Five countries (Australia, Canada, New Zealand, the United Kingdom and the United States) recognize resilience as *the need for systems to have the capacity to be flexible and adaptable to changing conditions, both foreseeable and unexpected, and to be able to recover rapidly from disruption.* Similar to critical infrastructure resilience, one can reach a common definition for critical infrastructure security. It is implied that the end goal of security is to use physical, personnel and/or cyber defense measures to reduce both the risk to critical infrastructure and the risk of loss due to a disruption in essential services by minimizing the vulnerability of critical infrastructure assets, systems and networks (Critical 5 2014, 3).

According to OECD (2014, 27) resilience can be defined as *the capacity of critical infrastructure to absorb disturbance and reorganize while undergoing a change so as to still retain essentially the same function, structure, identity, and feedbacks*.

In England and Wales, The Water Services Regulatory Authority (Ofwat 2015, 6) definition for resilience of water utilities is: *"Resilience is the ability to cope with, and recover from, disruption, and anticipate trends and variability in order to maintain services for people and protect the natural environment, now and in the future."* Ofwat's resilience objective is given in Box 4 (Ofwat 2015, 3).

Box 4. The Water Services Regulatory Authority in England and Wales: Resilience objective.

The resilience objective is:

a) to secure the long-term resilience of water undertakers' supply systems and sewerage undertakers' sewerage systems as regards environmental pressures, population growth and changes in consumer behaviour; and
b) to secure that undertakers take steps for the purpose of enabling them to meet, in the long term, the need for the supply of water and the provision of sewerage services to consumers,

including by promoting–

i. appropriate long-term planning and investment by relevant undertakers; and
ii. the taking by them of a range of measures to manage water resources in sustainable ways, and to increase efficiency in the use of water and reduce demand for water so as to reduce pressure on water resources.

Source: Ofwat 2015, 3.

According to the administration of Barack Obama (2013, 11) the term "resilience" means *the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.* Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents.

Resilience is *a measure of the ability to adapt to changes and recover from disturbances, while providing options for future developments* (Fiering 1982; Hashimoto et al. 1982; Holling 1973; Walker et al. 2004).

The 2009 National Infrastructure Protection Plan of the Department of Homeland Security of the United States defines resilience as *"the ability to resist, absorb, recover from, or successfully adapt to adversity or a change in conditions"* (DHS 2009, 111).

According to Presidential Policy Directive-21 the term "resilience" means *the ability to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions.* Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents (The White House 2013).

In accordance with the definition by Holling, resilience is *the competence of a system to absorb changes and disruptions, and yet to maintain simultaneously its functionality.* This definition underlines the idea of the stability of the system's functions and structure: The weaker the system's resilience is, the less it can resist the disruptions (Holling 1973 cited by Nieminen, Talja, Heikkilä, Airola, Viitanen and Tuovinen 2017, 13)

Nieminen et al. (2017, 10) consider resilience as a holistic perspective on the organization's activity. They define resilience as follows: *The competence of an organization to adjust and change its activity in continually changing operational environment both by forecasting change and responding to it.* Resilience may also be a result from the ways and procedures of doing things which are not intentionally aimed at increasing resilience. The organization's resilience is a result of a complex interaction of these planned and unplanned actions increasing flexibility for change and adaptability (Nieminen et al. 2017, 4).

The Resilience Alliance defined the term as: *"The ability to absorb disturbances, to be changed and then to re-organize and still have the same identity (retain the same basic structure and ways of functioning)."* It includes the ability to learn from the disturbance. A resilient system is forgiving of external shocks. As resilience declines, the magnitude of a shock from which it cannot recover gets smaller and smaller. Resilience shifts attention from purely growth and efficiency to needed recovery and flexibility. Growth and efficiency alone can often lead ecological systems, businesses and societies into fragile rigidities, exposing them to turbulent transformation. Learning, recovery and flexibility open eyes to novelty and new worlds of opportunity" (Bach, Bouchon, Fekete, Birkmann and Serre 2013, 2-3).

Today, the Resilience Engineering Association considers resilience as *a system's competence to transform its activity before the occurrence of the event, during the occurrence of the event or after the occurrence of the event, and successively to maintain its functionality.* This kind of resilience is supported by the organization's or the system's ability to predict the changes, to monitor the environment and the system itself, to cope with disruptions and to learn from the experience gained (Hollnagel 2011 cited by Nieminen et al. 2017, 15).

Woods (2018a, 4) has developed *a theory of graceful extensibility* that explains the contrast between successful and unsuccessful cases of sustained adaptability. The theory of graceful extensibility is the ability of a system to extend its capacity to adapt when surprise events challenge its boundaries. Graceful extensibility is the opposite of brittleness, where brittleness is a sudden collapse or failure when events push the system up to and beyond its boundaries for handling changing disturbances and variations. As the opposite of brittleness, graceful extensibility is the ability of a system to extend its capacity to adapt when surprise events challenge its boundaries. All systems have an envelope of performance, or a range of adaptive behavior, due to finite resources and the inherent changing variability of its environment.

According to Woods (2018a, 29) resilience as graceful extensibility asks the question: *how does a system function and adapt when events produce challenges at and beyond its boundaries?* Observing/analyzing how the system has adapted to disrupting events and changes in the past provides the data to assess that system's potential for adaptive action in the future when new variations and types of challenges occur. The empirical foundation for the theory comes from analyzing past cycles of adaptation to disrupting events and analyzing how the system stretched to accommodate or take advantage of the reverberations arising from those events.

Continual improvement only operates far from saturation. It does not continually reduce the potential for surprise. But such improvements do change facets of the potential for surprise leading to the need to re-adjust the response capabilities (and required resources) needed to handle the new forms of surprise. Improving performance far from saturation (i.e., exhausting a unit's range of adaptive behavior or capacity for maneuver as that unit responds to changing and increasing demands) does not consume a larger and larger share of the variability to be accommodated. There are always events and changes occurring outside the current envelope that challenge and fall outside of base capacity to handle. Continual improvement does not guarantee a reduction in the potential for surprise, but continual improvement does change what contributes to the potential for surprise and therefore what response capabilities are needed to support graceful extensibility. Thus, some capacity for graceful extensibility is always present and needed; the nature of that capacity, and the resources required, moves around as the world changes and as the base capacity changes. When base adaptive capacity changes, the risk of saturation remains real. Changes in base adaptive capacity affect what threatens saturation and affect where and how graceful extensibility is needed to produce sustained adaptability. The theory highlights how both forms, *base and extensible*, are necessary. As a result, the theory of graceful extensibility *reframes optimality and pursues optimization* (Woods 2018a, 38-39).

UNDRR (2021) defines *the disaster risk governance* as follows: *The system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee disaster risk reduction and related areas of policy.* Good governance needs to be transparent, inclusive, collective and efficient to reduce existing disaster risks and avoid creating new ones. According to UNDRR (2021) *disaster risk management* is: *The application of disaster risk reduction policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of resilience and reduction of disaster losses.*

Having accurate information and analysis about risks is essential to achieving resilience. Resilient infrastructure assets, systems, and networks must also be *robust, agile, and adaptable*. Mitigation, response, and recovery activities contribute to strengthening critical infrastructure resilience. Security and resilience are strengthened through *risk management* which is *the "process of identifying, analyzing, and communicating risk and accepting, avoiding, transferring, or controlling it to an acceptable level at an acceptable cost* (DHS 2013, 7).

Barami (2013 cited by OECD 2019, 38-39) emphasizes the complex and multi-faceted nature of critical infrastructure resilience. Barami applies a risk-based and layered approach accounting for complex infrastructures interdependencies, while considering potential solutions applicable through the infrastructure system lifecycle (i.e., design, construction, and operation). Resilience is therefore defined not as a single outcome or an exclusively post-disaster recovery capability but rather *as a dynamic process that applies a risk and lifecycle-based method for addressing the vulnerabilities of critical infrastructure systems, making systems more fault-tolerant, more efficient, smarter, and better able to adapt to unexpected challenges*. Only a risk-based and layered approach can account for complex infrastructures interdependencies, while considering potential solutions applicable through the infrastructure systems across the lifecycle.

Volpe (2013, 2) considers that resiliency is a process for managing complex infrastructures. Volpe points out that resiliency is not a single outcome, but it is a cradle-to-grave process for engineering, building, and operating a fault-tolerant, safe, secure, smart, efficient, and sustainable infrastructure system. Resiliency is *a risk-based and lifecycle process for addressing the vulnerabilities of our critical infrastructure systems, making the system work smarter and better able to adapt to unexpected challenges.* Resiliency is not just about a post-disaster capability for rapid recovery, nor is resiliency only about protecting assets.

According to Volpe (2013, 5), by approaching infrastructure asset management in accordance with a systematic process of engineering system resiliency, we are more likely to have a safe, efficient, survivable, and sustainable infrastructure system. The outcome of instituting a resiliency process is that the infrastructure systems that are engineered in accordance with these principles are likely to meet three high-level performance criteria: *efficiency, sustainability, and survivability*:

- *Efficiency.* This criterion requires that an infrastructure system perform its functions in order to meet its specified functional requirements (technical efficacy) at lowest cost (cost-effectiveness).
- *Sustainability.* This performance criterion evaluates the extent to which the system uses resources – natural, human, and manufactured – in a sustainable manner. Sustainability is defined as a resource-use pattern that meets today's needs while protecting resources for future use. To be sustainable, critical infrastructures must be designed and operated within the context of their impacts on the surrounding ecosystems, now and in the future.
- *Survivability.* A third key performance criterion for resilient infrastructure is the ultimate test of safety, security, and survival of the people, infrastructure assets, and the ecosystem. In accordance with this criterion, an infrastructure meets the resiliency standards if it is capable of withstanding damages with minimal adverse impacts – lost lives, ecological impacts, structural damage – on the people, transportation operations, economy, and the environment.

Resilience can be boosted through any measure that contributes to increasing the capacity of systems to resist the negative impacts of disruptive shocks and to enabling a fast re-establishment of the core functions of a system after a disruptive shock. Therefore economic, environmental and social conditions in general influence the level of resilience (OECD 2014, 51). According to OECD (2011c cited by OECD 2019, 36-37), ensuring the resilience of critical infrastructures is done by ensuring the combination of several key qualities:

- *Robustness* describes the ability to keep operating or to remain standing in the face of disaster. This entails designing structures or systems, which are strong enough to sustain a foreseeable shock. It also entails investing in and maintaining elements of critical infrastructure so that they can withstand low probability but high-consequence events.
- *Redundancy* describes the ability to keep operating through a substitute or redundant systems that can be brought to bear should something important break down or stop working.
- *Resourcefulness* describes the ability to skillfully manage a shock event as it unfolds. This includes identifying options, prioritizing what should be done both to control damage and to begin mitigating it, and communicating decisions to the people who

will implement them. Resourcefulness depends primarily on people, not on technology. Rapid recovery is the capacity to get things back to normal as quickly as possible after a disaster. Contingency and business continuity plans, efficient emergency services, and the means to get the right people and resources to the right places are crucial.

- *Adaptability* describes the means to absorb new lessons that can be drawn from a catastrophe. It involves revising plans, modifying procedures, and introducing new tools and technologies needed to improve robustness, resourcefulness, and recovery capabilities before the next crisis.

According to Bach et al. (2013, 3) applying the concept of resilience as defined in the socio-ecological approach to critical infrastructures (CIs) can be of great value. Shifting the focus away from the maintenance and equilibrium of the infrastructure system towards *the delivery of system services and its external relations* permits a better consideration of external effects and changes as well as interaction with other systems, in this case society. They argue that with regard to the society and CIs, resilience strategies need to integrate the potential failure of infrastructure services instead of focusing only on their robustness and reliability (Bach et al. 2013, 7).

For urban communities and infrastructure Bruneau, Chang, Eguchi, Lee, O'Rourke, Reinhorn, Shinozuka, Tierney, Wallace and von Winterfeldt (2003, 738 cited by Bocchini et al. 2014, 5) identify that resilience can also be conceptualized as encompassing four interrelated dimensions: *technical, organizational, social, and economic.* The four dimensions are as follows: (1) technical, which includes all the aspects associated with the construction and the other technological aspects; (2) organizational, which deals with the management plan, maintenance, and response to emergencies; (3) social, which involves the impact on the society and its mitigation; and (4) economic, which addresses indirect and direct costs associated with the reduction of functionality of the infrastructure and its renovation (Figure 7).

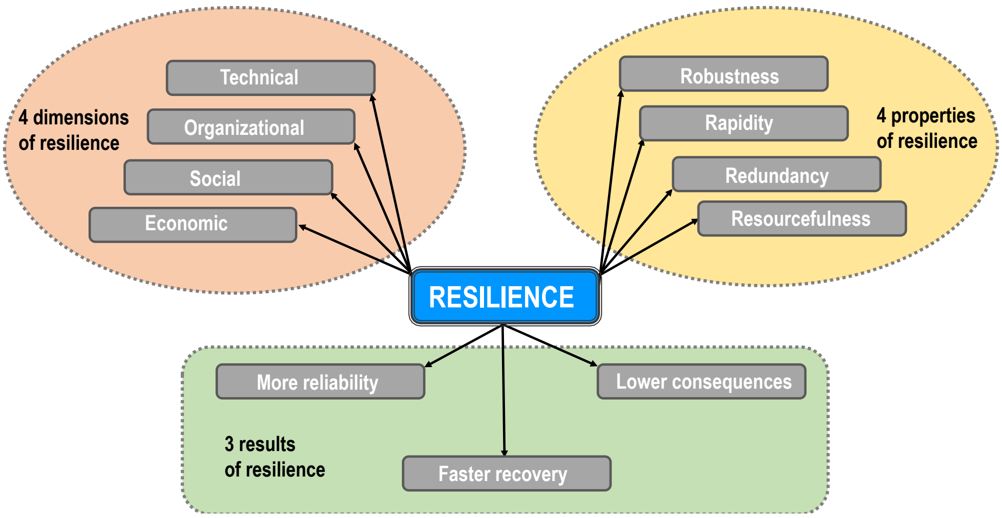


Figure 7. Aspects of resilience considered in the comprehensive definition by Bruneau et al. (2003 compiled by Bocchini et al. 2014, 5).

Bruneau et al. (2003, 736 cited by Bocchini et al. 2014, 5) also list three results of resilience namely: i) *more reliability*, ii) *lower consequences* and iii) *faster recovery*. According to Bruneau et al. (2003, 737-738 cited by Bocchini et al. 2014, 5) resilience is also characterized by four properties: (i) *robustness* is the ability to withstand a given extreme event and still deliver a service, often measured by the residual functionality level after the occurrence of the event; (ii) *rapidity* is the speed with which a structure recovers from such an event to reach a high functionality level; (iii) *redundancy* is the extent to which elements and components of the investigated system are substitutable; and (iv) *resourcefulness* is the capacity to make the appropriate budget available, identify problems, establish priorities, and mobilize resources after an extreme event.

Brown, Boltz, Freeman, Tront and Rodriguez (2020, 3) consider that three capabilities characterize a resilient system:

1. *Persistence:* Its ability to maintain coherent function in response to disruption and changing conditions without altering its identity;
2. *Adaptability:* Its ability to maintain coherent function by modifying its identity to accommodate change; and
3. *Transformability:* Its ability to change identity and to establish a new, stable function when pushed beyond tipping points that preclude maintaining its prior state

Biggs, Blenckner, Folke, Gordon, Norström, Nyström and Peterson (2012 cited by Folke 2016, 13) and Biggs, R., Schlüter, M. and Schoon (2015 cited by Folke 2016, 13) have identified a set of seven generic and policy-relevant principles for enhancing resilience of critical ecosystem services for human well-being in the face of disturbance and ongoing change in complex social-ecological systems. These principles are: (P1) *maintain diversity and redundancy*; (P2) *manage connectivity*; (P3) *manage slow variables and feedbacks*; (P4) *foster an understanding of social-ecological systems as complex adaptive systems*; (P5) *encourage learning and experimentation*; (P6) *broaden participation*; and (P7) *promote polycentric governance systems*.

According to Hollnagel and Woods (2006 cited by Woods 2018b, 1) resilience is about what a system can do – including its capacity:

- *to anticipate* – seeing developing signs of trouble ahead to begin to adapt early and reduce the risk of decompensation
- *to synchronize* – adjusting how different roles at different levels coordinate their activities to keep pace with tempo of events and reduce the risk of working at cross purposes
- *to be ready to respond* – developing deployable and mobilizable response capabilities in advance of surprises and reduce the risk of brittleness
- *for proactive learning* – learning about brittleness and sources of resilient performance before major collapses or accidents occur by studying how surprises are caught and resolved.

Hollnagel (2009 cited by Resilience Engineering Association 2021) argues that there should be four essential capabilities in a resilient system:

1) *Learning from experience* requires actual events from both what goes well and what goes wrong, not only data in databases. This requires selecting what to learn and how the learning is reflected in the organization, i.e., what is reflected in changes in procedures and practices. This ability is related to coping with the factual.
2) *Responding* (including readiness to respond) to regular and irregular threats in a robust and flexible manner. The system is designed to provide a limited range of

responses. There is still a necessity to adjust responses in a flexible way to unexpected demands. This ability enables coping with the actual.

3) *Monitoring* in a flexible way means that the system's own performance and external conditions focus on what it is essential to the operation. This includes internal monitoring as well as monitoring the external conditions that may affect the operation. This will make it possible to identify what could be critical in the near future.
4) *Anticipate* threats and opportunities. It is required to go beyond risk analysis and have the requisite imagination to see what may happen, and see key aspects of the future (Westrum 1993). It is not only about identifying single events, but how parts may interact and affect each other. This ability addresses how to deal with the irregular events, possibly even unexpected events thereby allowing the organization to cope with the potential.

Nieminen et al. (2017, 18) acknowledge that resilient systems are by nature, i.a., diverse (not uniform with each other), maintain their own diversity, recognize and utilize in their operations critical points, which may change considerably the system's functions (threshold values), consist of a significant amount of social capital and networks, emphasize the learning of new things and innovations, appreciate the experimentation and the change, and consist of redundancies, which create flexibility in the system.

A system, which is tuned up to a maximal efficiency, functions close to the threshold value and thus its resiliency will be low (Walker and Salt 2006 cited by Nieminen et al. 2017, 14). Nieminen et al. (2017, 54) argue that there should be a certain amount of "hanging around" time and resources for apparently unproductive experiments and development activity, which create, however, new competencies and solutions. It must also be accepted that some of the developed solutions will be kind of "useless", because they will never be utilized in changing conditions.

Nieminen et al. (2017, 17) recognize that an organization, which is competent to anticipate and prevent negative events, is not necessarily competent to keep operations running during this kind of events or after them, because they do not have gained experience from this. Respectively, the organization may rely too much on its ability to react and recover from disruptions, and thus the prediction of them may be forgotten. Nieminen et al. (2017, 53) argue that resilience as the organization's adaptability and flexibility to change is, however, *situation-specific*. There are no universal solutions to unique and constantly changing conditions. The leadership and management principles should be built on the acceptance of the diversity of perceptions, and on the enhancement of transparency, learning and self-organization.

Nieminen et al. (2017, 80) suggest the introduction of the following leadership and management principles to enhance resiliency in complex events and organizations: a) Value diversity and multi-voiced working environment; b) Count on the organization's competence for defining objectives and for self-organization; c) Accept apparent "hanging around"; d) Accept tensions and extraordinariness as a part of the organization's capacity to reform itself; and e) Ensure that all share and understand the objectives of the organization and are committed to them.

It's obvious, however, that in addition to emphasizing self-organization, there is also need for traditional rules and administration to execute essential bureaucracy required for keeping the organization's activities running. The traditional bureaucratic organizational model, therefore, remains alongside the newer operating models (Nieminen et al. 2017, 33-34).

Bach et al. (2013, 7) argue that building resilience is a "bottom-up" process and governments as well as regional authorities need to agree on a communication framework to inform and engage people about risk. Accordingly, analysis of how top-down and bottom-up approaches can be matched is required. Citizens can not only improve their own resilience by these measures but also serve as a source of information for civil protection agencies. People can provide relevant information to allow first responders to identify what is happening, where the priorities are, and what types of resources need to be mobilized. This may entail, for instance, analyzing information circulating among social networks, although this raises the question of validating and guaranteeing the accuracy of the information. The implementation of resilience strategies by concrete measures and monitoring activities remains a challenge. In this regard, indicators of the efficiency of resilience strategies would be needed to evaluate results and to benchmark different approaches in order to generate arguments in favor of appropriate action.

The OECD Survey on critical infrastructure resilience has identified twenty-two policy tools to enhance critical infrastructure resilience (Table 2). This comprehensive list aims at presenting the different policy options that governments can use once they have set up a critical infrastructure resilience program, identified their most critical infrastructure and their vulnerability, and established an information sharing mechanism with critical infrastructure operators (OECD 2019, 54).

Table 2. Policy tools to foster critical infrastructure resilience (OECD 2019, 54).

1.	Provision of hazards and threats information	12.	Inspections and performance assessments
2.	Voluntary information-sharing mechanisms or platforms	13.	Fines for non-compliance with resilience requirements
3.	Mandatory information-sharing mechanisms or platforms	14.	Other types of penalties for non-compliance
4.	Awareness raising activities and trainings	15.	Ranking based on inspection / performance results
5.	Resilience guidelines for critical infrastructure operators	16.	Reporting on operators’ resilience
6.	Fostering the development/use of professional standards	17.	Sharing best practices
7.	Incentive mechanism to assess risks and vulnerabilities	18.	Public investments in infrastructure resilience
8.	Incentive mechanisms for investing in resilience	19.	Guidance for sub-national levels of government
9.	Sectoral prescriptive regulations dedicated to CIP	20.	Mandatory insurance for critical infrastructure
10.	Performance-based regulations on business continuity	21.	Peer-reviews, monitoring and evaluation
11.	Mandatory business continuity plans	22.	Sectoral mutual aid agreements

Note: This listing of policy tools was prepared by the OECD Secretariat, based on approaches presented at the OECD High Level Risk Forum and desk research.
Note: These policy tools are further described in detail in Annex 1 (OECD 2019, 69-70).
Source: OECD Secretariat.

The International Risk Governance Council (2006, 20 cited by Bach et al. 2013, 6) also recognizes the importance of communication as a key element of successful stakeholder collaborations. According to Bach et al. (2013, 6) communication is principally a question of defining responsibilities, roles, duties and obligations with respect to specific procedures and crisis situations. Since communication always involves the exchange of information, it is important to address the type of information that can be exchanged (e.g., intelligence or commercially sensitive information) and technical questions related to the information exchange, such as protection measures, secure information sharing platforms and their limitations in disaster risk management (DRM).

3 REVIEW OF THE STATE OF WATER INFRASTRUCTURE

> *"More of the same will not be sufficient if we are to achieve the water-related SDGs"* UN and WB 2018, 30.

Today, the challenge of water security is global and growing. Achieving and sustaining water security, in both OECD and non-OECD countries, is likely to increase in complexity and priority – as the demands of economic growth increase. The criticality of this challenge is reflected in the World Economic Forum's 2016 Global Risks Report, in which water crisis and water-related risks are ranked as the global risk *with the single greatest potential impact on economies over the next ten years* (World Economic Forum 2016, 13).

Cities in developing countries are already faced with enormous backlogs in shelter, infrastructure and services as they are confronted by insufficient water supply, deteriorating sanitation and environmental pollution. Larger populations will demand larger proportions of water while simultaneously decreasing the ability of ecosystems to provide more regular and cleaner supplies. In most cities worldwide, there has been *years of neglected maintenance* to water storage, treatment, and distribution systems. Poorly maintained water supply systems can generally be traced to insufficient financial resources and poor management. This deterioration in the water infrastructure threatens the quality and reliability of all water services.

In particular, there has been *little or no management and maintenance* of underground infrastructure. A large proportion of this infrastructure is over one hundred years old, placing it at increased risk for leaks, blockages and malfunctions due to deterioration. The escalating deterioration of water and sewer systems threatens our ability to provide safe drinking water and essential sanitation services for current and future generations. As the pipes crumble and leak, many cities are faced with an expensive water and sewer problem. The longer these problems go unresolved, the more serious they become, placing vital public assets at risk of further degradation and posing an unacceptable risk to human health and the environment, damaging public and private property, and impacting state and local economies.

The cost of renovation of water infrastructure systems is substantially increasing across the world due to *their accelerating deterioration*. These deterioration processes are more severe in developing countries, due to ageing of the systems, poor construction practices, little or no maintenance and renovation activities, operation at higher capacity than designed for, and so on. There is limited knowledge about specific classes of asset deterioration and the technical service life of infrastructure. In addition, there is insufficient data to know the extent and/or value of infrastructure assets (Marjoram 2010, 286-287).

Globally, a staggering 90 per cent of sewage and 70 per cent of industrial wastes in developing countries were estimated to be discharged without treatment, often polluting the usable water supply (UNDPI 2003, 1). The financial, environmental and social costs were projected to dramatically increase unless wastewater management would receive urgent attention. Under-dimensioned and aging wastewater infrastructure is already overwhelmed, and with the predicted population increases and changes in the climate the situation is only going to get worse. Without better water infrastructure and management, there will be *several million excess deaths each year* and also further losses in biodiversity and ecosystem resilience, undermining prosperity and efforts towards a more sustainable future (Corcoran, Nellemann, Baker, Bos, Osborn and Savelli 2010, 9-11).

Water storage, treatment and distribution systems are often poorly maintained. Moreover, in many countries of the developing world, water losses due to technical leakage and water theft often exceed 40-60 per cent of the total water distribution (UN-Water 2012a, 4-5). Survey participants in the United Nations World Water Assessment Programme's (WWAP) World Water Scenarios Project (WWSP) pointed out that aging water infrastructure, lack of data and deteriorating monitoring networks are major risks for the future in nearly all regions. They considered access to drinking water and adequate sanitation facilities as the most important developments in this regard. According to them, 90% of the global population would likely have reasonable access to a reliable source of safe drinking water by the beginning of the 2040s. Further, 90% of the global population would most likely have reasonable access to appropriate sanitation facilities towards the end of the 2040s. Investments in infrastructure were also considered to be of importance. They also considered that globally, water services income (*tariffs, taxes and transfers*) would most likely cover all operating costs and depreciation of infrastructure from the beginning of the 2040s. This was also the case for the write-off of external debt of low-income countries, freeing funds for investment in water infrastructure (WWAP 2012, 263).

The WWSP survey participants (mainly demographers) considered that *population growth* could overwhelm past gains in water and sanitation accessibility. They argued that by the 2030s, population growth in the majority of developing countries could reduce the percentage of those with improved access to water supply and sanitation achieved since 1990 by 10%. Participants (from the fields of economy and security) gave almost equal importance to two possible developments. Many survey participants (governance) saw the failure of urban water supply infrastructure in many cities as important (underscoring the need to upgrade urban water systems). This could happen in more than two dozen major cities by 2030. This indicates that urban water system governance badly and urgently requires attention (WWAP 2012, 263-265).

According to the United Nations Department for Economic and Social Affairs, 3.9 billion people, or 54% of the global population, lived in cities in 2014, and by 2050, two-thirds of the global population will be living in cities (UNDESA 2014, 2). Major growth will take place in developing countries, particularly in urban areas that already have an aging, inadequate or even non-existent sewage infrastructure, unable to keep up with rising populations. It was estimated that the urban infrastructure of the world’s cities over the next 20 years will require USD 41 trillion for investments in urban infrastructure, including USD 22.6 trillion on water and sanitation (UNEP 2011a, 44).

The increase in the number of people without access to water and sanitation in urban areas is directly related to the rapid growth of slum populations in the developing world and the inability (or unwillingness) of local and national governments to provide adequate water and sanitation facilities in these communities. The current world's slum and informal settlements population, approximately 1,034 million in 2018, is also more vulnerable to the impacts of extreme weather events (UN-Habitat 2020, 26; WWAP 2015, 3). Water storage, treatment and distribution systems are often poorly maintained. Moreover, in many countries of the developing world, water losses due to technical leakage and water theft often exceed 40-60 per cent of the total water distribution (UN-Water 2012b, 4-5).

In Indian megacities, water inequity is a major concern with a large proportion of informal settlements denied equitable share of available water and sanitation services (Sinha and Sekhar 2017 cited by Australian Government 2020, 5). In Mumbai, 46 per cent of the population use 95 per cent of the water, while 54 per cent, those living in slums, use only about five per cent of the supplied water (The Diplomat 2020 cited by Australian Government 2020, 5). The poor and disadvantaged groups are forced to buy water from private tankers with price as high as 52 times that of piped water (World Resources Institute Report 2019 cited by Australian Government 2020, 5). In Mumbai alone, the tanker economy reaches USD 1-1.5 billion (Bhaskar 2020 cited by Australian Government 2020, 5).

Although water and sanitation are explicitly recognized as a human right, according to UNICEF and WHO (2019, 7), out of the global population (7.6 billion people) 29% (2.3 billion people) did not have safely managed drinking water services in 2017. Only 5.3 billion people used safely managed drinking water services, 1.4 billion used at least basic services, 206 million people used limited services, 435 million used unimproved sources, and still 144 million used surface water. UNICEF and WHO (2019, 24) estimate that 90% of the world’s population (6.8 billion people) used at least basic drinking water services in 2017. The population using piped sources increased from 3.5 billion to 4.8 billion between 2000 and 2017. Over the same period, the population using non-piped sources increased from 1.6 billion to 2.2 billion. In 2017, 75% of the world's population (5.7 billion people) used improved drinking water sources located on premises (UNICEF and WHO 2019, 49-52).

In 2017, alarmingly more than a half (55%) of the global population (4.2 billion people) *did not have safely managed sanitation services* (UNICEF and WHO 2019, 60). Only 3.4 billion people used safely managed sanitation services, 2.2 billion used at least basic services, 627 million people used limited services, 701 million used unimproved facilities, and 673 million still practised open defecation (UNICEF and WHO 2019, 7-8). In 2017, 74% of the world's population (5.5 billion people) used at least basic sanitation services, compared with 56% (3.4 billion people) in 2000 (UNICEF and WHO 2019, 30). Worldwide, 6.2 billion people used improved sanitation facilities (including those shared with other households), with this population split evenly into those using sewer connections and those using on-site facilities (septic tanks, latrines and other improved facilities) in 2017 (UNICEF and WHO 2019, 63).

In 2017, 60% of the global population (4.5 billion people) had a basic handwashing facility with soap and water available at home. A further 22% (1.6 billion people) had handwashing facilities that lacked water or soap, and 18% (1.4 billion people) had no handwashing facility at all (UNICEF and WHO 2019, 36).

Of critical importance is the fact that access to an *"improved"* water source does not necessarily mean access to *"safe"* water fit for human consumption. Not all improved water sources meet the new SDG criteria, and the proportion of sources that are accessible, available and free from contamination widely varies between countries. This illustrates the challenge that many countries face in meeting the SDG target for safely managed services (UNICEF and WHO 2019, 50).

On-site storage and treatment systems may be compromised due to poor design, damage or flooding. Not all households are able to access or afford emptying services for on-site systems such as septic tanks and latrines (UNICEF and WHO 2019, 67-68). Excreta that do enter sewer networks may also leak out or be discharged before reaching a treatment plant due to pump failure, breaks, blockages or flooding, causing discharge of untreated wastewater into the environment (UNICEF and WHO 2019, 73).

Hutton and Varughese (2016, xi) estimated that the total capital investments of meeting SDGs targets 6.1 and 6.2 are **USD 114 billion per year**. These capital outlays amount to about *three times* the current investment levels. The majority of the world's low- and middle-income countries are included, as well as selected high-income countries that have low coverage of basic WASH services in the study. The 140 countries (GP_{140}) included represent 85 percent of the world's population. The costs estimated are those for capital investment, program delivery, operations, and major capital maintenance to sustain the life span of the infrastructure created. This excludes the costs for financial and institutional strengthening needed for operations and maintenance (Hutton and Varughese 2016, 7 cited by Rognerud, Fonseca, van der Kerk and Moriarty 2016, 23).

The funding challenges are daunting in the OECD countries, too. OECD (2009a, 7) warned that *France* and *the United Kingdom* need to increase their water spending as a share of gross domestic product (GDP) by about 20% to cope with urgent renovation and upgrading of water infrastructure. Significant investments are required to rehabilitate existing infrastructure, to bring it into conformity with more stringent environment and health regulations, and to maintain service quality over time. OECD (2009a, 7) assumed that *Japan* and *Korea* may have to increase their water spending by more than 40%.

In the United States of America, the estimated funding for water and wastewater infrastructure is USD 3,269 billion for the years 2020-2039, but the total investment need is estimated to be USD 5,754 billion for the same period. The funding gap is thus USD 2,485 billion for the period of 2020-2039 (ASCE 2021a, 7). The 2021 Report Card for America's Infrastructure reveals that the drinking water infrastructure condition score was C- (mediocre, requires attention) on a scale A-E (ASCE 2021b, 34). The score for the wastewaters systems was D+ (poor, at risk) (ASCE 2021b, 151).

The American Water Works Association's 2020 State of the Water Industry report lists the top three issues impacting water sector: 1) Renewal and replacement of aging water and wastewater infrastructure; 2) Financing for capital improvements; and 3) Long-term water supply availability (AWWA 2020, 5). The implications of the America's aging water infrastructure are becoming clear. Between 2012 and 2018, the rate of water main breaks increased by 27 percent (Folkman 2018, 4). Folkman's literature review (2018, 4) indicates that there are 250,000 to 300,000 breaks per year. This is equivalent to a water main break every two minutes (Value of Water Campaign and ASCE 2020, 10). The analysis of the current state of the nation's water infrastructure found that (Value of Water Campaign and ASCE 2020, 9):

- The nation's water infrastructure is aging and deteriorating.
- The nation is chronically underinvesting in water infrastructure.
- Federal investment is lagging, placing added pressure on local and state governments.
- New challenges and a growing demand are shaping infrastructure needs.

According to Infrastructure Australia (2017, 2), a range of pressures are emerging that could challenge *Australians'* expectations for water supply and demand: i) meeting the needs of a growing population; ii) improving resilience and managing the impacts of climate change; iii) maintaining, renewing and replacing aging infrastructure; iv) reflecting changing community expectations; and v) keeping services affordable for customers and minimizing costs to taxpayers.

As with other forms of infrastructure, the water sector has faced mounting challenges from factors such as population growth, climate change and changing user expectations. These risks are compounded by the age and condition of many water, wastewater and stormwater assets. Many are reaching the end of their lifecycle and are approaching their full capacity or were designed and built many decades ago, for a nation of a different scale and distribution than it is today (Infrastructure Australia 2019, 601). The utilities are thus expected to require an increasing level of investment to replace aging water and sewerage assets (Infrastructure Australia 2019, 609).

Yet, the extent of investment required to replace aging assets is unclear, owing to a lack of data on the age of some water assets, particularly those associated with stormwater management. It is clear, however, that there will need to be substantial investment in water-related infrastructure over coming decades (Productivity Commission 2020, 22). With the value of water poorly understood, governments have been reluctant to embrace the pricing reforms that are required to properly reflect the cost of provision and support rational investment (Infrastructure Australia 2109, 609).

In Australia, under the base case, which assumed a 4.5 cent increase in capital and operating costs per annum, the aggregate annual revenue requirement across all service providers that service metropolitan areas were forecasted to increase from just under AUD 9.9 billion in 2017 to approximately AUD 17.2 billion in 2027. By 2040, the aggregate annual revenue requirement is forecast to reach approximately AUD 28.8 billion and to rise to over AUD 90 billion in 2067. By 2040, the average water services bill could be more than double what it is today in real terms (Aither 2017, 3, 8).

In Canada, the replacement cost for the drinking water infrastructure in fair to very poor condition was assessed to be CAD 26 billion, and the replacement cost for the wastewater infrastructure in fair to very poor condition was estimated at CAD 39 billion. Because wastewater infrastructure is now subject to more stringent federal regulations, even good or very good wastewater infrastructure may require upgrading or replacement (CIRC 2012, 2). In 2019, approximately 30% of potable water infrastructure was in very good condition, 40% is in good condition and 25% is in fair, poor or very poor condition (CIRC 2019, 31). Approximately 25% of wastewater infrastructure was in very good condition and 30-40% was in good condition. Approximately 15% of linear wastewater assets had an unknown condition, which highlighted the challenges in assessing underground assets (CIRC 2019, 36).

In Finland, Rajala and Hukka (2018, 587) reveal that although there are rather stringent judicial obligations with regard to covering the costs of maintaining, renovating and replacing the water services fixed assets, the water services professionals are extremely worried that, by and large, water and sewage networks are still deteriorating, although the networks are nowadays rehabilitated more systematically. Heino, Takala and Katko (2011,5) point out that the decaying networks was assessed to be *the most significant challenge* in the water services sector in the next 20-30 years. The interviewed water utility experts, consultants, authorities, associations, researchers and educators pointed out that the state of networks was already truly alarming. They also revealed that the situation will become even worse if the renovation and renewal activities are not considerably increased in the next few years.

Furthermore, a group of water sector professionals assessed the future challenges facing the water services in Finland in 2016. The investment gap of water services infrastructure is alarmingly large. The cost recovery is not implemented adequately enough. Therefore, the responsible stakeholders should take proper actions to advocate and convince the municipal decision-makers to impose viable charges (Rajala and Hukka 2018, 589). According to Silfverberg (2016, 4, 18) this would also require development and introduction of the asset management systems and practices for the water services undertakings. In addition, the related judicial regulation and enforcement or voluntary measures should be introduced for the management of water industry assets in Finland.

If the useful lifetime of water distribution pipes is estimated at 50 years on average, and the renovation volume has been evenly increased up to the level of 0.55% annually between the years 1999 and 2008, the renovation gap is approximately 8,000 km. If the useful lifetime is estimated to be 60 years, there is no renovation gap yet. It was impossible to give any reliable estimates of the renovation gap on the basis of available data. It can, however, be reasonably estimated that during the next ten years the renovation volume has to be increased from the current level – approximately 600 km annually – up to the level of approximately 1,800 km annually, in order to avoid network condition deteriorating considerably. The renovation gap of wastewater network is 1,500 km, if the useful lifetime is estimated to be 50 years, and nil, if the useful lifetime is estimated to be 60 years. Since the 1970s, approximately 800 km of sewers were constructed annually, and thus the renovation volume has to be increased up to this rate within some time limit (Berninger, Laakso, Paatela, Virta, Rautiainen, Virtanen, Tynkkynen, Piila, Dubovik and Vahala 2018, 30).

When the state of the built environment was assessed in 2016-2017, the condition of water services infrastructure was rated at 7.5 on a scale from 4 (fail) to 10 (excellent) by a group of Finnish water and wastewater experts (Finnish Association of Civil Engineers 2017, 30). In 2021, the condition of water services infrastructure was also rated at 7.5 (Finnish Association of Civil Engineers 2021, 31). A recent report on the investment requirements concludes that the annual investment requirements will nearly double during the next 20 years, and they will still increase after that period. The total renovation value of water services assets was estimated to be EUR 42.3 billion (Kuulas et al. 2020, 76).

The total annual investment need estimate is approximately EUR 777 million (Kuulas et al. 2020, 76). The renovation investment need of networks is approximately 60% of the total investment requirements, i.e., EUR 466 million annually (Kuulas et al 2020, III). The share of completely new investments is estimated to be approximately 26%, i.e., EUR 160 million annually (Kuulas et al. 2020, 76).

Over the next 20 years the current annual renovation investments in Finland should be increased so that the investments in water distribution networks should be *doubled* and the investments in sewerage networks should be *tripled* (Kuulas et al. 2020, 78). The total investments in water services infrastructure were EUR 530 million in 2019 (Ministry of Agriculture and Forestry 2021). We have estimated that the total annual turnover of the Finnish water utilities was approximately EUR 1.4 billion in 2019. Consequently, we estimate that the water and wastewater tariffs should have been – depending on debt servicing costs – approximately 20-25 per cent higher on average in Finland in 2019. This would have facilitated sufficient funding for the total investments in the coming 20 years.

In New Zealand, drinking water, wastewater and stormwater assets together have a replacement value worth around NZD 45.2 billion (National Infrastructure Unit 2015, 4). Over 55 per cent of water assets are graded 3 (moderate) or worse and about 45 per cent of both the potable and wastewater network lengths is categorized as “ungraded” (52 per cent for stormwater). Over 55 per cent of water assets that have been graded are graded 3 (moderate – described as adequately performing now but likely to require replacement within 5-15 years) or lower (National Infrastructure Unit 2015, 6-7).

A review reveals some of the main challenges for water systems and communities in New Zealand (Department of Internal Affairs 2019, 1):

- Meeting community expectations for water quality, treatment and management.
- Meeting regulatory requirements for water quality, treatment and management.
- The ability to replace aging infrastructure or fund and manage new infrastructure (by local authorities but also for rural communities).
- Declining water services rate bases in some areas, high growth in others.
- High seasonal demand in small tourism centres.
- Adapting for climate change (including water shortages) and adverse natural events.

The Water Industry Commission for Scotland (WICS) commissioned a study in New Zealand and conservatively estimates a minimum of NZD 27 billion of additional investment (over and above that required to maintain and replace existing assets) will be required over the next 30 years to upgrade existing the “three waters” assets (drinking water, wastewater and stormwater) to meet environmental and drinking water standards. Its higher estimate is around NZD 46 billion. These estimates make no allowance for investment required to meet population growth or to address seismic resilience. This almost certainly means the NZD 27 billion estimate is too low (Department of Internal Affairs 2020,5).

In Norway, the state of the drinking water systems was estimated to be 3 (on a scale of 1–5; with 5 being best) in 2019, and the state of the wastewater systems was estimated to be 3. The value of the systems was estimated to be EUR 146 billion, and EUR 41 billion was needed to upgrade the systems to level 4 (Rådgivende Ingeniørers Forening 2019, 13).

In Portugal, the recent national strategic plan for the sector (MAOTE 2014 cited by Amaral, Alegre and Matos 2016, 542) warns of a clearly insufficient renovation rate. For the current rate to be sustainable, pipes would need to last on average 100 and 200 years for water and wastewater networks respectively. Furthermore, more than 3.5 million people (over 33% of the population) are served by utilities that do not ensure cost recovery. A large number of utilities do not even know the true cost of their services. As a result, many national and regional administrations are currently facing challenges to ensure long-term sustainability of urban water services.

In Sweden, the replacement value of water services infrastructure was estimated to be EUR 78 billion in 2020 (Svenskt Vatten 2020, 10). The investments were approximately EUR 1.5 billion annually, but the annual investment need to cope with the future requirements is estimated to be EUR 2.1 billion for the period 2020–2040. The report also notably points out that many water services organizations lack the capacity to implement the necessary investment projects (Svenskt Vatten 2020, 2).

In the United Kingdom, the state of the water services infrastructure was rated B (on a scale of A–E) (ICE 2014, 22). In England and Wales, the private water companies can use their own methods to set prices. The Water Services Regulatory Authority (OFWAT) sets a limit for price increases for given five-year intervals. No other requirements exist in these regions for water price calculation (EEA 2013, 30).

One of the large private water and wastewater companies in England, where water services were privatized in 1989, stated that there are a number of limitations in the existing structure for water services regulation that potentially undermine long-term infrastructure resilience. The Institution of Civil Engineers further pointed out that the current economic regulation of the water industry in England and Wales can encourage short-term efficiency savings at the potential cost of ensuring that vital infrastructure would be maintained and improved to meet future requirements, long-term sustainability, and customer needs. Therefore, these water sectors simply cannot cope with issues that require investment beyond the five-year regulatory cycle (ICE 2009, 11-12). OFWAT's price review has also had one unfortunate consequence: because of the slowdown of capital investment that occurs during each price review – compounded in 2009 by credit shortages – some supply chain companies and many experienced experts have left the sector. This loss of expertise is not being addressed and represents a risk to the future of the water industry in England (ICE 2010, 15).

In addition, the United Kingdom's National Audit Office (2007, 10) pointed out that there were inherent weaknesses in the data on water demand and leakage. Private water companies were able to measure with relative certainty the quantity of water that they distributed into their systems, but they were unable to measure as precisely the water that was consumed. This was because only 28% of households paid for their water on a metered basis. ICE (2012, 15) recommends that metering should be universally applied throughout the UK, though introduced on a regional basis according to the extent of water stress. Whilst some areas are not currently considered to be stressed, ICE argues that metering, combined with other measures, is an important tool in the long-term management of water.

Water services privatization in England and Wales led to *a complicated regulatory system*, which is very expensive. The economic regulation regime applied to private water companies in England and Wales also creates heavy transaction costs (Defra 2011, 24-25). Findings from the privatised UK water industry confirm other emerging constraints. According to Bayliss and Hall (2017, 1-2) the key problems of the English system are the following:

1) Upward pressure on pricing due to payments of dividends and debt interest;
2) Narrow regulation by OFWAT, with a system of price controls that fails to deal with all of the methods of value extraction by shareholders;
3) Poor performance, for example, in terms of leakage and sewage flooding, for which companies were continued to be fined millions of pounds in 2016 and 2017;
4) Lack of accountability or public control, with complex corporate structures, a dense web of intercompany loans and opaque offshore ownerships in some cases;
5) Rising inequality as many are struggling to pay water bills, but at the same time huge dividends are being paid to some of the world's richest; and
6) The cost of maintaining and improving the infrastructure for the last 28 years has not been financed by investors – it has been met by borrowing. With most of the profit,

> allocated to dividends, the companies have been borrowing ever-increasing amounts in order to pay for the actual physical investment. The companies which were debt-free at privatization in 1989 have now accumulated over GBP 40 billion in debt, which now finances over three-quarters of the companies' assets.

Further, Bayliss and Hall (2017, 3-4) point out that almost all of the post-tax profit of GBP 18.8 billion has been paid out in dividends (GBP 18.1 billion) from 2007-2016. These are funds that could have been used to finance physical investment or to reduce company debt (and thereby lower debt interest payments). Furthermore, three companies – Anglian, Severn Trent, and Yorkshire – have paid out more in dividends than their total pre-tax profits over the past ten years. This is not economically sustainable. On average, over the past ten years, water and sewerage companies have paid dividends equating to approximately GBP 75 per household per year. This is an expensive way to finance infrastructure. Yearwood (2018, 27) concluded that the way the privatized industry operated over the last 30 years may no longer be sustainable. The industry's Debt/Capital ratio stands above 70%, and some companies are on the verge of receiving a junk investment rating.

The National Audit Office (2015, 10) estimates that companies made net gains of at least GBP 800 million between 2010 and 2015 because of unexpected falls in borrowing costs and the corporation tax rate. Customers would have benefitted if they rather than the companies had borne these risks, though they could have lost out if borrowing costs or tax rates had risen. The conclusion is that the price cap regime does not balance risks appropriately between companies and consumers, and so does not yet achieve the value for money that it should.

In 2019, the Environment Agency report (2020, 5) reveals that water company performance deteriorated for the second year in a row in England. From 2011, when it first introduced the Environmental Performance Assessment (EPA), to 2017 there was a trend of gradual improvement. However, the sector now moved further away from the performance expectations for 2015 to 2020 which the Environment Agency set out in 2013.

4 SUSTAINABLE WATER SERVICES AND VIABLE WATER UTILITIES

4.1 Sustainable Water Services

In 2015, on the basis of the UNCSD, all 193 Member States of the United Nations General Assembly unanimously agreed to *Transforming our world: The 2030 Agenda for Sustainable Development* (the 2030 Agenda). The 2030 Agenda is described as a plan of action for people, planet and prosperity. It comprises *17 Sustainable Development Goals* (SDGs) and *169 global targets*. These are integrated and indivisible to balance the social, economic and environmental dimensions of sustainable development. The 2030 Agenda commits UN member states to take bold and transformative steps to shift the world onto a sustainable and resilient path (Transforming Our World 2015 cited by UNICEF and WHO 2019, 10).

The establishment of SDG 6: *Ensure availability and sustainable management of water and sanitation for all* reflects the increased attention on water and sanitation issues in the global political agenda. It recognizes that social development and economic prosperity depend on the sustainable management of freshwater resources and ecosystems and it highlights the integrated nature of SDGs. Fresh water, in sufficient quantity and quality, is *essential for all aspects of life and sustainable development*. The human rights to water and sanitation are widely recognized by Member States. Water resources are embedded in all forms of development, for example, food security, health promotion and poverty reduction, in sustaining economic growth in agriculture, industry and energy generation, and in maintaining healthy ecosystems (United Nations 2018, 10).

In addition, several other SDGs include targets that aim to progressively reduce inequalities related to water, sanitation and hygiene (WASH) (UNICEF and WHO 2019, 10-11):

- *SDG 1* aims to end poverty in all its forms everywhere and includes a target for universal access to basic services (1.4).
- *SDG 4* aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. It includes targets for upgrading education facilities to provide safe and inclusive learning environments, including basic drinking water, sanitation and hygiene (4.a.1).
- *SDG 3* aims to ensure healthy lives and promote well-being for all at all ages. It includes a target for achieving universal health coverage (3.8) which focuses on access to quality essential health care services and implies that all health care facilities should have basic WASH services.

The World Bank (1994) referred to public utilities, including piped water supply, as *economic infrastructure*. Milbrath (1989) argues that a sustainable economic system must serve a variety of values, and it must thus:

a) Preserve and enhance a well-functioning ecosystem;
b) Provide humans with goods and services – necessities for a good life;
c) Provide opportunities for fulfilling work – self-realization;
d) Achieve and maintain economic justice; and
e) Utilize resources at a sustainable rate – justice for future generations.

According to the United States Environmental Pollution Agency (EPA), sustainable water infrastructure (the collection and distribution systems, treatment plants and other infrastructure that collects, treats and delivers water-related services) and the sustainable water sector systems (all aspects of effective operations and maintenance practices of the utilities and systems that provide water-related services) is critical to ensuring the sustainability of communities (EPA 2012a). It depends, however, on the practices on three levels that support each other (Figure 8):

1) *Sustainable Water Infrastructure:* Sustaining the collection and distribution systems, treatment plants and other infrastructure that collects, treats and delivers water-related services.
2) *Sustainable Water Sector Systems:* Sustaining all aspects of the utilities and systems that provide water-related services.
3) *Sustainable Communities:* Promoting the role of water services in furthering the broader goals of the community.

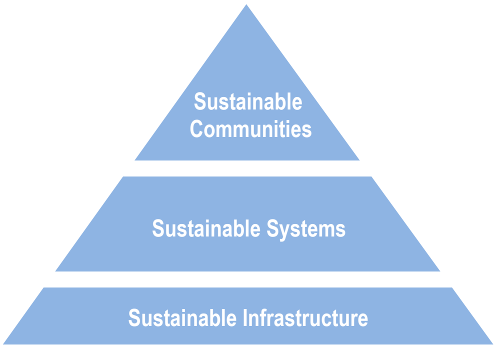


Figure 8. Sustainable communities are based on sustainable water infrastructure and on sustainable water sector systems (EPA 2017).

Silfverberg (2017, 5) points out that since the water services are the basic services of the society, they have to meet the social, technological, economical, and environmental criteria before they can be considered sustainable and well-managed (Figure 9 and Table 3).

Figure 9. Components of sustainable water services (Silfverberg 2017, 32).

Table 3. Components of sustainable water services (Silfverberg 2017, 5-6; Berninger et al. 2018; Infrastructure Australia 2017; Renko, Sahlstedt, Aurola, Vilpanen and Härkki 2021; Takala 2017, compiled and modified by the authors 2021).

Component	Description
Social and societal sustainability	Services are delivered fairly and equally, reflect changing community expectations, meet the customers' long-term interests, and promote the sustainable urban/ community and regional development.
Safety and reliability	The technical reliability of the systems is sound and will also adequately meet the more stringent health and safety requirements in the future. The service production will remain reliable in abnormal conditions (technical malfunctions, accidents, extreme weather conditions, malevolent acts).
Environmental sustainability	Raw water abstraction, water treatment, wastewater treatment and disposal are environmentally sustainable. They are developed to meet the environmental requirements, and also to respond to the challenges of climate change. The water utilities practice and promote sustainable economic and innovation policy, resource-wise economy, and responsible procurement in their own operations. The utilities set the objectives for recycling nutrients and for measures to achieve carbon–neutral society.
Economic sustainability and efficiency	Funding of the water utilities is secured and enables the operations and development of the utilities in the long term. Subsequently, the services are affordable, fair and equal for customers.
Systems adaptability	Safe and appropriate water services can be maintained and provided also by adapting proactively to changes in community structure (growth or decline in population, changes in industrial and commercial water consumption etc.).
Good management and adequate resources	Corporate and customer governance of the water utilities are open, transparent, accountable and efficient. The utility leadership and management are professional, and the human resources of the utilities are sufficient and skilled to proactively produce and maintain efficient and reliable services both during normal and emergency conditions. Water utilities support and participate in research, development and innovation (RDI) activities.

Hukka, Castro and Pietilä (2010, 23) indicate that lack of good governance principles, however, is regarded as one of the root causes of all major constraints within our societies, including problems behind unsustainable management of water ecosystems and the global crisis of water and sanitation services. This notion of *'good governance'*, emerging from recent global debates on the water crisis, is essentially normative and assumes compliance with a number of principles commonly associated with substantive democratic practice. That is, good governance should be *participatory, consensus-oriented, accountable, transparent, responsive, effective and efficient, equitable and inclusive and should follow the rule of law.* It must also assure that public and private corruption is minimized, that the views, values, rights, and material interests of all water users are taken into account, and that the essential needs of the most vulnerable sectors of society are given priority. Good governance must also be responsive to the future needs of society (Figure 10, Seppälä 2004, 27).

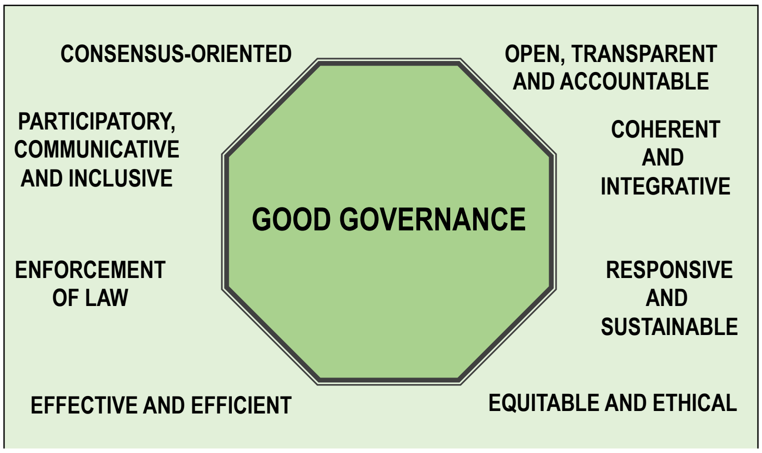


Figure 10. Characteristics of good governance (Rogers and Hall 2002; UNESCAP 2003 modified by Seppälä 2004, 27).

These principles of ‘good’ water governance have important implications for the management of water resources at all administrative levels – global, regional, national and local – and are considered to be a prerequisite for successful implementation of such policies as Integrated Water Resources Management (IWRM) (Grigg 1996; Mitchell 1990 cited by Hukka et al. 2010, 238).

Water governance, therefore, is also an exercise of political, economic, administrative and social authority, influencing the development and management of water resources and related services delivery. It comprises mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations, and mediate their differences in relation to water resources (UNESCO 2003 cited by Seppälä 2004, 28). To achieve democratic water governance, it is necessary to create an enabling environment which facilitates: (1) efficient private and public sector initiatives; (2) a regulatory regime which allows transparent transactions between stakeholders in a climate of trust; and (3) shared responsibility for safeguarding water resources whose management affects many people but is often the responsibility of no-one (GWP 2002; Rogers and Hall 2002; UNESCO 2003, 103 cited by Seppälä 2004, 28).

OECD (2002 cited by Momen 2021, 5) defines the scope of regulatory governance that includes both the design and implementation of the authoritative set of rules and the principles of governance, such as transparency about activities, accountability for acts and behavior, professional effectiveness, true adaptability, and sense of coherence. Kjaer and Vetterlein (2018, 500-501) recognize that formal as well as informal rules provide the functional and normative nucleus of regulatory governance, establishing the purpose and mechanisms of regulatory governance, and thereby defining the focus and direction of regulatory governance frameworks. Responsibility emphasizes the normative foundation of regulations and thus addresses questions of legitimacy within regulatory governance. Rules and regulations are, however, based in values and worldviews that are provided as justifications.

Good regulatory governance (GRG) is characterized by effective enforcement of tools, the resilience of institutions, and the process that governments ensure that the activities of regulatory bodies are effective in enforcement, transparent in actions, inclusive, and sustained (World Bank Group 2019, 12 cited by Momen 2021, 5). Therefore, Momen (2021, 5) argues that GRG *increases trust in society and strengthens social integrity*.

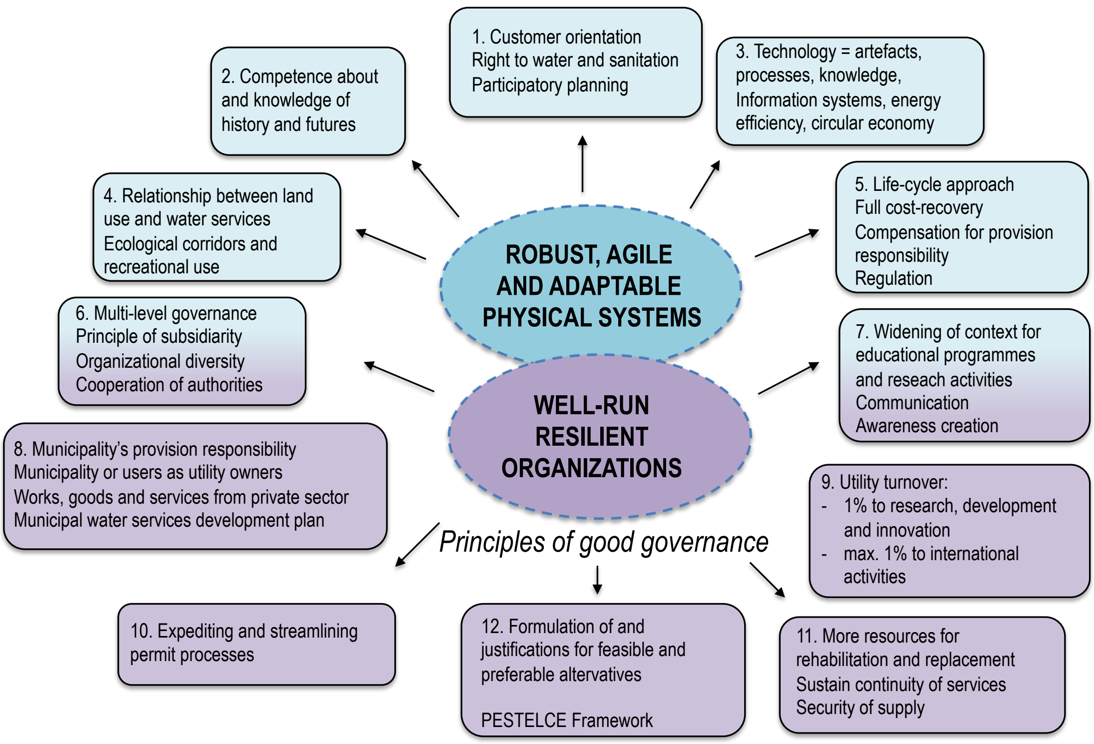
Gieske, Duijn and van Buuren (2020, 16) explored a dual concept of *ambidexterity* – the ability to balance and reconcile the inter-dependent processes of innovation and optimization – in eight public regional water authorities (RWAs) in the Netherlands. While low ambidextrous RWAs have adopted a legalistic task orientation and focus on optimization only, high ambidextrous RWAs use a societal value-orientation, integrative strategies, and a more transformational management style leading to more innovation practices. Aither (2018, 42) indicates how engaging stakeholders can be used to improve people's understanding about water infrastructure and services. Their increased understanding can increase support for vital changes and reforms (Box 5).

Box 5. Engaging stakeholders.

Everybody has a stake in water infrastructure and services, but few realize the expense and complexity in maintaining essential water supply and wastewater services for domestic and other uses. Improving people's understanding of how water is delivered to them, or what might be required to enable it to be delivered where it is not already, will increase support for important reforms, including to pricing for cost recovery.
Stakeholders can be involved right from the identification of what improvements to infrastructure and services are required, through to the monitoring of infrastructure and service performance. Essential infrastructure is often the most 'real' point of contact between citizens and the broader water management and policy framework that sits behind the infrastructure; as such, there are opportunities to use that point of engagement to improve alignment between stakeholder attitudes and the overarching vision for water management and use outcomes.

Source: Aither 2018, 42.

Based on the findings about the Finnish context, Katko, Juuti and Juuti (2021) have developed the following framework for sustainable water services (Figure 11):



Note: PESTELCE Framework (Political, Economic, Social, Technological, Ecological, Legal, Cultural, Ethical)

Figure 11. Framework for sustainable water services (Katko, Juuti and Juuti 2021, modified by the authors 2021).

4.2 Viable Water Utilities

Although the term "sustainable" became a household word following the Brundtland Commission Report (WCED 1987a) in the late 1980s, Hukka and Katko (1997, 161) propose that the term *"viable"* may be more justified in the economic analysis of systems such as water utilities. Viability can be defined as *the ability to function adequately or as the ability to succeed or be sustained* (Merriam-Webster Dictionary 2021b). According to Cromwell III, Rubin, Marrocco and Leevan (1997 cited by Seppälä 2004, 28) viable water systems are: 1) *self-sustaining*, 2) *committed*, and 3) *have the financial, managerial, and technical capability to meet performance requirements on a long-term basis.*

The American Water Works Association's White Paper on "Building Water System Viability" defines viable water services as *self-sustaining systems that can reliably meet all present and future requirements in a dynamic, comprehensive manner that assures the continued delivery of safe water*. The key factor that separates viable and nonviable water system is the capability and commitment of a system to implement the changes indicated by a planning process on its own. The most fundamental measure of viability is a system's ability to bring in more money than it will spend to provide reliable water service, i.e., financial self-sufficiency. A water system plan is thus incomplete without a multiyear capital and operating budget, which balances revenues and expenditures based on a comprehensive needs assessment. Non-viability is not simply a problem of drinking water enforcement policy; it encompasses broader issues important to the health and well-being of the community – infrastructure, economic stability, rural development, and poverty (AWWA 1995a; AWWA 1995b).

North Carolina State Water Infrastructure Authority (2017, 14) defines that a viable system is one that *functions as a long-term, self-sufficient business enterprise, establishes organizational excellence, and provides appropriate levels of infrastructure maintenance, operation, and reinvestment that allow the utility to provide reliable water services, now and in the future.* The North Carolina State Water Infrastructure Authority (2017, 16) recognizes that best practices in utility management are essential for viable utility systems. These practices are grouped into three integrated focus areas (Figure 12):

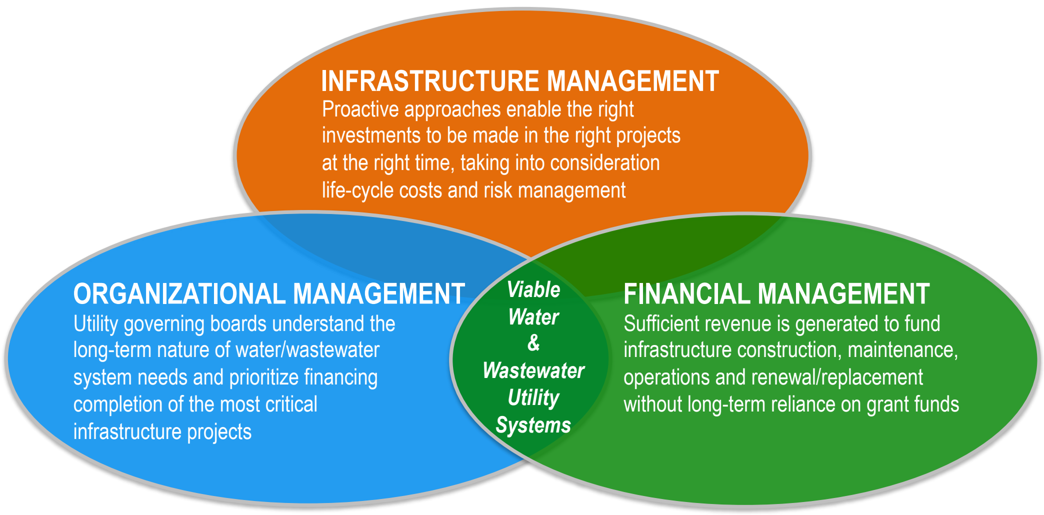


Figure 12. The best practices in utility management for viable utility systems (North Carolina State Water Infrastructure Authority 2017, 16).

Infrastructure Management – Utilities take proactive approaches to enable the right investments to be made in the right projects at the right time, taking into consideration life-cycle costs and risk management.
Organizational Management – Utility governing boards understand the long-term nature of water/ wastewater systems and prioritize the financing and completion of the most critical infrastructure projects.
Financial Management – Utilities generate sufficient revenue to fund infrastructure construction, maintenance, operations and renewal/replacement without long-term reliance on grant funds.

Figure 13 shows the proposed main components for a viable water utility (Renko et al. 2021, 40).

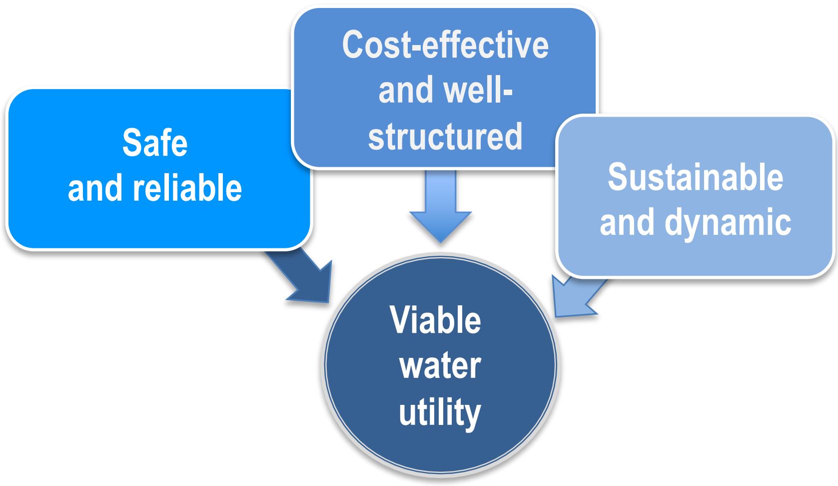


Figure 13. Components of a viable water utility (Renko et al. 2021, 40 modified by the authors 2021).

The "Safe and reliable" component consists of the criteria, on the basis of which it can be verified that the water utility meets the health and operational reliability requirements, manages the risks, is prepared to respond to the disruptions and makes the required renovation and replacement works on time (Renko et al. 2021, 40).

The "Cost-effective and well-structured" component consists of the criteria, on the basis of which it can be verified that the leadership and management of the water utility is professional, that corporate and customer governance is open, transparent and accountable, the water utility has adequate human resources and qualified and trained personnel, the funding is secured and guarantees up-to-date operational management as well as long-term development, and the services produced for the customers are affordable, fair and equal (Renko et al. 2021, 47).

The "Sustainable and dynamic" component consists of the criteria, on the basis of which it can be verified that treatment of water and wastewater does not pollute the environment or increase emissions accelerating the climate change. The water utility is also resilient, adaptable and anticipating, i.e., it can adjust to climate change, to changes in demography, regional structure, customer habits and needs, it utilizes the possibilities offered by digitalization in operations and communication, and it has set targets for carbon neutrality and circular economy (Table 4, Renko et al. 2021, 54).

Table 4. Criteria for components of viable water utility (Renko et al. 2021, 40-54).

Criteria for the "Safe and reliable" component
1. High-quality water treatment process taking into consideration raw water quality.
2. Up-to-dated contingency and disaster preparedness plans and cooperation with other actors.
3. Critical customers, interim water delivery and state of emergency communication.
4. Chemicals, spare parts and critical services.
Criteria for the "Cost-effective and well-structured" component
5. The utility has adequate human resources, qualified and trained personnel, and planned and well-organized stand-by arrangements.
6. Asset management, operations and maintenance are systemic and systematical.
7. Leadership and management are well-planned and business operations are profitable.
8. Operational economy and procurement are planned, streamlined and transparent.
Criteria for the "Sustainable and dynamic" component
9. Environmental pollution from wastewater treatment and disposal is minimized.
10. Sustainable, resilient, robust and energy efficient.
11. Customer services and communication are well-planned and transparent.

Each component consists of the criteria which are assessed either verbally or numerically. The criteria are also divided further into five categories based on the number of served customers. This utility size category should be a minimum target level that may be exceeded when deemed relevant (Renko et al. 2021, 40):

- *Category 1*: Approx. less than 500 customers;
- *Category 2*: Approx. 500-5,000 customers;
- *Category 3*: Approx. 5,000-30,000 customers;
- *Category 4*: Approx. more than 30,000 customers; and
- *Category 5*: Complementary criteria.

Category 5 consists of complementary criteria which are not focused on a particular size of the utility, and thus any utility can utilize and meet the criteria in category 5. The criteria in each category are given in detail in Renko et al. (2021, 41-58), and defining of the total rating is shown in Renko et al. (2021, 59-60).

In Australia, the National Water Commission (NWC), state and territory governments and the Water Services Association of Australia (WSAA) led the formation of a performance reporting and benchmarking steering committee, the Roundtable Group (RTG), in 2005. The RTG led the development of a national performance reporting framework, including a set of urban water utility performance indicators and definitions, as well as data collection, collation, auditing, and reporting processes and practices. The urban water utilities report on a broad-ranging set of indicators and required data under this framework, and outputs have sought to support economic regulation, policy development and industry innovation and efficiency (Aither 2019, 16).

The benefits of the framework are expected to be the following: a) National performance reporting provides an annual benchmarking of utilities across a range of parameters that influence the cost and quality of urban water supply and wastewater service across Australia; b) The independent and public nature of the report helps consumers and governments determine whether the urban water sector is operating in an efficient and cost-effective manner. Benchmarking informs customers, and provides a catalyst to support industry innovation, improved service delivery and efficiency gains (Bureau of Meteorology 2018, 2).

Bhagwan (2009, 5) emphasizes that water supply and wastewater utilities are organizations where *physical infrastructure assets are important and critical factors* in achieving its business objectives, and effective service delivery. These water and wastewater infrastructures are increasingly challenged by a growing demand due to urbanization, problems related to aging and sometimes disintegration of the existing infrastructure, and the impact of climate change.

The significance of water services infrastructure assets for the well-being and vitality of the societies is of the utmost importance and will only increase in the future. The volume, diversity, longevity and renewability of the capital assets require that associated strategic, tactical and operational management and activities have to be based on *the understanding and perception of the total lifecycle value and costs of the assets* (Paavilainen 2019, 1).

Viability of a water utility depends – first and foremost – by large on *its capability to maintain a continuity of preferred quality and level of service which meets regulatory and other goals by minimizing the total cost of owning and operating infrastructure capital assets*, i.e., at the lowest life cycle cost of the utility's assets. The utility has to be able to make sure that required and planned maintenance can be conducted, and capital assets can be repaired, replaced, or upgraded on time and that there is a sufficient amount of money to cover those capital expenditures.

According to EPA (2012b), asset management can be defined as follows: *"Asset management is a framework being widely adopted as a means to pursue and achieve sustainable infrastructure. It is the practice of managing infrastructure capital assets to minimize the total cost of owning and operating them while delivering the desired service levels. A high-performing asset management program incorporates detailed asset inventories, operations and maintenance tasks, and long-range financial planning to build system capacity, and it puts systems on the road to sustainability."*

The growing recognition by infrastructure organizations of the need to improve effectiveness, overall operating performance and reliability *requires clear understanding of how to manage infrastructure assets* in a way that allow their current performance to improve and be competitive, while ensuring they are planning and re-investing for the future. Consequently, organizations that manage infrastructure assets are driven to adopt a formal and holistic approach to the management of infrastructure assets in order to provide services in the most cost-effective manner, and to demonstrate this to customers and stakeholders (Too 2012, 2)

Disaster risk management is a vital component of the network asset management. Renovation is one of the measures for accounting and coping with the risks: renovations are aimed at reducing the probability of disruptions caused by the poor condition of the networks or by its appliances. The objective is to completely prevent the possibility of disruption risks or at least to considerable reduce the possibility of risks (Berninger et al. 2018, 4-5). The aim of network renovation is to maintain the performance of a network and to protect the value of network assets. Renovation is required when the performance of the network is deteriorated or the possibility of malfunctions in the performance has increased (Berninger et al. 2018, 7).

Renovating, renewing/replacing of public water infrastructure is *an ongoing task*. Many utilities use asset management to pursue and achieve sustainable infrastructure. Asset management can help a water utility *maximize the value of its capital as well as its operations and maintenance dollars*. Asset management provides utility managers and decision-makers with critical information on capital assets and timing of investments. Asset management is a scalable approach that can be used by systems of any size. Whether running a small drinking water system serving 50 customers or drinking water and wastewater systems of the largest cities, asset management means putting in place a long-term plan to sustain these systems and the services they provide. The benefits that can be achieved by utilities through asset management are as follows (EPA 2021):

a) Prolonging asset life and improving decisions about asset renovation, repair, and replacement.
b) Meeting consumer demands with a focus on system sustainability.
c) Setting rates based on sound operational and financial planning.
d) Budgeting focused on critical activities for sustained performance.
e) Meeting service expectations and regulatory requirements.
f) Improving responses to emergencies.
g) Improving the security and safety of assets.
h) Reducing overall costs for both operations and capital expenditures.

The lifecycle functions of water industry asset management comprise planning, asset selection, acquisition, operations, maintenance, repairing, upgrading and ultimate disposal or renewal of capital assets (Water Services Association of Australia 2015, 1). Some key steps for asset management are making an inventory of critical assets, evaluating their condition and performance, and developing plans to maintain, repair, and replace assets and to fund these activities (EPA 2021).

Vinnari (2006, 33-34) defines the water undertakings' asset management as a business philosophy, the key component of which is an operations, maintenance, renovation and replacement strategy based on customer service standards and economic objectives. According to her, asset management is applied in practice, for example, to extend the lifecycle of the facilities and networks, to decrease the expenses without lowering the service level, and to secure that the water undertaking has enough funds to acquire, maintain, rehabilitate, upgrade and replace capital assets. She also gave an example representing a comprehensive asset management system (Table 5).

Table 5. Components of Seattle Public Utilities (SPU) asset management system (Vinnari 2006, 34).

Component	Implementation activity
Define service levels	Annual customer surveys, stakeholder interviews.
Learn about risks	Tracking and tagging of most critical assets by probability of failure/consequence analysis; lower risks by renovation, operations and maintenance.
Focus on life cycle costs	Assess life cycle costs and benefits of each planned project/investment.
Use triple bottom line	Prioritize projects/investments based on societal, economic and environmental impacts.
Optimize data and data systems	Inventory of technical characteristics, age, location, maintenance history, condition and current value of each asset component.
Create strategic asset management plans	Description of current condition of asset components, and operations, maintenance and renovation strategies; risk management plans for operational and economic risks.
Clarify roles and responsibilities	Define responsibilities of work teams and individual members, responsibility areas, and decision-making authorities.
Make large investment decisions via asset management committee	Meets once a week, analyses and finances large investments (>EUR 200,000), ensures that decisions are based on life cycle cost and triple bottom line principles, approves project plans, decides customer service and environmental standards.

In practice, the water utility has *de facto* a position of natural monopoly. From the owner's corporate governance point of view, this means that in particular, the changes in the institutional framework – such as the increase in customer base, and the new regulatory and enforcement measures adopted and applied by the authorities – have to be fully recognized.

In addition, the robustness and redundancy of the assets with regard to achieving and maintaining service quality and level, and to preventing disaster risks and coping with the disruptions have to be determined.

In addition, the owner's corporate governance has to pay attention to ensuring the effectiveness of the asset management, since the market forces do not directly steer the effectiveness of the monopoly activities. Regardless of the organizational model and structure, the institutional framework or the volume of operations, the water utility should define the measures and practices for decision-making and management, which would sustain the long-term asset management considering the utility's current and future conditions. The measures and practices should be delineated in the water utility strategy, and they should be formulated in close collaboration by the administrative and technical management (Paavilainen 2019, 9).

5 DISCUSSION

> *"Regulatory governance is a significant issue for achieving sustainable development goals, especially in the developing countries"* Momen 2021, 8.

In this chapter, we are summarizing the key issues reflecting on our major findings from the review of the previously published works.

Water services and sustainable development

Although water and sanitation are explicitly recognized as a human right, globally 2.3 billion people did not have safely managed drinking water services in 2017 (UNICEF and WHO 2019, 7), and 4.2 billion people did not have safely managed sanitation services (UNICEF and WHO 2019, 60). The total capital investments of meeting SDGs targets 6.1 and 6.2 by the year 2030 are estimated to be USD 114 billion per year. These capital outlays amount to about three times the current investment levels. The majority of the world's low- and middle-income countries are included, as well as selected high-income countries that have low coverage of basic WASH services (Hutton and Varughese 2016, 3).

The absent of safely managed water services and drinking water and sanitation facilities causes vast economic losses to citizens and businesses, environmental degradation, social inequalities, and takes a huge toll on dignity, health and well-being in communities worldwide. The aging and decaying water infrastructure – a creeping crisis – exacerbate these problems in non-OECD countries and comes at a large financial cost – including a sizeable loss of economic activity – also in OECD countries. Therefore, it would be incorrect to consider this mankind's unsustainability challenge as being limited to the developing world; rather, it is *a global challenge that concerns all of us*, including the developed world.

The water services can, however, be seen to be *at the heart of sustainable development*, as the basic idea of sustainable development is the advancement of human well-being within the planetary boundaries (WCED 1987a; Steffen, Richardson, Rockström, Cornell, Fetzer, Bennett, Biggs, Carpenter, de Vries, de Wit, Folke, Gerten, Heinke, Mace, Persson, Ramanathan, Reyers and Sörlin 2015 cited by Takala 2017, 501). The focus should, however, not be only on the sustainability of water services themselves, but the role these services can play in wider society. After all, the way water services are organized affects the well-being of people, society's use of resources, and the state of our environment (Malmqvist, Heinicke, Kärrman, Stenström and Svensson 2006 cited by Takala 2017, 502).

For the past couple of decades, there have been lively discussions on how to conceptualize and operationalize sustainable development. Brinkerhoff and Goldsmith (1992, 370 cited by Kayaga, Mugabi and Kingdom 2013, 3) point out that there can be no sustainable development in any sector without the support of effective institutions, hence underpinning the importance of understanding institutional sustainability in development. Brinkerhoff and Goldsmith (1992, 369) show that institutional sustainability depends upon maintaining: a) responsive output flows (high quality and valued goods and services); b) cost-effective goods and services delivery mechanisms (organization and management); and c) resource flows (recurrent costs, capital investments, human resources).

Takala (2017, 511) argues, however, that if we understand sustainable development as *a dialogue of values* and an encompassing learning project that is to simultaneously answer to the combined environmental and developmental concerns, then extensive focus on water services is problematic. Sustainable development receives meaning in water services only if water services are examined as *part of the community or municipality* they are serving.

Subsidiarity approach

A virtue ethicist approach to practice the principle of subsidiarity offers a starting point to organize societal problem-solving in real-world situations. The virtue ethicist approach is appropriate in fuzzy ill-structured problem situations involving human beings and cultural considerations in exploration of possible, plausible, and desirable development paths for the institutional framework of water services. According to Burbridge (2017, 161-162) it meets the demands of many points – if not all of points – raised in discussions regarding the subsidiarity. The virtue ethicist approach takes the practice of solving social problems as generative of greater awareness of human needs, demands and capacities. This should consequently create debate on *what level of authority would best realize particular goods* in tandem with the debate on the meta-explanation of *the aim of human society*.

It should be pointed out that an advocate of *the virtue ethics* can appeal, with regard to problem-solving, that there are no common solutions to moral conflicts, but *a virtuous personality facilitates making the best possible context-specific decision* (Helsinki Term Bank for the Arts and Science 2021).

Subsidiarity, at its core, envisions a society in which problems are solved and decisions made from the bottom up (Vischer 2001, 142). The principle of subsidiarity can be used in a political context, although it is best characterized as *a social and moral principle*. Subsidiarity advocates for greater participation of the individual in society. Therefore, the principle can be applied to enhance democracy and human rights by promoting the participation and dignity of the individual. The efficiency of the political system can be improved through decentralization and by ensuring that the most appropriate entities resolve problems closest to the problem autonomously and without interference or duplication from other entities (Evans 2013, 60).

In addition, subsidiarity advocates a social order for *the more efficient functioning of society*. The paramount attribute of the principle of subsidiarity holds that authority should rest with the member units unless allocating them to a central unit would ensure higher comparative efficiency or effectiveness in achieving certain goals. This principle can be defined in several ways, for instance concerning which units are included, which goals are to be achieved, and who has the authority to apply it. When individuals or subsidiary organizations are allowed to resolve the matters closest to them, larger organizations, such as the state, are exempted to better carry out the functions specifically allocated to them. The aim is that individuals are empowered and responsible for problems affecting them and close to them. At the same time, the state and its organizations can function more effectively, without overlap, and are able to more efficiently resolve matters pertinent to their respective spheres. Subsidiarity is not reducible to a simple test of comparative efficiency because the exercise of local self-government is, in itself, sufficiently valuable to justify tolerance of some inefficiency (Follesdal 2014; Evans 2013, 47; Barber and Ekins 2016, 9 cited by Burbridge 2017, 155).

The principle of subsidiarity has emerged to become *a pillar of integrated water resources management.* As long as subsidiarity is pursued with rigorous and transparent intent, and not as a panacea, water resources and human communities will stand to benefit. Like the general principle of subsidiarity, the subsidiarity principle of water resources management suggests that water management and service delivery should take place at the lowest appropriate governance level (Stoa 2014, 45). In many cases, the subsidiarity principle of water resources management has been applied with undue haste, assuming that water resources management should occur at the local level when in fact *institutional capacities* would suggest that local institutions are not the appropriate governance level (Stoa 2014, 32).

Subsidiarity is better understood as apolitical with respect to how the state should be structured: ***"Subsidiarity is a call for social functions to be fulfilled, not at the lowest***

possible level but rather at the right level." This implies that all communities have a responsibility towards all other communities (and to persons) to offer them various kinds of help or service. It should be recognized that the subsidiarity has a dual aspect: negative subsidiarity requires that a higher authority should not intervene in what a lower one can do for itself; while positive subsidiarity requires that it must intervene to provide assistance when needed. The principle has not only a vertical but also a horizontal relevance. Therefore, subsidiarity is not a principle of decentralization, but rather, a principle of 'non-absorption' (Brouillet 2011, 605; Delchamp 1994, 10-11; Chaplin 2014, 72, 76 cited by Burbridge 2017, 144).

Multi-level governance

According to Papunen (1986, 52 cited by Haapalainen 1990, 9), *the planning of multi-level governance* can be done in accordance with *the principle of subsidiary*. Heikkila (2004, 102) suggests that a public service industry, or a local public economy, should have *three components*. These components are jurisdictions and organizations that *provide a good or service*, jurisdictions and organizations that *produce or supply a service or good*, and jurisdictions and organizations that *legislate and administer rules governing provision and production*.

According to Heikkila (2004, 111), local public economy (or public service industry) theory conceptualizes institutional boundaries as being formed around local problems that affect a group of individuals, rather than around a physical resource or good.

Low et al. (2003, 108) argue, however, that the presence of larger, overlapping jurisdictions is *an important complement* to the work undertaken by parallel, smaller-scale units. Larger units can back up the smaller units in several ways: 1) providing support at times of natural disasters; 2) addressing corruption or gross inefficiency; 3) providing scientific and technical skills to complement the local knowledge; 4) providing conflict resolution arenas for conflicts among parallel units; and 5) taking on functions that are generally more efficiently undertaken by larger units.

Local systems may in general be best able to verify local information, address locally specific conditions, and respond rapidly. The checks and balances on local interests, however, may work best at greater-than-local levels. The fact that "redundant" local variations exist may mean that system-level responses may be more potent and rapid than otherwise, and/or that local variations may be able to meet unforeseen contingencies. Individuals who interact with others more frequently on a face-to-face basis, and know that future interactions are likely repeated, are more suitable to build trust and adopt forms of reciprocity than when interactions are more antonymous and infrequent. More experimentation can also occur when local units have some autonomy to create their own rules and policies (Low et al. 2003, 106-107).

In addition, Hooghe and Marks (2002, 7) raise a criticism of large-scale government: it cannot accommodate diverse citizen preferences. Preferences of citizens may differ widely, and if one takes this heterogeneity of preferences into account, the optimal level of authority may be lower than economies of scale dictate. Therefore, they argue that multi-level governance allows decision-makers to adjust the scale of governance to reflect heterogeneity of citizen preferences.

Local government also provides an important source of stability, equity, and voice. The concerns with democracy, community, and equity should not, therefore, be destroyed by a singular focus on efficiency (Warner and Hefetz 2002). Although efficiency is important, public service production is also about *equity, democracy, and community building* (Frug 1999 cited by Warner and Hefetz 2002, 71).

Further, sustainable development of water systems needs to be examined as part of the public services and public good. Public good is not defined by the experts alone, but necessitates dialogue and community involvement (Takala 2017, 503). Yet, it is important to mention that 'more' or 'better' multi-stakeholder participation with 'more actors' may still not resolve the complex array of challenges and competing interests inherent to water governance processes. Stakeholders with the best of intentions at moments can be deeply dissatisfied with the outcomes of multi-stakeholder processes to activate the necessary reforms, or when ideas proposed by vested interests may prevent lasting change (UN 2021, 123).

Hukka, Castro and Pietilä (2010, 239-240) point out that while for some actors governance is mainly an instrument to achieve certain ends such as the implementation of full-cost recovery policies or the re-organization of water utilities on the basis of market principles, for others governance entails substantive participation by citizens and water users in the actual definition of the goals and direction of water policy. While the former considers citizens and water users passive subjects and water policy decisions the domain of a small circle of expert politicians and sector professionals mostly outside public debate and scrutiny, the latter feel that democratic water governance requires *substantive* – not merely formal, consultative – *involvement of citizens and water consumers*. Therefore, we can neither simply rely on normative or policy/institutional understanding of governance nor expect the principles of substantive democratic water governance to be adopted as a necessary outcome of good governance at the policy and institutional levels.

Efficiency vs. resilience

The societies throughout the world depend on a set of systems that supply food, water, public health services, energy, and transport (IRGC 2006, 11). The disasters and disturbances with regard to communities' crucial systems and essential services – such as water and wastewater assets, networks, systems and facilities – can result in substantial economic, environmental and social damage. Security and resilience of the critical infrastructures are strengthened through risk management which is the "process of identifying, analyzing, and communicating risk and accepting, avoiding, transferring, or controlling it to an acceptable level at an acceptable cost (DHS 2013, 7).

The growing recognition by infrastructure organizations of the need to improve effectiveness, overall operating performance and reliability requires clear understanding of how to manage infrastructure assets in a way that allows their current performance to improve and be competitive, while ensuring they are planning and re-investing for the future. Consequently, organizations that manage infrastructure assets are driven to adopt a formal and holistic approach to the management of infrastructure assets in order to provide services in the most cost-effective manner, and to demonstrate this to customers and stakeholders (Too 2012, 2)

Disaster risk management is a vital component of the comprehensive asset management. In addition, focusing on effectively managing assets to sustain services can be as important as focusing on new infrastructure (WHO 2012b, 3). The cost of renovation of water infrastructure systems is, however, increasing substantially across the world due to their accelerating deterioration. *These deterioration processes* are more severe in developing countries, due to ageing of the systems, poor construction practices, little or no maintenance and renovation activities, operation at higher capacity than designed for, and so on. There is little knowledge about specific classes of asset deterioration and the technical service life of the assets. Further, there is insufficient data to know the extent and/or value of the infrastructure assets (Marjoram 2010, 286-287).

A resiliency approach to designing, building, operating and protecting our critical infrastructures enables us to address these risks at the systemic level. By approaching infrastructure asset management in accordance with *a systematic process* of engineering system resiliency, we are more likely to have a safe, efficient, survivable, and sustainable infrastructure system. The outcome of instituting a resiliency process is that the infrastructure systems that are engineered in accordance with these principles are likely to meet three high-level performance criteria: efficiency, sustainability, and survivability (Volpe 2013, 1-2, 5).

Governments have a key role to play in critical infrastructure resilience, as responsible to provide security and safety to citizens, but also as an infrastructure policymaker, and regulator, owner or operator in some cases, and major user or client. Critical infrastructure owners and operators, however, bear the primary responsibility for protecting their assets and maintaining the continuity of the services they provide. Be they public, private or of a hybrid form, owners would normally want to protect their capital asset against suffering damages or destruction from a disaster, or another shock event. Similarly, operators have a strong interest in maintaining the continuity of their services and avoid disruptions, not only because of the losses they can potentially suffer when services stop, but also because they are concerned with their reputation and image towards their clients or users. Nevertheless, owners and operators cannot address all their vulnerabilities on their own and may not have incentives to assess a complete overview of the full extent of their interdependencies. *Interdependencies* between critical infrastructure sectors and the potential cascading effects that may follow in case of disaster require cooperation across sectors (OECD 2019, 40).

Sustainability and resilience should not be seen as fringe concepts in infrastructure debates, but as good economic practice. Infrastructure that is sustainable and resilient can support growth and a higher standard of living. There are costs – both upfront and ongoing – in making our infrastructure more sustainable and resilient. These should not be seen as an economic or administrative burden. Incorporating sustainability and resilience as foundation concepts in design, construction and operation often reduces whole-life costs by improving the efficiency of operations and maintenance, while optimizing benefits for the community and environment. These upfront costs represent an opportunity to invest in our future and secure our well-being, quality of life and prosperity (Infrastructure Australia 2016, 124-125).

The economic, environmental and social conditions in general influence the level of resilience (OECD 2014, 51). In applying the concept of resilience, the focus should be shifted away from the maintenance and equilibrium of the critical infrastructure system towards *the delivery of system services* and its external relations permitting a better consideration of external effects and changes as well as interaction with other systems, such as the society. Therefore, resilience strategies need to integrate the potential failure of infrastructure services instead of focusing only on their robustness and reliability (Bach et al 2013, 7).

For example, Roberson (2007, 34) points out that one promising approach is developing a better understanding of *the economic effects of a complete loss of water service* in a community. Most water systems and their customers are familiar with a boil water notice resulting from potential microbial contamination or a treatment failure. Yet, this scenario assumes water is still being delivered for basic sanitation and fire protection. A total-loss-of-service scenario is much more severe because it assumes that alternative methods of delivering drinking water would be available. Yet, in this scenario no water would be available in the distribution system for other uses, such as showering, flushing the toilet, food preparation, fire protection, or manufacturing.

In a total-water-loss scenario it is also critical to consider customers who depend on potable water and how water is used throughout the community. It should be considered how water is used by all businesses and the potential effects from a loss of service, especially if that loss of service goes on for a few days, a week or two, or even a month or longer. There is a potential for significant economic impact from a loss of service that extends beyond a few days, and there is always the potential for a longer loss of service. At local level, this type of economic analysis can be qualitative in order to argue for more resources for water utilities to further develop and implement security and emergency preparedness plans (Roberson 2007, 35-36).

It should be recognized that a system, which is tuned up to a maximal efficiency, functions close to the threshold value and thus *its resiliency will be low*. A certain amount of "lazing around" time and resources are thus needed for unproductive experiments and development activities which create new competencies and solutions. The leadership and management principles should also be built on the acceptance of *the diversity of perceptions* and on the enhancement of transparency, learning and self-organization (Walker and Salt 2006 cited by Nieminen et al 2017, 14; Nieminen et al 53-54).

Perfectly resilient infrastructure is neither possible nor productive. The response to risks should be proportionate and efficient. It has to be accepted that even resilient infrastructure will on occasion be negatively impacted by extreme events or conditions and will fail in some circumstances. Resilience strategies should seek to minimize the impact of disruptions and restore services as quickly as possible in the case of failure (Infrastructure Australia 2016, 135).

The resilience of a community with regard to any hazard or event is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need (UNISDR 2009, 24 cited by DESURBS 2014, 4). Resilience as the organization's adaptability and flexibility to change is, however, *situation-specific*. There are no universal solutions to unique and constantly changing conditions, and unforeseen events and changes may occur that exceed the finite and inherent base response capacity of an organization. Woods (2018a, 4) presents *the theory of graceful extensibility* that explains the contrast between successful and unsuccessful cases of sustained adaptability. Graceful extensibility is the ability of a system to extend its capacity to adapt when surprise events challenge its boundaries.

The organization should pursue optimization of its own response capacity, but simultaneously there should still be readiness and means to readjust and deploy required "external" response capabilities and resources to adapt to and handle the new threat (Nieminen et al 2017, 53; Woods 2018b, 1, 5; Woods 2018a, 38). Therefore, effective organizations build *reciprocity* across roles and levels (Ostrom 2003 cited by Woods 2018b, 4). Reciprocity in collaborative work is commitment to *mutual assistance*. With reciprocity, one unit donates from their limited resources to assist another in their role, so both achieve benefits for overarching goals, and trusts that when the roles are reversed, the other unit will in turn respond and come for help (Woods 2018b, 4).

Water sector managers must, however, *balance resilience with affordability*. Resilience at all costs is neither feasible nor efficient. This means that it may not always be possible to protect entire systems from every risk. The challenge for water managers is to undertake proportionate and efficient risk mitigation. Measures to improve resilience should be tailored to each local context, and customers' capacity to pay should be taken into account. Asset managers should consider the whole-life costs of their water infrastructure, including additional costs or savings through operations and maintenance for investments that enhance resilience (Infrastructure Australia 2017, 22).

The costs of resilience must also be balanced with the potential costs of inaction. Improvements in resilience will generally come at a cost to customers or taxpayers, but the costs of not adequately managing risks to infrastructure assets and networks can be far greater. Aside from the costs of repair and renewal in the case of extreme weather or network failure, a lack of resilience can cause losses in productivity and connectivity when infrastructure is unavailable (Infrastructure Australia 2016, 124 cited by Infrastructure Australia 2017, 22). For water infrastructure, system failure could also have serious health and environmental costs. Responses to extreme events should be delivered in collaboration with local emergency services and government agencies. These should prioritize protection of customers in the case of failure, and the re-establishment of services as soon as possible to minimize the economic, social and environmental impact of failure on households, businesses and natural habitats (Infrastructure Australia 2017, 22).

Systems blindness

The challenges facing the urban water sector require lasting solutions that focus on efficiency as a key priority. Short-term measures such as running down legacy assets will do nothing to address long-term affordability of urban water services – in fact, such measures are likely to exacerbate cost issues (Infrastructure Australia 2017, 4).

The increased awareness of the need for sustainable services has not, however, yet been translated into increased budget allocations for operations and maintenance (Rognerud, Fonseca, van der Kerk and Moriarty 2016, 24). Many non-OECD and OECD countries have paid insufficient attention to maintaining and expanding their infrastructure assets, creating economic inefficiencies and allowing critical systems to erode (Woetzel, Garemo, Mischke, Hjerpe and Palter 2016 cited by World Economic Forum 2019, 82). Costs of infrastructure operations and maintenance are often neglected or not well factored into water mobilization projects. As a result, many water systems are inadequately maintained, leading to damages, losses, unreliability, and decreasing quality and quantity of service to users (UN-Water 2015, 15). In addition, many governments reporting inadequate funding for water, sanitation and hygiene also indicate a poor absorption capacity – difficulties in spending the limited funds that are received (WHO 2012b, 4).

Most of the aforementioned inherent challenges of water services coverage and aging water services infrastructure and systems can thus mainly be attributed to – what Fonseca and Pories (2017, 4) call ***"systems blindness"*** – a focus on the tangible infrastructure without attention to the supporting systems including renovation, i.e., major maintenance (Figure 14).

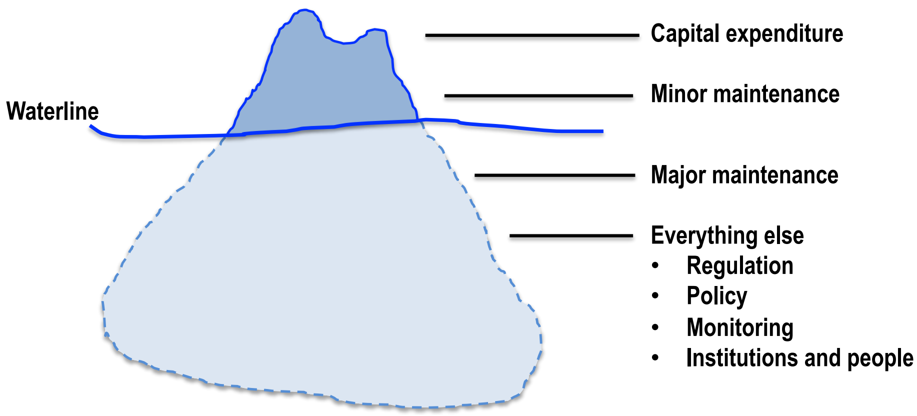


Figure 14. Systems blindness to non-capital expenditure (Fonseca and Pories 2017, 4).

Fonseca and Pories (2017, 4) argue that globally, investments concentrate on the physical construction of infrastructure (capital outlay) with *insufficient attention on the institutional arrangements* needed to make the water and sanitation infrastructure function properly: regulations, policies, monitoring, institutions and the people that provide WASH (water, sanitation and hygiene) services at regional, district and municipal levels. According to them, the lack of non-capital expenditure and support for service authorities, service producers and the necessary innovative institutional structures results in high rates of non-functionality, poor services and stagnation in coverage.

Underinvestment is an utmost challenge in the water and sanitation services sector, but so are wasteful or ill-conceived investments. In this context, water pricing is first and foremost a financing mechanism: it generates revenues that can be used to maintain, renew and extend the infrastructure when and where appropriate (OECD 2010, 18).

Valuing water appropriately is a cornerstone for better water management, preventing conflicts over water allocation, and pollution, allowing for more sustainable service delivery from both natural and built infrastructure. Valuing water means identifying and taking into account the multiple and diverse values of water to different groups, and interest in all decisions affecting water. *Appropriate pricing of water and of water services* are a critically important way of recognizing part of the value of water (United Nations and World Bank 2018, 18). Supplying water and providing sanitation services has an inherent financial cost not only with regards to capital investments but also during the operations and maintenance, renovation and expansion phases. These financial costs are reasonably straightforward to identify and potentially match in order to recover costs (Cardone and Fonseca 2003, 25).

Water pricing has, however, to be *regulated* in order to safeguard the full cost recovery and to make sure that citizens and businesses are getting affordable, fair and equal pricing. For example, in Finland, such regulation does not exist. According to Gustafsson (2013, 74) the Finnish Competition and Consumer Authority's (FCCA) specific jurisdiction is the supervision of the Competition Act (948/2011), but the FCCA can make judgments on water service charges only based the Competition Act, not based on the Water Services Act. In addition, the FCCA is an authority, not a court. Therefore, the most serious constraint related to the regulation of the water utility's business operations is that actually the regulation of the water services charges does not belong to any authority's jurisdiction (Belinskij 2010, 352 cited by Gustafsson 2013, 83). ELY Centres and the municipal authorities are not competent authorities in this matter. Therefore, in theory, and considering the aforementioned restrictions, only the consumer protection and competition authorities could regulate the water services charges (Gustafsson 2013, 83).

Further, Saarinen (2020, 32) reveals that the lack of economic regulation is one of the reasons behind the renovation investment gap in Finland. The utility owner's requirement for a high rate of return is often blamed for the lack of adequate capital expenditures. The reasonability of the rate of return is also difficult to determine and it is, however, not regulated.

Cardone and Fonseca (2003, 18-19) add that the water service charges should also cover the administrative costs of sustaining the service, including also the costs incurred in regulating the service, institutional capacity building, and the cost of devising and implementing the policy and enabling environment for the sector. Rees, Winpenny and Hall (2008, 7) argue that this should be further extended to more systematically include the costs associated with all of the water resources management activities that are needed for the stewardship of the water resource base, and therefore for the long-term sustainability of service production. According to OECD (2009c, 27) an essential aspect of water policies is ensuring that these costs are covered so that water-related infrastructure and services continue to perform their functions.

In reality, very few countries, however, developed or developing, practice full cost recovery (FCR) through tariffs (OECD 2009c, 55). Nevertheless, there are often significant opportunities to move progressively towards higher levels of cost recovery through tariffs, while ensuring that poor and vulnerable groups have access to water services. Indeed, there is probably no alternative, given the limitations of other sources of revenue (OEDC 2009c, 56).

OECD report (2010, 70) points out that – whatever the status of the water services producer is – the financial sustainability is *a requisite* for the sustainable operation of water services. The key issues are the level of revenues and their stability or predictability. Cost recovery through tariffs is considered a paramount driver of the financial sustainability of water services producers, since other financing instruments (taxes and transfers) are volatile and beyond the reach of the water services sector. It is becoming ever clearer that the sustainability of any investment will depend on the capacity to tap local users for financing, including lower-income users (OECD 2009c, 90).

Regulatory agencies are mainly responsible for the execution of enforcement and inspection for complying with rules and requirements (Momen 2019 cited by Momen 2021, 5). Therefore, operational independence and accountability of regulatory bodies are regarded as a pillar for good regulatory governance. Barth, Caprio and Levine (2006 cited by Momen 2021, 5) also developed a relationship between the degree of operational independence and accountability and the performance of regulatory bodies. However, governments often experience a trade-off situation between the independence of the regulatory bodies and control over their activities (Correa, Melo, Mueller and Pereira 2019 cited by Momen 2019, 5). Regulatory bodies are responsible to monitor the "players of the game"; therefore, it raises fundamental issues regarding the accountability of their actions (Marques and Pinto 2018 cited by Momen 2019, 5-6).

Achieving a regulatory system that is as efficient as possible over time – and within the constraints of other social values – requires actions on many different levels. The main challenge is one of institutions and incentives. Good regulatory governance rests on a system of institutions, driven by supporting incentives, that set transparent goals for regulation; apply, advocate, and monitor regulatory quality; and implement a host of better regulation tools. These tools could include regulatory impact assessment (RIA), public consultation, measures to regularly update existing regulation, alternatives to regulation, and measures to promote regulatory transparency, access, and user friendliness (Jacobs and Ladegaard 2010, 7).

According to UN-Water report (2015, 99) *accountability* is at the heart of well-functioning regulatory systems. The regulator holds to account water service producers and industries, for example, by verifying compliance with rules and regulations. Regulatory measures can take the form of administrative and legal or economic incentives. A wide range of measures exists to strengthen social, administrative and political accountability, such as public expenditure tracking, auditing, public access to water utility budget and performance information, citizen report cards, consumer redress mechanisms, establishment of model contracts, and raising consumer awareness of their rights and obligations.

To clarify the rules and roles of different water sector actors for improved water services management, Inha, Katko and Rajala (2019, 2) compare institutions and organizations to *a soccer analogy*. They recognize that this metaphor – often used in teaching different aspects of collaboration and integration – allows us to illustrate various stakeholder roles and the concept of institutions in a clear manner that is easy to understand even for people outside the water sector. This is important in increasing the general awareness and understanding of water services management.

According to OECD (2015, 5) structuring, institutionalizing, and/or formalizing institutions should not, however, detract from the ultimate objective of delivering sufficient water of good quality, while maintaining or improving the ecological integrity of water bodies.

There is, therefore, an urgent need to address the systems blindness and to build strong institutional arrangements (enabling environment) that are able to professionalize the water services sector and attract increased funding to reach universal coverage and to improve water services' ageing infrastructure and facilities. We conclude that also the ignorance, negligence, or lack of understanding of the consequences of unsafe and unreliable water services contribute to the poor service coverage, poor service level and aging infrastructure as illustrated in Figure 15.

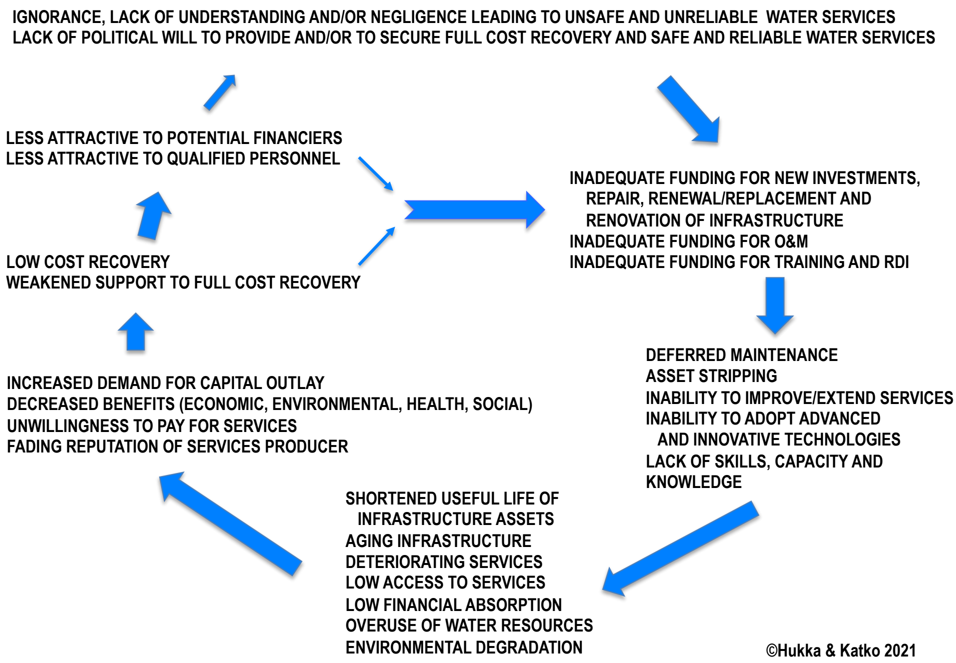


Figure 15. Vicious circle of unsafe water services pricing regime (modified from Hukka and Katko 2015, E44).

Many studies have emphasized *the need for institutional changes*. For example, UN-Water report (2015, 104) points out that in addition to adequately financing the development, operations and maintenance of infrastructure, increased funding is also needed in order to develop institutional capacity and ensure well-functioning governance structures, if countries are to meet the emerging SDGs. In addition, the High-Level Panel on Water stipulated that SDG 6 goes beyond basic access to water and sanitation and calls for safe levels of service that are sustainable and provide more inclusive and equitable access (United Nations and World Bank 2018, 22).

In most countries, funding for water infrastructure is neither adequate nor sustainable. *Water services remain rather low on the scale of policy priorities* despite well-documented contributions to human and economic development (UN-Water 2015, 14-15). Therefore, the challenge of meeting future demands and achieving sustainable water and sanitation for all is significant. *Strong political will and commitment* are required. Yet, as the UN-Water report (2018, 26) emphasized there is no standard approach for sequencing the policies and institutional developments and investments required for effective management of water resources, and provision (and production) of services that will be valid for all countries and under all circumstances.

In addition, we need also *professional will*: willingness to view the development of water services in a wider institutional context. Wider collaboration with many stakeholders of water services is also required which is a challenge to sector professionals and stakeholders (Katko 2016, 243-244).

For example, in New Zealand, the Office of the Auditor-General (2014, 17) recommends that decisions on how to manage infrastructure need to be made in the context of each local authority's financial position and prospects, and the circumstances of its community. Local authorities cannot separate decisions on their assets and service delivery from considerations about funding sources and timing (of funding and of renewal or replacement work). Asset intentions need to be matched with revenue and financing policies and funding tools, which, in turn, are based on information about assets and service delivery. Decisions on infrastructure investment and services require effective and defined connections between assets, service delivery levels, and funding. Asset management decisions are so closely linked to a local authority's financial strategy that any weak link can undermine the strength of the asset management chain.

6 CONCLUSIONS AND RECOMMENDATIONS

> "*Subsidiarity is a call for social functions to be fulfilled, not at the lowest possible level but rather at the right level"* Chaplin (2014, 72).

The water services are *at the heart of sustainable development*. The way water services are organized affects the well-being of people, society's use of resources, and the state of our environment. Sustainable development of water systems needs to be examined as part of the public services and public good. Public good is not defined by the experts alone but necessitates dialogue and community involvement. Predominantly, however, *a public utility* is responsible for the development and operational management of community water services infrastructure worldwide.

S*ubsidiarity* envisions fundamentally a society in which problems are simply solved and decisions made from the bottom up. The aim of *the principle of subsidiarity* is *to promote efficiency and local ownership* over policies and regulation, while placing a check on centralized governance and consolidation of authority at the highest levels of government. *A virtue ethicist approach* to practice the principle of subsidiarity offers a starting point to organize societal problem-solving in real-world situations. The virtue ethicist approach is appropriate in fuzzy ill-structured problem situations involving human beings and cultural considerations in exploration of possible, plausible, and desirable development paths for the institutional framework of water services.

Efficient governance must be *multi-level*, and the planning of multi-level governance can be done in accordance with the principle of subsidiary. *Local government* is an important source of stability, equity, and voice. The concerns with democracy, community, and equity should not be jeopardized by a singular focus on efficiency. Although efficiency is important, public service production is also about *equity, democracy, and community building.* Local systems may in general be best able to verify local information, address locally specific conditions, and respond rapidly. The checks and balances on local interests may work best at greater-than-local levels.

A public service industry, or a local public economy, should have *three components*. These components are jurisdictions and organizations that *provide a good or service*, jurisdictions and organizations that *produce or supply a service or good*, and jurisdictions and organizations that *legislate and administer rules governing provision and production*. When provision, production, and governance are separated, jurisdictions have opportunities to address a shared problem related to the management or use of a resource by coordinating service production.

Sustainability and resilience of water infrastructure should be seen as good economic practice. Infrastructure that is sustainable and resilient can support growth and a higher standard of living. There are costs in making infrastructure more sustainable and resilient. Yet, incorporating sustainability and resilience as key concepts in design, construction and operations often reduces whole-life costs by improving the efficiency of operations and maintenance, while optimizing benefits for the community and environment. In applying the concept of resilience, the focus should be shifted towards *the delivery of system services* and its external relations permitting a better consideration of external effects and changes as well as interaction with other systems, such as the society.

Therefore, resilience strategies need to integrate the potential failure of infrastructure services instead of focusing only on their robustness and reliability. Perfectly resilient infrastructure is neither possible nor productive. The response to risks should be proportionate and efficient. Water sector managers must *balance resilience with affordability*. Resilience at all costs is neither feasible nor efficient. Resilience as the organization's adaptability and flexibility to change is also *situation-specific*. The organization should pursue optimization of its own response capacity, but simultaneously there should still be readiness and means to readjust and deploy required external response capabilities and resources to adapt to and handle the new threat. Therefore, effective water utilities build *a reciprocal relationship*.

Viability of a water utility depends by large on *its capability to maintain a continuity of preferred quality and level of service which meets regulatory and other goals by minimizing the total cost of owning and operating infrastructure capital assets*, i.e., at the lowest life cycle cost of the utility's assets. The utility has to be authorized and capable to allocate sufficient amount of money to cover the operating and capital expenditures.

Supplying water and providing sanitation services has an inherent financial cost not only with regards to capital investments but also during the operations and maintenance, renovation and expansion phases. These financial costs are reasonably straightforward to identify and potentially match in order to recover costs. Yet, w*ater pricing* has to be *regulated* in order to safeguard the full cost recovery and to make sure that citizens and businesses are getting affordable, fair and equal pricing.

Accountability is at the heart of well-functioning regulatory systems. The regulator holds to account water service producers and industries by verifying compliance with rules and regulations. Regulatory measures can take the form of administrative and legal or economic incentives. A wide range of measures exists to strengthen social, administrative and political accountability, for example, public expenditure tracking, auditing, public access to water utility budget and performance information, citizen report cards, consumer redress mechanisms, establishment of model contracts, and raising consumer awareness of their rights and obligations.

We advocate – as one of our institutional innovations – that in any country subsidiarity approach (based on the virtue ethicist approach), multi-level governance, and resilience approach should be studied and applied thoroughly in formulation and development of the institutional framework for water services regulatory governance, provision and production. Their adoption would generate and offer outstanding opportunities to improve and maintain economic, social and environmental sustainability of the water services and, subsequently, sustainability of the society as a whole. Therefore, they can be considered the pillars of the institutional framework of sustainable water services as we indicate in Figure 16.

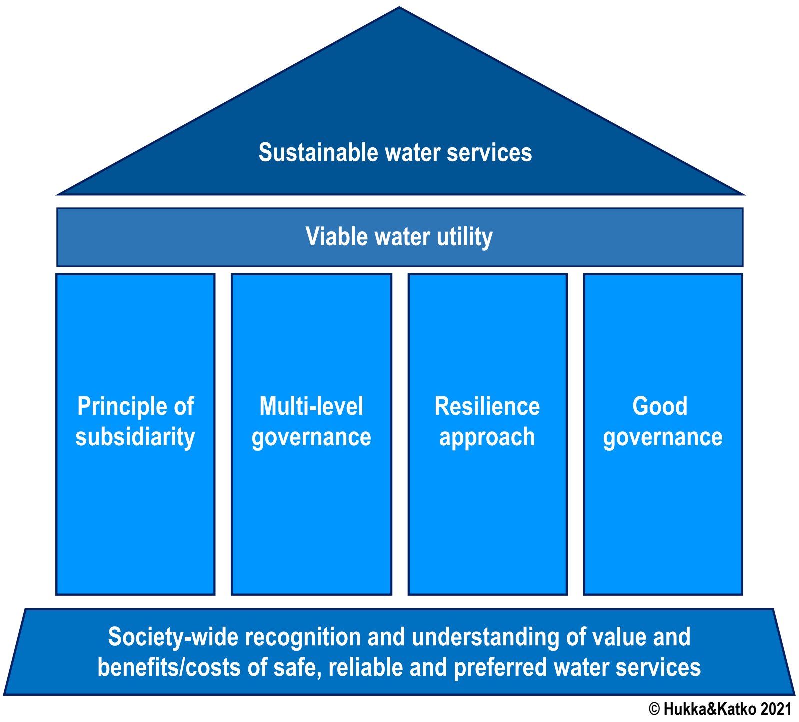


Figure 16. Four pillars of sustainable water services.

We highly recommend that the water utility as a local natural monopoly should be *owned by a local government or a water user cooperative*. *The local government* should be responsible for the provision of water services. In the strict conformity with law, however, the jurisdictions of the local government owner, the local government provider, the governing local authorities and the water utility should definitely and formally be independent and separated.

The local public utility or *the water cooperative utility* should have the responsibility for the production of water services. In the conformity with law, however, *amalgamation of*, or *collaboration* – in particular, *reciprocal and responsive collaboration* – between water utilities should be permitted, enhanced and encouraged. This might also be highly advisable and justified, for example, if the owners have ample evidence that economies of scale through amalgamation or collaboration – in a specific case – allow for attracting and retaining skilled management and personnel, for changing business models, or for improving performance, resilience or good governance.

Further, we would like to point out that amalgamation or collaboration can also build up competence and enhance opportunities for cutting-edge procurement of works, goods and services from the private sector. One benefit can also be better prospects for advancement of research, development and innovation activities (RDI). Yet, amalgamation should not be seen as *a panacea* but needs to be considered on a case-by-case basis. The utilities could also practice collaboration by establishing on a regional basis, for example, *an umbrella joint venture/cooperative* which could be responsible for giving specified assistance, for pooling resources, for joint procurement and production of the works, goods and services, and for the risk governance and asset management frameworks and strategies on behalf of all partner utilities.

In order to improve *comprehensive disaster risk governance and management*, especially to cope with the creeping and invisible threats and risks, we recommend that more and more attention should be paid to *the development of regulatory governance of asset management, critical human resources, corporate governance, and good management practices*. Vulnerability of the water infrastructure may be increased and water utility resilience may be subconsciously decreased, if various possible, plausible and preferable alternatives are not considered thoroughly or if there is no willingness or capability to comprehensively and systematically predict and assess the risks related to these alternatives.

All the costs related to the regulatory governance, provision and production activities should be studied and verified thoroughly. Thereafter, decisions may be made on which costs have to be covered and how to safeguard the long-term sustainability of the water services and resilience of water utilities.

All key strategic decisions – also related to the institutional framework for regulatory governance, provision and production of water services – as well as the principles and practices related to utility business activities and asset management in particular should be considered from *the perspectives of resilience, disaster risk governance and management*. In strategic decision-making, possible alternatives should be brought up and strengths, weaknesses, opportunities and threats of each alternative should be examined. At least in theory, this should guarantee that the societal or strategic decision-making as such will not severely jeopardize resilience of water utilities or efficiency, sustainability and survivability of critical water infrastructure assets.

Typically, water services are regulated strongly and formally to ensure robustness and reliability of the infrastructure assets, to protect the health of the citizens and the natural and built environment, and to ensure that citizens and businesses are getting affordable, fair and equal pricing. We conclude, however, that in order to apply the principle of subsidiarity – on the basis of *the virtue ethicist approach* – to water services regulatory governance, provision, and production, at least the following key findings should be considered:

i) The key principle of the framework should be, however, that a higher level jurisdiction, when it intervenes – first and foremost – assists a lower level jurisdiction to resume full responsibility for its legitimate functions (based on the virtue ethicist approach to subsidiarity, Figure 17);

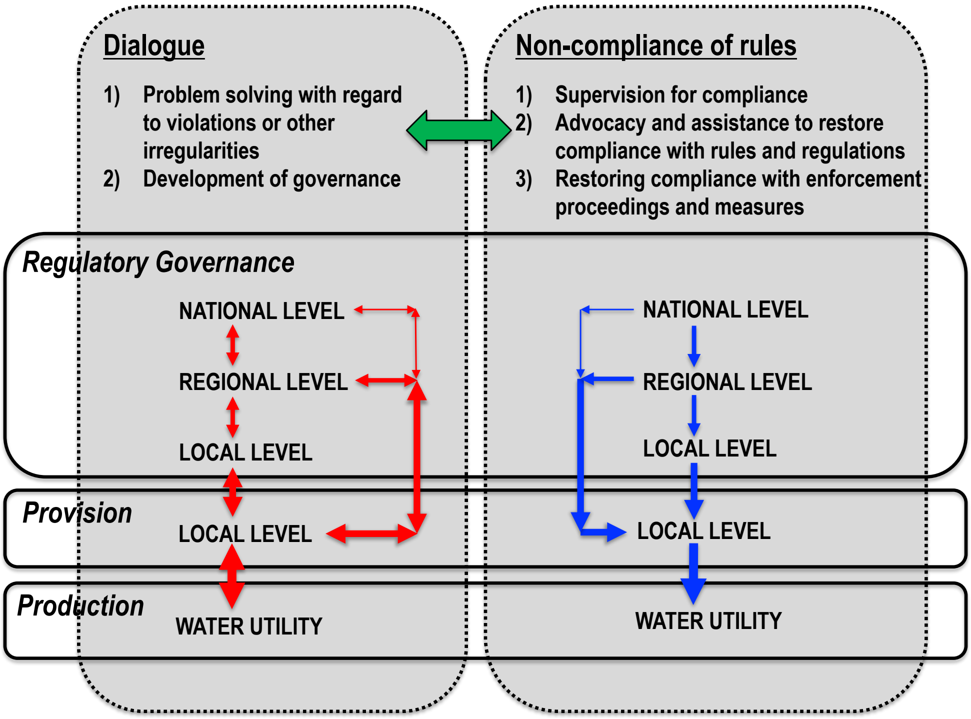


Figure 17. Dialogue and compliance-restoring processes in multi-level governance of water services.

ii) Legislation and good management practices should ensure that jurisdictions (regulatory governance, provision, production) have adequate resources and support to enable them to perform their functions and to comply with rules and regulations enacted for their functions and powers;

iii) A formal regulatory governance framework for water services should be planned and adopted which would provide the powers, procedures and enforcement instruments for intervention, possible precautionary measures, and restoring compliance by a higher level jurisdiction when it becomes aware of violations or other irregularities concerning the incapacity of a lower level jurisdiction to perform its functions in conformity with law and other formal rules and regulations;

iv) The framework should define performance assessment protocols, performance metrics and key performance indicators on the basis of which the performance of a lower level jurisdiction is evaluated with regard to possible interventions and compliance-restoring measures.

An early warning mechanism (EWM) should be included for this subsidiarity control, for example, a yellow-orange-red card warning system.

v) Jurisdiction at each level shall assist, support, consult and co-operate the other levels of jurisdiction to comply with rules and regulations enacted for their functions and powers;

vi) The framework should include dispute resolution procedures for settling disputes between different levels of jurisdictions; and

vii) The utilities should develop and adopt reciprocal and responsive relationships with other utilities – in particular to extend disaster management response capabilities and resources – but also to collaborate under normal circumstances, whenever mutually deemed necessary. In this regard, for example, *a regional umbrella joint venture/cooperative* could be a viable alternative from which all partner utilities are benefitting in the form of assistance, pooling resources, joint procurement and production of the works, goods and services, and of the risk governance and asset management frameworks and strategies as specified in a memorandum or the statutes of the joint venture/cooperative.

There are several definitions of viable water utilities and resilience formulated by various well-known organizations and prominent scholars. After carefully reviewing and diagnosing those definitions we have formulated our own state-of-the-art definitions for a viable water utility (Box 6) and resilience of a water utility (Box 7).

Box 6. Viable water utility.

A viable water utility is a well-managed, service-oriented, customer friendly, resilient and proactive public or user-owned entity. It has managerial and technical competence as well as financial capability to produce and maintain safe, reliable and preferred services which meet regulatory and performance requirements as well as its own economic, social, environmental and business objectives by minimizing the total cost of owning and operating infrastructure capital assets, now and in the future. A viable water utility promotes and actively participates in the development of regulatory governance, provision, and production to enhance sustainability of water services. It also has reciprocal and responsive relationship with other utilities to facilitate resilience.

Box 7. Resilience of a water utility.

The competence of a utility – also by extending and readjusting its response capabilities and resources needed – to predict, prepare for, adapt to, withstand, communicate and recover promptly, efficiently, and effectively from the consequences of any human-caused intentional and unintentional or naturally occurring hazard, threat or incident – both foreseeable and unexpected – in order to successively produce and maintain safe, reliable and preferred services, to protect the society and the environment, and to learn from the experience gained, now and in the future.

As our final institutional innovation, we recommend the following conceptual framework as a starting point for development and planning of multi-level governance (regulatory governance, provision and production) for sustainable water services (Table 6).

Table 6. Conceptual framework for multi-level governance for sustainable water services.

GOVERNANCE LEVEL	KEY RESPONSIBILITIES AND DUTIES	PERFORMANCE ASSESSMENT
REGULATORY GOVERNANCE National level	Drafting of legislation, rules and regulations for regulatory governance, provision and production Overall oversight and guidance for legal framework enforcement and compliance Leading and guiding national water policy and strategy preparation processes Leading and guiding development of national intersectoral framework for disaster risk governance and management	Evaluations Regulatory Impact Assessments Indicators for regulatory governance National water utility performance reporting framework
Regional level	Execution of enforcement, guidance and inspection for complying rules and requirements (local level regulatory governance, services provision and production) Environmental permitting	See: Above Local level water supply and sanitation development plans (every 5 yrs)
Local level	Execution of enforcement, guidance and inspection for complying rules and requirements (services provision and production)	See: Above
PROVISION Local level	Responsibility and oversight for water services development, extension and upgrading Participation in supramunicipal general planning Designation an approval of utility service area Execution of enforcement, guidance and inspection for complying with rules and requirements (services production) Oversight of services production Participation in multi-agency and cross-regional emergency response planning Intersectoral coordination of disaster risk governance and management Oversight for development of communication framework to inform and engage people about disaster risks Advocacy and assistance to water utilities/water associations	Performance metrics Performance indicators Balanced Scorecard/ Maturity model(s) Local water supply and sanitation development plans (every 5 yrs; incl. 5 and 20 yrs investment budgets and financing plans for utilities)
PRODUCTION Local level utility Sub-regional level utility Regional level utility	Taking care of coverage, level and functioning of services with due diligence and integrity in designated service area meeting economic, social and environmental goals Delivering services, sustaining and securing continuity of services based on business continuity plan Strategic asset management Service quality management and assurance Infrastructure condition and vulnerability assessment Developing business continuity plan (incl. water safety plan, sanitation safety plan, contingency plan, reciprocity plan) Participation in supramunicipal general planning Making service contracts (connections and charges) Inspecting plumbing appliances in connected premises Annual reporting (incl. financial statement) Providing required performance data for national performance reporting framework Engaging, informing and advocating stakeholders Creating awareness and increasing public understanding of water services, and of value and benefits/costs of services Communication framework to inform and engage people about risks Reputation management	Performance metrics Performance indicators Balanced Scorecard/ Maturity model(s) Water utility development plan (every 5 yrs; incl. 5 and 20 yrs investment budgets and financing plans)
PROPERTY OWNER/OCCUPANT	Water/wastewater systems and plumbing appliances within premises Providing relevant information on disruptions, threats and malevolent acts	Research and studies on service level, customer perceptions and satisfaction, and willingness and ability to pay for services
CITIZEN	Providing relevant information on disruptions, threats and malevolent acts	

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Annex 1. List and descriptions of policy tools to strengthen the resilience of critical infrastructures (OECD 2019, 69-70).

Policy tool	Description
Provision of hazards and threats information	Governments provide the results of national or infrastructure-specific hazard and threats assessments to owners and operators of critical infrastructure.
Voluntary information-sharing mechanisms or platforms	Governments encourage critical infrastructure owners and operators to share information relevant to the security and resilience of assets and systems amongst each other and with the government on a voluntary basis.
Mandatory information-sharing mechanisms or platforms	Laws and regulations require critical infrastructure operators to share information relevant to the security and resilience of assets and systems with the government.
Awareness-raising activities and trainings	Awareness raising activities and trainings promote a risk culture within critical infrastructure. Trainings and exercises test the emergency management systems of critical infrastructure and create familiarity with corresponding responsibilities during crises.
Resilience guidelines for critical infrastructure operators	Resilience guidelines outline steps and methods that operators of critical infrastructure should carry out to improve the resilience of their assets and systems at large. Such guidelines can be narrow in scope, providing, for example, only guidance for hazard assessments at operator level, or wide in scope, listing multiple tools and measures.
Fostering the development/use of professional standard	Development of professional standards for critical infrastructure resilience such as codes and benchmarks for capabilities and standards of operations.
Incentive mechanism to assess risks and vulnerabilities	Governments provide incentives that encourage operators of critical infrastructure to carry out hazard, risk and vulnerabilities assessments. Incentives could be the provision of technical support and guidance documents, or reward mechanisms, such as publicized reviews of meeting resiliency targets or certifications.
Incentive mechanisms for investing in resilience	Governments provide incentives that encourage operators of critical infrastructure to invest in critical infrastructure resilience including: subsidies, cost-benefit analysis, or government participating in insurance schemes.
Sectoral prescriptive regulations dedicated to CIP	Governments design regulations that specify operators of critical infrastructure to carry out certain proactive measures. This tool sets mandatory obligations for critical infrastructure to meet to ensure protection and resilience based on sectoral specificities.
Performance-based regulations on business continuity	Regulations that provide incentives for critical infrastructure operators to reach a targeted level of performance for maintaining services during disruptions.
Mandatory business continuity plans	Governments require operators of critical infrastructure to develop business continuity plans. Such plans feature prevention and preparedness measures (incl. contingency plans) that operators can rely on during hazardous events to ensure that business operations can keep running.
Inspections and performance assessment	Mandated inspectors check that operators of critical infrastructure have implemented the required resilience measures.
Fines for non-compliance with resilience requirements	In cases where inspections find that operators of critical infrastructure have not carried out the required resilience measures, the government issues fines (see incentive mechanisms).
Other types of penalties for non-compliance	Other types of penalties for non-compliance can include: revoking an operational license or temporary removal from service until requirements are met.
Ranking based on inspection / performance results	The government ranks and advertises the results of inspection/performances. Operators have an interest in doing well in such rankings, as maintaining their image and reputation is an important business success factor.
Reporting on operator resilience	Self-assessments on the resilience of operators of critical infrastructure and sharing the results with government and/or the wider public.
Sharing best practices	Using case-studies and results from events can indicate good practices for making critical infrastructure more resilient. Sharing best practices is an effective information tool to indicate how similar critical infrastructure owners and operators may address sectoral security issues, including relevant interdependencies on other sectors.
Public investments in infrastructure resilience	Government investments in resilience are applied to new public infrastructure in addition to ensuring that resilience gaps are being met where there are needs. Public financing for building resilient critical infrastructure systems can set standards for industry and demonstrate the value of these up-front investments in resilience.
Guidance for sub-national levels of government	Guidelines for sub-national level of government on awareness about critical infrastructure in their respective jurisdictions and close by that may pose transboundary risks, and how to strengthen resilience of these systems.
Mandatory insurance for critical infrastructure	Obligations set for critical infrastructure owners and operators to purchase insurance ex-ante a situation of shock or disruption of services.
Peer-reviews, monitoring and evaluation	Experts review and evaluate progress based on agreed upon evaluation criteria in accordance with sector- specific resilience guidelines... The outcome may identify potential gaps and provide suggestions for areas of improvement.