WATER AND DEVELOPMENT

8th World Water Forum

Results and Discussions

Volume 2

Adasa

The information contained in this publication is the result of quantitative and qualitative analyses of the documents generated during the sessions held at the 8th World Water Forum and was generated through means of sampling all available material using a method developed to systematize the research under the theme *"Water and Development"*.

The authors of this volume hereby declare that the content presented solely and exclusively reflects the analyses and opinions developed with support from the teams involved, the literature cited, and an analysis of the material available and therefore they do not represent any view or position taken by Adasa with regards to the themes addressed.

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Index Card

Water and Development : 8th World Water Forum Results and Discussions – Volume 2 / Brasília, DF : Adasa, 2022.
100 p. : il.
1. Water resources. 2. Sustainable development. 3. Water-energy-food nexus. 4. Integrated water resources management.

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Introduction

The Regulatory Agency for Water, Energy and Sanitation of the Federal District - ADASA, in partnership with the National Water and Sanitation Agency (ANA), and the World Water Council (WWC), had the honor of organizing the largest event on water and sanitation ever held on the planet, the 8th World Water Forum, with participation from more than 120,000 individuals from 172 countries. This Forum took place in Brasília, from March 18th to March 23th, 2018 under the theme *"Sharing Water"*.

Experts consider the Forum to be much more than an event that takes place every 3 years. It is a permanent process of reflection and discussion of issues related to water and its different dimensions: technical, political, social, economic, cultural, environmental, spiritual, development-related, among others. In keeping with the Forum's spirit of sharing, ADASA, through the publication of this document, seeks to systematize the results and discussions stemming from the 8th World Water Forum as a means of contributing to the sequence of discussions and fostering the necessary advances in water and sanitation sectors worldwide.

This publication is the result of a study coordinated by ADASA providing an extensive analysis of the discussions and documents generated during the Forum and is divided into three major thematic perspectives: *"Water and the Environment", "Water and Development",* and *"Water and Society"*. Studies focusing on each of these themes generated three publications/volumes on the 8th World Water Forum: Results and Discussions.

As part of these efforts, after the systematization of the audio and reports for the approximately 300 sessions that took place during the event (more than 400 hours of recordings), a single methodology was established for the analysis and identification of the main sessions to be assessed as part of each of the studies. Different working groups subsequently reviewed the sessions and analyzed documents in order to identify initiatives, ideas, comments, and experiences that would guide discussions and indicate trends and recommendations in relation to the proposed themes.

In this second volume, which deals with the theme *"Water and Development"*, experiences presented and discussed on six selected key topics were extracted, summarized and discussed: (i) *water as an input to economic development;* (ii) *water-energy-food nexus;* (iii) *water and financing;* (iv) *new technologies related to water;* (v) *water infrastructure;* and (vi) *integrated management necessary for water security*.

We hope that the results of the effort made as part of these publications can contribute to the continuous improvement of initiatives implemented by the sectors involved, not only with regards to ADASA's activities, but to those institutions and actors working in the areas of water resources and basic sanitation in other parts of the world as well.

Raimundo Ribeiro
ADASA's CEO

Executive Summary

The World Water Forum (WWF), organized by the World Water Council together with institutions from the host city and country, is the largest event on water held worldwide and takes place every three years, on an itinerant basis. Its 8th edition took place in Brasília, Brazil, from March 18th to 23th, 2018 under the theme "Sharing Water", and the event was co-organized by the Regulatory Agency for Water, Energy and Sanitation of the Federal District (Adasa) and the National Water and Sanitation Agency (ANA). Most of the sessions and discussions held were recorded and the respective documents were organized and systematized by Adasa in a database.

This publication is the result of a study, coordinated by Adasa, which promoted an extensive analysis of the sessions held at the 8th World Water Forum and is divided into three major thematic areas: "Water and the Environment", "Water and Development", and "Water and Society". The publication is presented in three volumes, one for each thematic area mentioned above.

This volume presents the results related to the theme *"Water and Development"*. Experiences, innovations and opportunities associated with water as an input to economic development, the water-energy-food nexus, financing and technologies necessary for water infrastructure, integrated management of water resources, water security and the overarching themes of education and training were identified.

Based on the theme *"Water and Development"* and taking the main topics related to the subject into consideration, the study covered the extensive material presented at the 8th Forum, from which the most relevant sessions were selected for a detailed survey of the content addressed. An analytical matrix was prepared that brings together the most significant experiences, innovations and opportunities on the subject, as well as respective recommendations. This volume also presents an overview of these findings, contextualized within the current scenario.

Local solutions for water supply and sanitation are at the base of global sustainable development. The supply of good quality water and adequate sewage treatment are directly linked to the health of the population, which, in turn, is directly related to the ability to work and generate income and tax revenue, as well as the reduction in demand for the health system, contributing to a self-perpetuating cycle of economic development.

Within the scope of the water-energy-food nexus, dialog between sectors, transparency, technology, knowledge sharing and governance stood out. The approach to water management in the territory was observed in the sessions that dealt with reservoirs for multiple uses, water reuse, and public policies associated with the use of water in irrigation. With regards to this last topic, experiences with technologies associated with local irrigation systems are presented.

Reuse was highlighted as promising in helping to minimize the impacts that possible water crises may bring. It appears both as an alternative to expand wastewater management alternatives in the sanitation sector and as a solution to growing problems of water stress. The Water in Business Day held during the Forum demonstrates the growing concern of the business sector regarding water resources and the resulting impacts on business, both in the economic, social and environmental spheres.

With regards to the issue of financing for water management, different arrangements involving the public-private partnership were addressed, with an emphasis on blended finance and hybridism as a way to further encourage the flow of private capital to the sector and reduce the funding gap in order to meet the targets of SDG 6 (Sustainable Development Goal 6: Ensure the availability and sustainable management of safe drinking water and sanitation for all). Two other important issues presented under the theme of 'funding' were: the crucial role of governance and the need for funding for effective governance systems; and the importance of regular maintenance of water infrastructure as a way to reduce costs.

Although with a special chapter dedicated to the topic, technology for water management was addressed in almost all sessions. Technological advances have allowed and still allow local solutions associated with water supply and sanitation to be found. In addition, those advances make it possible to approach the water-energy-food nexus and the intrinsic benefits of this integration, monitor water resources and predict events associated with water, as well as enable the use of water several times (reusing water) within cities before returning it to the basins.

Considering the growing process of urbanization and the prospect that two thirds of the global population will be living in cities by 2050 according to United Nations reports, water management in cities is becoming crucial and permeates all proposed themes. Examples of cities that have come to consider the water cycle as essential were highlighted, in order to integrate its management into urban processes and within the scope of the watershed, with improvement for water security, adaptation and mitigation of the effects of climate change associated with water resources.

Education and training for the integrated water resources management was also addressed from the perspective of the analyzed sessions as a key element in multi-faceted approaches to water resources management. Some proposals and considerations related to training and education were identified and structured as a form of work organization according to the respective target audiences: water users, workers and managers in the water sector, and workers and managers in other sectors.

Finally, recommendations were highlighted that reinforce the commitment of participants in the 8th World Water Forum to recognize the extensive work that still needs to be developed, in order to ensure the achievement of the targets set out in the Sustainable Development Goals (SDGs), whether directly or indirectly related to water.

1. Background and context

1.1 Water as an Input to Economic Development and the Water-Energy-Food Nexus

1.1.1 Water and Sustainable Economic Development

Water is essential to the life and sustainability of the planet. It permeates all aspects of socioeconomic development, whether for energy and food production, industrial processes, human consumption, transportation, service provision and recreational activities, as well as for maintaining the balance of terrestrial ecosystems. Water is a key factor in sustainable development, but it is a limited natural resource and a valuable, complex, and irreplaceable economic good.

The term sustainable development is widely used. Publications in the area are plentiful and make use of varied approaches and concepts (Giddings et al., 2002; Grzebyk and Stec, 2015; Taylor, 2014).

Meadowcroft, (2007) argues that, in fact, there is still no political or scientific agreement on the definition of sustainable development, which remains an ideal political concept similar to democracy, justice and freedom, that is, it is universally desired, understood in different ways, extremely difficult to achieve, does not disappear, and involves the need to balance the use of resources.

The first expressions of this concept emerged at the conference held in 1972 in Stockholm to discuss issues of the natural environment. Subsequently, the United Nations (UN), through the report "Our Common Future", defined sustainable development as one that meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). However, it was at the United Nations Conference on Environment and Development (1992) that the term "sustainable development" gained notoriety. The conference became known as the "Earth Summit" and adopted Agenda 21, a program of action with the aim of moving the world towards a more sustainable model of economic growth, reconciling methods of environmental protection, social justice, and economic efficiency.

In relation to the water resources sector, agenda 21 highlights, throughout the document, the conflict between development, fresh water, consumption and the environment. It emphasizes the need to preserve the hydrological, biological, and chemical functions of ecosystems, adapting human activities within the limits of nature's capacity. Sustainable development emphasizes the need for efficiency and equity in the distribution of water and the development of innovative technologies to safeguard this finite and vulnerable resource (UNCED, 1992).

Five years later, in 1997, a special session called the "Earth Summit +5" was held to review the implementation of Agenda 21, in which it was recommended that legally binding targets be adopted to reduce greenhouse gas emissions, ensure greater movement towards sustainable patterns of water and energy use, and eradicate poverty (Lopes et al., 2017; ONU Brasil, 2017).

In 2000, the Millennium Development Goals (MDGs) were launched, and in 2002, the World Summit on Sustainable Development sought to transform the goals of Agenda 21 into concrete and tangible actions through an implementation plan. In 2012, the United Nations Conference on Sustainable Development, Rio + 20 took place, but it was only in 2015, on the occasion of the Sustainable Development Summit in New York, that the 2030 Agenda was adopted, in which the new Sustainable Development Goals (SDGs) were defined in order to continue the work started with the Millennium Goals. There are 17 SDGs established, which seek to guarantee human rights and gender equality, in addition to proportionally mixing economic, social and environmental issues (Lopes et al., 2017). Within the scope of these objectives, we see water again as a central factor for development in SDG 6: ensuring the availability and sustainable management of safe drinking water and sanitation for all.

Finally, the definition that has been built on sustainable development encompasses three components: economic, social and environmental, which together and in relation to one another constitute the current basis of economic development (Ihlen and Roper, 2014). These components must be worked on simultaneously with a view to achieving lasting development, thus requiring significant changes in the economy, society and the environment (Grzebyk and Stec, 2015). In this manner, sustainable economic development must contribute to a more balanced and fair flow of income, guarantee a socially accepted concept of equity and preserve the capital produced by human beings and the capital that involves the preservation of life processes and the environment (Giddings et al., 2002; Grzebyk and Stec, 2015; Pudło, 2014), with water resources being the basic factor that permeates all these processes.

According to the United Nations University and the United Nations Office for Sustainable Development - UNU and UNOSD (2013), water is a resource and a sector. As a sector, infrastructure development and operating funds are needed; as a resource, water permeates sectors and requires integrated approaches to management. Financing, monitoring and infrastructure have all been identified as high-priority management issues facing governments today. Water development is critical to economic and social development, and these developments in turn increase water use and present environmental consequences.

The management of water resources has always therefore been and will be a differential in development throughout history and in the mediation of conflicts; after all, the greater the ability of a nation to manage this resource, the greater its development, social and economic welfare and the smaller its vulnerability in all aspects, including climatic extremes.

1.1.2 Integrated Water Resources Management and the Water-Energy-Food Nexus

The recognition of access to clean and safe water and basic sanitation as an essential human right by the UN General Assembly in 2010 made water resources appear on the agenda of States as a basic element for the eradication of poverty and sustainable development. The understanding that natural resources are beginning to limit the goals for socio-economic development and the view that water resource are the main link of interdependence between other resources create the necessary political context for the emergence of the water-food-energy nexus approach. .

This concept emerged at the Nexo Conference on Water, Energy and Food Security, which was a preparatory session for Rio+20, promoted by the German government and the United Nations in 2011. According to the document prepared by Hoff (2011) for the conference, the concept of the water-energy-food nexus emerged in response to climate-related uncertainties, capitalized by climate change and social changes, including population growth, globalization, economic growth, and urbanization, with a theoretical basis in the adaptive management of these resources.

Identifying the links between these key natural resource sectors and jointly improving their efficiency was considered a win-win-win strategy for human well-being and environmental sustainability (Ringler et al., 2013). The water-energy-food nexus refers to balancing different goals and interests of resource users while maintaining the integrity of ecosystems. The nexus emphasizes promoting cross-sector cooperation and offers the opportunity to break down disciplinary divisions (Endo et al., 2017).

According to Ringler et al. (2013), the nexus approach focuses on increasing the efficiency of resources use, seeking to maximize the benefits of the scarcest resource, and produces cross-sectoral benefits, which can be enhanced through cooperation, for example, through an Integrated Water Resources Management (IWRM) platform, which requires cooperative behavior among actors.

The Global Water Partnership (GWP) defines IWRM as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2000) and therefore includes "land and related resources" in its definition.

However, according to Ringler et al. (2013), the IWRM concept rarely went beyond the water sector in river basins and ended up not gaining the necessary strength due to the diverse interests and conflicts in the existing (mis)management of water and little evidence of the construction of a water market when compared to energy, food and even land markets.

Therefore, IWRM and the nexus concept end up becoming complementary strategies in which the nexus emphasizes engagement with other sectors to promote social welfare and equity, while IWRM focuses more on a comprehensive approach within the water sector as it provides tools for its implementation. Both are management-related, multi-sectoral approaches that help enable sustainable growth and protect essential environmental services (UNDESA/DSDG).

Finally, investment in water security has emerged more recently as a key strategy for driving and maintaining sustainable growth. Therefore, the water security challenge is global and growing. As populations, cities, and economies grow and the climate changes, greater pressure is being placed on water resources, increasing the exposure of people and assets to water hazards and increasing the frequency and severity of extreme weather events (OECD, 2016). Hoff (2011) brings a systemic approach between the nexus and investment (Figure 1) that we adapt here to characterize the complementarity that exists between the nexus approach, IWRM, and investment to allow access to available water resources and ensure water, food, and energy security.

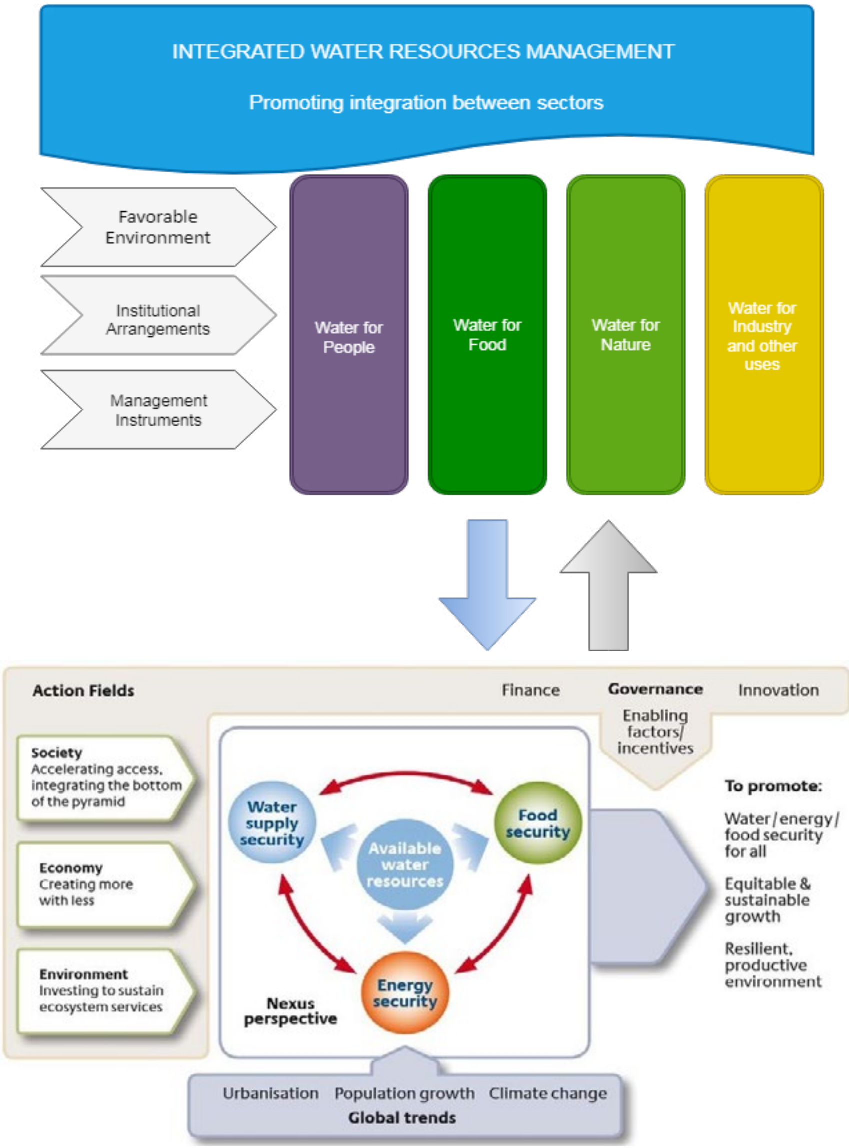

Figure 1. IWRM and the Water-Energy-Food Nexus
Adapted from Hoff (2011) and GWP (2000)

1.2 Financing, Technologies, Infrastructure, and Integrated Management for Water Security

1.2.1 Water Security

Water is the basis of human development and well-being and a good management of the access to this resource means ensuring sustainable economic development. Humanity, since its beginnings, has strived to obtain the necessary water resources for human supply and irrigation while limiting losses from floods. This constant struggle to seize opportunities and manage risks while meeting social and environmental demands is at the heart of water security (Sadoff et al., 2015).

Water is an overarching concept, permeates all sectors and, without a systemic vision, water security and economic development are compromised. For example:

- *Water is a central factor in adapting to climate change:* The impacts of climate change will be felt (manifested), mainly through water, caused by changes in the frequency and intensity of extreme hydroclimatic events. These impacts fall into three main categories – too little water (droughts, water shortages), an excessive amount of water (floods) and an excess of dirty water (pollution). Several cities around the world, including cities in Brazil, already face these impacts in the main water user sectors, such as agriculture, energy generation, fishing, industry, among others (Babel et al., 2020).
- *Human displacement:* Natural hydrological disasters and limited or compromised access to water carry a high cost for the global economy and are linked to major humanitarian crises, including sudden and temporary large-scale displacements of people. When perceptions of future risks exist, these displacements can become permanent, and around 90% of all natural disasters are linked to extreme hydrological issues. Global estimates report that by 2050, an estimated 150 to 200 million people will be permanently displaced due to droughts, floods and hurricanes (Michels Brito, 2018; Milleto et al., 2017; Osterwalder, 2011).
- *Access to water and sanitation:* Nearly 2.2 billion people worldwide do not have access to safe water supply and 4.4 billion do not have access to sanitation services (UNESCO and UN-Water, 2020a). It is not surprising, therefore, that the water crisis presents the greatest threat to global prosperity. It is noteworthy that, often, the poorest and most vulnerable are those who pay the highest prices for access to water. These high costs are due, in part, to the lack of infrastructure or the means to exploit the

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infrastructure, which means they have to pay for bottled or well water. Many of those who do not have access rely solely on informal water providers – known as "the tanker truck mafia" – present in slums around the world. The price of water in these informal markets is much higher than the formal price charged by utilities, reaching up to US$ 15 per cubic meter (Boccaletti and White, 2016; UNESCO and UNESCO i-WSSM, 2019). They also pay in the form of lost income and illness. The World Health Organization has estimated that the global economic losses associated with inadequate water supply and sanitation total approximately US$ 260 billion per year. In summary, the lack of access to safe and efficient piped water networks imposes even more costs, impacts, and challenges on the poorest (UNESCO and UNESCO i-WSSM, 2019).

Water security is a concept under development and, depending on the sector, comes with different frameworks and definitions, but which, in general, are quite similar and converge upon the same central idea (Castro, 2018; Chiluwe and Claassen, 2020). Gray and Sadoff (2007) brought the concept into focus on the issue of risk and water availability, defining water security as *"the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies"*. In 2013, the OECD re-emphasized the issue of risk, defining water security as managing risks associated with water, but including the risks of water storage, excess and pollution, as well as the risks of weakening the resilience of fresh water systems (Melo and Johnsson, 2017).

According to UNU-INWEH (2013), water security is *"the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability"*. The main focus under this definition is access to water. Thus, the UN states that water must be managed sustainably throughout the hydrological cycle, in an interdisciplinary manner, in order to contribute to socioeconomic development and reinforce society's resilience to environmental impacts and water-borne diseases, without compromising the present and the future (Bigas et al., 2013).

Water security also focuses on a population's capacity to meet water-related goals. It should be noted that the term capacity, in this concept, refers to several elements, such as finance, governance, innovation and human resources, among others. Water management definitions point to the same water security goals, but focus on the process of how they are achieved (UNESCO and UNESCO i-WSSM, 2019).

The UN considers the following elements to be key to achieving and maintaining water security, (Bigas et al., 2013) and to complement this, we will add funding and innovations:

- Access to safe and sufficient drinking water at an affordable cost;
- Protection of livelihoods, human rights, and cultural and recreational values;
- Preservation and protection of ecosystems in water allocation and management systems - fair, efficient and transparent allocation;
- Water supply for socio-economic activities and development (such as energy, transport, industry, tourism);
- Wastewater treatment to protect human life and the environment from pollution;
- Collaborative approaches to the transboundary management of water resources within and between countries;
- Ability to deal with uncertainties and risks related to water, such as floods, droughts and pollution, among others;
- Good governance - looking after the interests of all parties through appropriate and effective legislation and regulation, transparent, participatory and accountable institutions, properly planned, operated and maintained infrastructure and capacity building;
- Financing - new sources of financing to complement public sector financing, including private sector investments and microfinance schemes;
- Scientific, technological and non-technological innovations to support all management activities, such as monitoring, conservation, recovery and reuse, cost reduction and efficiency in the supply and use of water resources.

These elements are factors that vary and are often outside the domain of the water sector. Therefore, approaches to water security require interdisciplinary collaboration across sectors, communities, and political boundaries, so that the potential for competition or conflict in water resources, between sectors and between water users, is properly managed (Zeitoun, 2011).

Dimensions of water security vary depending on context and approach. The GWP has established three different dimensions to water security: economic, social and environmental. In order to ensure water security, within all the variables through which it is composed, we highlight the importance of governance and the legal framework. Without these aspects, financing and new technologies are jeopardized, and the integrated management of water resources is compromised.

Water Security in Brazil

Despite the great availability of water in Brazil, water security represents a challenge to be overcome due to the heterogeneous distribution pattern of water in the country. Areas with greater abundance have low population concentration and other regions experience long periods of drought (ANA, 2017, 2007). In addition, inadequate water management subjects (due to lack of infrastructure or inadequate maintenance) even regions with abundant water to periods of water crisis. It is the prevalence of sectored and fragmented approaches that turns water crises into governance crises (Zamignan, 2018), and vice versa, a fact that is not unique to Brazil, but affects many countries.

According to the report on the Current State of Water Resources in Brazil (ANA, 2015, 2016, 2017), since 2012 there have been sharp reductions in rainfall, in relation to the annual historical average, in some regions of Brazil. These reductions resulted, as of 2014, in a severe water crisis, showing that climate change is another factor adding to current crises. As a consequence, it was necessary to introduce water rationing for the population, even in regions where extreme drought situations are not common, such as in the southeast of the country.

The Federal District went through a similar crisis between 2016 and 2018 (Lima et al., 2018), originating from the same combination of factors: rainfall below the historical average, high temperatures, disorderly land occupation, clandestine water withdrawal, and an increase in population (Governo do Distrito Federal, 2017). However, it was these crises that brought the concept of water security to greater prominence and provided the greatest advances in the water agenda (Castro, 2018; Lima et al., 2018).

The current legislation on water in Brazil is extensive, beginning with the Federal Constitution which, at its core, placed water under the protection of the members of the federative pact by guaranteeing the environment as a fundamental right (article 225) and surface or groundwater as goods belonging to the Brazilian states, except for those under the domain of the Union (article 26, item I). With Federal Law 9.433/97, the National Water Resources Policy (PNRH) was instituted, which laid the foundations for the construction of the water security concept, established norms for the management of water resources (decentralized and participatory), declared that water was a public domain good (Article 1, I) and recognized that it was a limited resource and therefore of significant economic value (Article 1, II) (Martins and Oliveira, 2019).

Governance and the Legal Framework

Recognizing governance as a topic that permeates all discussions in this publication, it is essential to contextualize it within the scope of the interface with the Integrated Water Resources Management, firstly by understanding the distinction between governance and management. Governance concerns the fundamental objectives, institutional processes and structures that are the basis for planning and decision-making, and defines the stage at which management takes place; while management is the process by which human and material resources are used to achieve a certain objective within a defined institutional framework (Granit et al., 2017).

The legal framework and regulations are also essential to address the complex challenges of the water sector and form one of the foundations of the water sector governance system. Without an appropriate legal framework, the State's ability to regulate, control and allocate its water resources becomes inefficient, compromising its role in ensuring the effective and appropriate use of resources. In addition, the possibility of degradation increases because there are no means of guaranteeing the protection of resources, promoting mitigation and adaptation to climate change, nor the implementation of scientific, technological, and non-technological innovations.

Thus, the legal component of governance plays a relevant role in the management of water resources at all scales, from local legislation, including national legislation (which encompasses domestic use) to international treaties governing (transboundary) waters shared by sovereign nations. According to GWP (2017a), there are 3 main functions of water legislation:

- Identify the legal rights and obligations of water users, public and private, and other actors linked to the use of water and provide the normative parameters for the development and management of water resources in order to promote public interest;
- Provide tools to ensure the ongoing integrity of the flow of activities - that is, through governance structures, mechanisms for monitoring, evaluating and facilitating compliance, conflict prevention and resolution; and
- Allow modifications to the flow of existing activities in order to be able to adapt to new needs and circumstances.

The multisectoral element of water management brings us to an understanding of the need to ensure coordination between different uses. It is a function of laws, public policies or property rights to regulate these different uses and ensure coordination between uses that do not necessarily have the same objectives, or

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the same terms of use. Regulation is essential, because it is through regulation that the rules on how to use water, when it can be used, and who can use the water will be defined. The challenge of bringing coherence to different uses is met through regulation, as the goals and objectives of these uses often differ according to the sector.

The multisectoral nature of regulations raises the problem of crossed regulatory frameworks. Indeed, if the rules or public policies are defined only with a sectoral logic, there is a risk of consistency problems for the general regulation of the resource system.

For example, regulation manages tension between the use of hydroelectric energy and the survival or adequate functioning of aquatic ecosystems. As a result, in many countries, instruments are used that define the residual or remaining flow through the implementation of national (federal) water protection laws, ensuring that there is a minimum amount of water that must always remain in the river to guarantee its sustainability – which would be considered an ecological flow. Another example is the opposition between water protection and wastewater disposal. Laws are needed that address how the issue of wastewater should be managed, with appropriate regulations establishing quality standards for water treated and reintroduced into the natural hydrological cycle. These regulations need to control, in addition to the point of departure and arrival of water, the infrastructure used, considering the rate of renewal of this infrastructure to involve the replacement of pipes to prevent leaks along the way.

These examples show the risk of inconsistency between sectors with different objectives and how necessary a systemic and integrated view of the resource is for the regulatory framework and its regulations in order to guarantee the availability of water in a sustainable way.

It is important to consider two main characteristics of water resources: first, that this resource is essential and indispensable not only to life, but also to many industrial processes that produce the goods and services that are essential in everyday life. Secondly, water is a limited resource that is difficult to replace and can have highly dependent uses (consumptive uses), such as drinking water and irrigation, in addition to less obvious uses (non-consumption uses) such as maintaining landscapes, transporting sediments, the survival of ecosystems, among others.

Water must also be shared with a significant number of other users. Thus, multisectorality is, above all, a matter of rivalry between uses, but these rivalries do not necessarily mean conflicts. It is natural that rivalries exist when several uses depend on the same resource; however, with a well-defined regulatory framework, clear public policies, regulated rights, monitoring, knowledge and transparency, it is possible to advance with sustainable development in a manner in which there is peace between sectors.

1.2.2 Water and Financing

Water is a natural resource that needs constant investment in order to meet diverse and growing demands and thus guarantee water security. To meet all needs, good governance is necessary and, in order to achieve good governance, it is essential that investment structures be created to guarantee its financing. Good governance is important to ensure the enabling environment to attract financing but often overlooked with regards to its own investment and financing.

The relationship between water governance and its financing is nothing new. For example, the presentation of the Camdessus Report (2003) at the 3rd World Water Forum in Kyoto, Japan, provided the topic "water financing" with greater visibility. Discussions intensified on new ways of financing in order to enable the delivery of essential services needed to meet the MDGs and the necessary changes in governance methods to make this possible. In addition to focusing on water and sanitation, the report featured a pioneering study of water infrastructure financing and the general elements of water security (Winpenny, 2003). It became clear that without good governance, accountability, participation, decentralization, transparency, along with government commitment and the ability to manage and use funds efficiently, funding would not be attracted to the water sector (Rees et al., 2008; UNESCO and UNESCO i-WSSM, 2019).

According to Money (2018b), the panorama described in the Camdessus report is still recognized today. Priority areas appear consistently in policy recommendation documents and the risk attributes of water projects are largely the same, such as:

- the need for most projects to require a high initial investment, which is paid in small installments over a long period, therefore not attracting many investors;
- the water sector generally offers a low rate of return on investments, as water tariffs charged to consumers are often regulated (and should be regulated);
- international investors face currency risk as returns on their investments are usually generated in local currency;
- the high execution risk for the project, as local developers may not have the financial, technical or managerial capacity to oversee a complex project;

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- the risk of political pressure on contracts and tariffs, particularly when the regulatory framework is weak or inconsistent; and
- contractual risk, especially in long-term projects.

The relationship between governance and finance was also addressed in Gurría's report at the 4th World Water Forum held in Mexico City in 2006. In this report, Camdessus' recommendations were revised and there was an increased focus on financing water infrastructure for agriculture and for managing water resources. The various services provided by water systems and the different management functions required to provide them were not clearly considered, much less the funding requirements to make them viable. It is understood that little emphasis was given to funding dedicated to water resources management and governance mechanisms (Rees et al., 2008). Financing these mechanisms is essential in allowing for the desired good governance and subsequently a safe environment conducive to raising other financial resources that can foster and consolidate a strong market with attractive opportunities in the water sector.

However, the issue of decentralization and the delegation of functions and responsibilities to local governments was addressed to strengthen their capacities in order to attract and manage increased revenues (Payen, 2006; van Hofwegen, 2006). The report also looked at how water infrastructure is financed by tariffs, taxes and transfers (3Ts), and showed the challenges each of these means faces. Tariffs are constrained by a limited willingness to charge for domestic water and irrigation services, as well as by accessibility issues. Tax revenues are unstable, especially in countries that are still in the fiscal consolidation phase (political and fiscal instability), and investments in water compete with other priorities for public funds. Transfers from the international community can help finance water infrastructure in developing countries, but they are less effective in operating and maintaining financing (UNESCO and UNESCO i-WSSM, 2019).

The OECD report (OECD, 2010), "Innovative financing mechanisms for the water sector", is also a relevant step in the international debate on financing. This report discussed the importance of strategic financial planning in finding the right mix of the 3Ts (tariffs, taxes and transfers) in order to achieve water and sanitation targets and deepened the debate on repayable sources of financing based on private funds, including concessional loans. The TrackFin study (WHO, 2016) also addressed these issues and expanded the discussion of funding and respective financial flows.

The GWP, on its website (GWP, 2017b), deals with Investment and Financing Structures (A3) – creating and funding the resources to meet water needs – and places the need for investment in the conservation, management and development of natural resources that support water supply, in the implementation of pipes, construction of dams, collection and treatment works, pumps, distribution systems, hydroelectric power plants, and in flexible infrastructure, including information technology (IT) systems. It argues that the cost of carrying out these investments needs to be financed, whether through charging water users, investments from government budgets, foreign aid, commercial loans, among others. It points out that even though most investments in water infrastructure are of public origin, there is increasing involvement from water user associations and private commercial entities in sharing these costs. It also emphasizes that, within the general framework of Strategic Financial Planning, the 3Ts approach has formed a consensus by first recognizing that, ultimately, water is paid for by these three sources. These sources create a stream of future revenues that can be used to leverage commercial sources of funding that eventually need to be met and repaid using those revenues. IWRM's vision for investment frameworks is to focus on the elements of sustainable water financing while improving overall financial coordination in ways that minimize errors in these allocations and investments (GWP, 2017b).

The report "Water: Fit to Finance?" from the high-level panel on Financing Infrastructure for a Water Secure World, organized by the World Water Council (WWC) and the Organization for Economic Co-operation and Development (OECD), focused on the urgency of aligning financing needs with sources of funding and the search for strategies for different situations with different funding channels (WWC and OECD, 2015). With a focus on aid and multilateral financing, the studies covered in the report tended to focus on general infrastructure project issues rather than sectoral management issues in order to involve operations and management alongside infrastructure renovation needs. However, water security involves more than new projects and requires stakeholders to also address issues that slip under the radar of project financing. Projects are a convenient focus for financing because they have a beginning and an end and are often tied to infrastructure development, which can be used to secure debt (UNESCO and UNESCO i-WSSM, 2019).

Financing for water security involves many actors such as governments, users (industrial, commercial and domestic), legislators, landowners, banks and other financial institutions, water utilities, service providers, donor agencies, regulators, civil society organizations, among others. These actors, regardless of their central roles in financing matters, have an influence on sources or its uses, which demonstrates how complex the situation is and how great of a challenge there is to be faced in order to achieve universal access to water and the targets of SDG 6.

In 2018, the World Water Council (Money, 2018a) proposed ten actions to finance water infrastructure, as an alternative to bridge the large gap between current investment and the amount needed to achieve the Sustainable Development Goals by 2030.

Each of the ten actions are described below, some with examples (Money, 2018a):

1) Develop a typology of water infrastructure projects.

Water infrastructure typology will help align specific projects with the most appropriate funding available. Water infrastructure operates on the watershed (or river) scale, passes through the underground infrastructure and reaches the domestic taps. It covers upstream functions including pumping, diversion, transport, storage, treatment and distribution and downstream functions such as sewage, treatment and sanitation services.

It is capital intensive, with funding needed to cover upfront construction costs that are typically paid over long periods. Projects as diverse as water supply and sanitation, flood protection, irrigation, reservoirs, among others, incorporate different levels of capital intensity, have different types of risks and different economic, financial and social payback periods. Therefore, aligning specific projects with funding sources whose investment mandates match project attributes can reduce project financing costs and accelerate the pace at which projects are funded, as well as increase the likelihood that projects will find appropriate funding.

In this manner knowledge asymmetries between the supply side (governments, technical partners, developers) and the demand side (project financiers, investors) are mitigated, bringing to developers the knowledge of which funding sources are appropriate for a given project and facilitating access to a portfolio of projects that adapts to the needs of investors.

There are several forms of classification that can be applied to a typology, including scale, function, and operating environment. Specialized funds can focus on a project's sustainability profile to the extent in which infrastructure is 'natural' or 'green'. The proposed financing and ownership agreements can include, for example, BOT (Build, Operate, Transfer) or BOOT (Build, Operate, Own, Transfer) types.

One way to visualize this first action proposed by Money (2018a) is the various functional configurations of public-private partnerships for wastewater management. These partnerships with the private sector create, for example, conditions for financing wastewater treatment plants through build-operate-transfer (BOT) contracts. They may also have supportive and collaborative institutional arrangements that can facilitate the collection, treatment, proper use and/or safe disposal of wastewater. Local institutions can provide technical assistance regarding water diversion and irrigation methods at the farm level to reduce the potential exposure of farm workers to pathogens and harmful chemicals. In addition, they can help to establish a minimum period between the dates of the last irrigation and the harvest of the crop to reduce the risk of contamination by agricultural products. In return, local institutions may consider implementing certification programs for consumer-safe agricultural products, particularly in markets where local farmers sell their products (Qadir, 2018) and receive premium prices for these products.

2) Develop a typology of water infrastructure investors.

These efforts will help align projects with affordable funding in terms of source (public or private), risk and return appetite (economic, social, financial), and mandate (time horizon, objectives and impacts).

Governments are and will continue to be key investors in water infrastructure, particularly in emerging markets and developing economies. However, the public sector is under constant pressure and it is essential that, in order to increase these funding sources, it is better to identify projects that need government investment to become viable and projects that can be financed mainly or exclusively with private capital. Therefore, improving the classification of infrastructure projects helps to identify the most appropriate sources of financing. This can help decision makers identify and prioritize projects that are strategic and those that are unlikely to be funded without government support.

There is a large gap between public and private investment that is occupied by entities, including Multilateral Development Banks and Sovereign Wealth Funds (SWF - a kind of financial instrument adopted by some countries that use part of their international reserves). These investors can make a significant contribution to filling the infrastructure funding gap. Therefore, they must be clearly understood and transparently incorporated into the investor typology.

3) Broaden the attribution of risk and return.

The "financial viability" of a water infrastructure project is a function of its perception of risk and return. The risks associated with infrastructure investment are typically classified into political and regulatory risks (uncertainty of the political environment), macroeconomic and business risks (volatility of economic variables such as inflation, interest and exchange rates, etc.), and technical risks (competence and skill needed to manage strategic and operational complexities). Return measures are almost exclusively financial. However, counterfactual risk, which generates economic, social and environmental consequences associated with not funding infrastructure, should be part of the project risk assessment process.

In terms of government actions, it is proposed that political risks can be reduced through public-private partnerships. Business risks can be mitigated through the proactive use of fiscal and monetary instruments, while technical risks can be managed through a rigorous assessment of operators and contractors.

4) Renew the emphasis on public finance.

This action emphasizes the central role of the public sector in financing water infrastructure to ensure compliance with SDG 6.

Although private investment is essential to achieve SDG 6, coordination between the different sources of financing is essential to ensure the necessary investments in water and sanitation infrastructure. This role belongs to the public sector, which must promote the efficient allocation of resources in order to ensure universal access to water and sanitation.

5) Exploit the opportunities of purposed finance.

Exploring the expanding universe of special purpose finance is one of the keys to bridging the infrastructure gap. This includes climate finance (green bonds), corporate investment (sustainability bonds), and regional initiatives to drive economic growth and trade, which often include an infrastructure financing element. These are new sources of capital that can be widely exploited.

There is a relationship between water infrastructure and climate change mitigation and adaptation, which makes the Green Climate Fund (GCF) an important source of incremental funding for the sector. The global green bond market has grown tenfold over the past five years, with issuance in 2017 approaching US$ 130 billion.

Investing in corporate sustainability is a growing area that has its origins in corporate social responsibility and responsible investing. To manage environmental risk and increase their license to operate, companies are increasingly engaging with suppliers, customers and policymakers in markets in which they rely on water infrastructure. As they better understand the risks that are faced due to inadequate water infrastructure, companies are considering more innovative approaches to the financing challenge.

6) Optimize the value of development finance.

The objective is to explore the capacity of development finance in order to arouse interest and attract investors and financiers to increase bankable projects.

Development finance can play a unique role in inviting investors and funders to collaborate on complex projects that would otherwise be outside the scope of any funding institution. By coordinating preparation, structuring and implementation, Development Finance Institutions can materially improve the flow of bankable projects.

Three of the main barriers to private investment in infrastructure are: i) a weak portfolio of viable projects; ii) perception that the risk is too high; and iii) the fact that emerging market infrastructure is not universally understood as an asset class. To improve the flow of projects, multilateral development banks are increasingly working in partnership with governments and private sector financiers. One example is the Global Infrastructure Facility (GIF)

GIF is a partnership between governments, multilateral development banks, private sector investors and financiers. It is designed to provide a new way to collaborate in preparing, structuring and implementing complex projects that no single institution could manage on its own. The extensive project support provided by GIF relies on the combined experience of its technical and consulting partners.

7) Improve project selection and development.

Funding gaps can be partially bridged by improving existing project selection, delivery, and asset utilization practices

One obvious way to reduce the amount of funding needed for infrastructure spending is to improve the productivity of the money being spent. This can be accomplished by comparing the total costs (including social and environmental factors) of a program to reduce unbilled water through leak reduction, a program to reduce unprofitable water through improved metering (more efficient meters), and through a capacity increase program (with the construction of a new reservoir). However, it is important that asset utilization is improved through the selection of cross-functional infrastructure projects that offer a combination of energy services, water supply and wastewater management, support for agriculture and fisheries, and provide recreational value. Other approaches include investing in operational maintenance expenses such as replacing pressure reducing valves and implementing demand management, including incorporating the Internet of Things (IoT) with supervisory control and data acquisition systems.

8) Distinguish between Capex and Opex.

In developed markets, investors are often excited about asset operations, but are wary of the risk of construction in greenfield projects (a project in which the product is built from scratch – new ventures). In developing markets, funding to develop new projects is often more affordable than funding for operating expenses. Ensuring sustainable funding for capital expenditures – Capex (investment in capital goods) and operating expenses - Opex (maintenance, contracting services, operating expenses etc.) is vital to closing the funding gap.

Capex and Opex have fundamentally different attributes, but both require access to sustainable financial flows. To close the infrastructure gap, it is critical to understand that investment in maintenance expenses is important. It is therefore recommended that, when identifying new projects, the existing infrastructure capacity is considered, along with the respective additional maintenance investments.

9) Explore hybridity and blended finance.

Money (2018a) emphasizes that blended financing and hybrid models (such as those leveraging traditional sources and blended sources in multipurpose projects) should be considered.

Blended Finance is defined as the strategic use of development finance to mobilize additional finance and should play a key role in closing the water infrastructure gap. New hybrid financing infrastructure models, which are increasingly used by the private sector, provide some visibility into how blended financing resources and funds can be deployed effectively. Blended Finance has been prominent in the sustainable development arena in recent years, which has motivated Money (2018b) to include the concept of sustainable development in its definition.

The problem of urban sanitation infrastructure can exemplify Money's argument. The provision of urban sanitation (sewage) infrastructure lags far behind the water supply infrastructure in most urban environments. This water deficit can erode the benefits of improved water supply in a number of ways, with consequences for the environment and public health. Where there is a significant improvement in water, this should be combined with a commensurate investment in sewage collection and treatment. Significant financial and political commitment must be channeled to closing the widening gap between water supply and sanitation services through new business models and strategies that make urban sanitation an attractive and cost-effective investment option for local government and businesses. In order for this to occur, blended financing approaches and a strengthening of local authority systems are essential (WWAP, 2019).

10) Revisit Tariffs, Taxes and Transfers (3Ts).

The aim is to unlock funding through innovative approaches such as:

- review of tariff structures (e.g. based on user volumes or social tariffs);
- mortgage taxes (for example, on property values that have been improved by new infrastructure); and
- financial transfers (for example, to finance infrastructure that contributes to reducing global carbon emissions or to mitigating climate change).

The 3Ts concept was developed by the OECD to help categorize taxes, tariffs and transfers (primarily development assistance) as a source of finance with different attributes of private equity or concessionary finance, which typically require a yield and/or repayment of principal. This useful distinction deserves to be repeated in the context of financing the water infrastructure gap.

These ten actions are a summary of recommendations from previous reports, which addressed similar issues but from different perspectives. Topics covered issues involving governance, development financing, new sources of financing, targeted aid, and financing of public goods, among others.

With these concepts clear, we understand that when it comes to financing and expanding financing for water and water security, fundamental reforms in water governance are needed. By improving water governance, commercial and political risks will be better understood and reduced, thereby creating an environment conducive to investment in the sector, and management will be efficient in fulfilling its purpose. Integrated Water Resources Management (IWRM) has evolved as a more holistic and sustainable management alternative to managing water and as a way to combat fragmented decision making and abusive uses of resources. There is a very close link between the integrated approach, good governance and water financing (Fonseca and Pories, n.d.; Rees et al., 2008).

In order for IWRM to continue to fulfill this role and to be able to solve problems arising from the uncoordinated and competitive use of water resources, it is essential that financing issues are considered in all processes, enabling adequate institutional arrangements for performing its integrative functions. IWRM must also take into account that water management problems are not only solved by investments in the water sector (Rees et al., 2008). It should be taken into consideration that the way other sectors are planned and financed can reduce pressures on water resources (e.g. forestry, agriculture and energy) and it is at this point that the water-energy-food nexus contributes and complements planning and becomes part of the ten actions proposed by the WWC. When funding is incorporated into governance reform, IWRM becomes an effective avenue to address issues affecting the water sector.

1.2.3 Innovations for Water Security

Water serves a multitude of uses in today's society, requiring improved management of the trade-offs between these uses and, at the same time, guaranteeing a balance in the environment. Innovations play a key role in managing the complex challenges of water security, governance and water resources management. They provide a new way of approaching water security with interdisciplinary collaboration across sectors, communities and political boundaries to enable more efficient use and manage the potential for competition or conflict. Over the coming years, innovations will affect the entire water cycle and the management of water-related services. This evolution will contribute significantly to supporting the concept of water security (Gourbesville, 2011; UNESCO and UNESCO i-WSSM, 2019).

Innovation is considered to include: scientific innovation; technological innovation - which enables new products, services and processes to be developed; and non-technological innovation - at the organizational, financial, management and cultural levels. These different forms of innovation contribute to the continuous improvement of water management in terms of efficiency and effectiveness, with the related benefits of economic (WWAP, 2016) and sustainable development. This current understanding of how to define innovation is in line with previous definitions of technology, but with a broader approach. For example, Silva (2003) states that "technology is a system through which society satisfies the needs and desires of its members".

The biological, physical, and chemical processes associated with water supply have advanced in terms of new technologies, but there is still much room for improvement. On the demand side, technological advances have been developed to increase the efficiency and productivity of industrial and agricultural water use. These advances aim to achieve financial and economic efficiency and minimize negative environmental impacts. Among the many advances in agriculture, we wish to highlight innovations in irrigation systems and the development of species that are more resistant to drought, more efficient in water consumption and able to survive with lower quality water.

Industrial production must seek out further innovations in water recycling and recovery, as well as in the use of water of lower purity grades. For some applications, such as refrigeration systems, renewable energy and transportation, it may be possible to completely replace the use of water. Environmental and sanitary engineering is advancing in providing smart sanitation, providing emergency post-disaster sanitation, resource-oriented decentralized sanitation, and fecal sludge management.

At this point, the importance of using unconventional water resources is highlighted. These unconventional resources are a by-product of specific processes or may result from specialized technology to collect or access water. They generally need proper pre-use treatment and, when used for irrigation, require proper on-site management. Key examples of unconventional water resources include groundwater confined in deep geological formations, atmospheric moisture collected through cloud seeding and mist collection, physical transport of water through icebergs, micro-scale capture of rainwater where it would otherwise evaporate, desalinated water, and wastewater from urban areas and agriculture. Improving unconventional methods can balance the amount of water currently extracted from surface and groundwater sources while minimizing environmental degradation and conflicting or competing uses (WWAP, 2019).

Advanced treatment processes in wastewater treatment plants have significantly improved water quality. The treated effluent achieves a level of technical development allowing it to reach the quality of drinking water with the removal of nutrients and pathogens in the treatment processes. Many countries such as the United States, Singapore and Japan have already developed policies and programs for the reuse of secondary effluents and have reached the stage of direct and indirect reuse. Water reuse is the process of transforming used water into new water resources, which can reduce water consumption from rivers or lakes. This reuse process can improve water quality and the aquatic ecosystem by reducing the mass of pollutants that is discharged into water bodies (UNESCO and UNESCO i-WSSM, 2019).

Decentralized wastewater treatment systems are becoming increasingly popular to serve populations in peri-urban areas. With decentralized systems, both investment costs and operating costs are substantially lower. The use of these systems also makes the transport of wastewater simpler. For example, pumping can often be avoided and low-cost sewer technologies can be used. In addition to efficient wastewater collection and treatment, on-site reuse for crop irrigation or fish production can generate a market based on the value of treated wastewater. In general, these systems are simple to operate and maintain and can be managed by relatively unskilled labor or community groups. These systems can also be networked or easily deactivated and are particularly appropriate wherever low-income populations are at risk from wastewater and fecal sludge that directly contaminate the water supply (Ulrich et al., 2009; WWAP, 2019).

New technologies can also change the manner in which the entire water distribution system is managed. Intelligent monitoring networks, combined with forecasting and optimization algorithms, can help improve water distribution in response to spatial and temporal variations in supply and demand and optimize storage and distribution (WWAP, 2016).

Advanced sensor technologies can support intelligent water management, particularly by enabling online and real-time monitoring of water availability and quality. Wireless sensors to monitor water consumption have been developed and are increasingly used together to enable remote measurement of water (UNESCO and UN-Water, 2020a). A sensor is any device that can receive a stimulus, such as heat, light, magnetism, or exposure to a particular chemical, and convert it into a signal. While the concept of sensors is not new, sensor technology is undergoing rapid transformation (UNESCO and UNESCO i-WSSM, 2019).

The use of sensors to monitor water quality at different stages of wastewater treatment processes is essential to ensure safe reuse. This safe reuse of water helps to reduce overall water stress. Monitoring is also vital to detect chemical leaks or spills involving some form of pollution in a timely manner, as well as to analyze the effectiveness of decontamination measures.

In the urban water domain, advanced sensor technology is impacting various business processes, improving the efficiency of water utility services and contributing to cost reductions with Automated Meter Readers, water quality control devices, and operational supervision (Gourbesville, 2011; Sadoff et al., 2015; UNESCO and UN-Water, 2020b).

The latest technological developments have brought communications to the forefront of technological advances. Evolutions in communication, such as the transfer of any type and form of information using high-speed internet networks with global coverage, have transformed personal computers into powerful workstations. Cloud computing and backup and storage services have a direct impact on technologies such as remote sensing, monitoring equipment, databases and spatial data analysis that have traditionally been used for water resource management (Skoulikaris et al., 2018).

These advances take IWRM to a new level and allow progress to once again be made in a more satisfactory way. This is due to the fact that without accurate, intensive, long-term data acquisition and exchange, the state of the world's water resources cannot be adequately assessed, conservation and mitigation programs will not be implemented more effectively, and the success of these programs will not be adequately measured.

The continuous emergence of information and communication technologies (ICTs) has introduced new standards in the collection, management and dissemination of water-related data, thereby allowing for these new solutions. The coupling of ICTs with mathematical models is proposed as a supporting tool for the implementation of the IWRM concept in different socioeconomic environments. Some of the advances that ICTs offer to the water sector are exemplified below (Skoulikaris et al., 2018):

1. Increasing the efficiency of telemetry monitoring networks in terms of real-time measurement of environmental parameters and variables;
2. Data storage capacity and energy autonomy together with the associated cost reduction;
3. The use of web-based information systems that facilitate spatial data, descriptive information, and observational data sharing in the cloud, which are accessible through common web browsers; and
4. The abundance of free high-resolution remote sensing data and the direct or indirect integration of geographic information system (GIS) technology for water management issues.

ICT tools can minimize differences in the use of technical standards and specifications for data collection and information sharing at national and international levels when dealing with transboundary water resources. In the case of several professionals, such as engineers and hydrologists, where emphasis is given to the modeling of water systems, these tools can contribute to a more precise modeling procedure, since accuracy is subject to the availability and precision of data and, subsequently, the analysis of the relationships between physical and ecological variables, such as precipitation, river flow or groundwater recharge (Skoulikaris et al., 2018).

Space technologies generate data and information about weather, climate and the development of water resources at various levels. Satellite-based Earth observation can help identify trends in precipitation, evapotranspiration, snow and ice coverage or melting, as well as runoff and storage. They also help improve the understanding of the impacts of climate change on water quality by monitoring river, marine and coastal ecosystems with high levels of accuracy (Skoulikaris et al., 2018).

Technologies such as the Internet of Things (IoT), Big Data, Artificial Intelligence (AI) and machine learning are also emerging, with several applications in reducing uncertainties, mitigating risks and improving resilience to climate changes.

IoT is a computing concept in which everyday physical objects are connected to the Internet and/or to each other, forming a network of interrelated devices that can communicate and transfer data without the need for human intervention. It is a combination of several technologies which are complementary in the sense that they enable this integration of objects from the physical environment to the virtual world. Among the many benefits of IoT, the main one is the minimization of costs with the optimization and automation of services in general. IoT is formed by a wireless sensor network (WSN), a special type of network that has the ability to monitor and process data collected from the environment. In the water sector, IoT can contribute to the structuring of smart cities with awareness in water management, collecting data, preventing losses, and contributing to water savings (UNESCO and UN-Water, 2020a).

Big Data analytics scans vast amounts of data to uncover hidden patterns, correlations, and other insights. Big Data analytics applications can help gain insights by processing the collection of continuous streams of water-related information and data to extract actionable information and insights for improved water management. Big Data also offers the possibility of integrating additional data related to water, such as trade patterns or electricity consumption, generating a broader understanding of the evolution of processes that impact water resources and, thereby improving water management in a changing context (UNESCO and UN-Water, 2020a).

Various AI-based machine learning techniques, models, and algorithms for effective water quality management are being explored, in particular for water quality simulation, prediction and projection, for statistical analysis of data and for pollution source identification. AI is also emerging as a projection and optimization technology for predicting the efficiency of different desalination technologies, preparing for and anticipating flooding, and improving water use efficiency, among others (Cabrera et al., 2017; UNESCO and UN-Water, 2020a).

The data these technological innovations have helped to generate must be made available and presented in a way that can be properly understood and used by decision makers. The lack of dissemination of such data represents a major challenge for knowledge management in the water sector.

The outdated or insufficient documentation of data acquisition systems is another issue and can often cause data that are incompatible with each other. As a result, parallel systems are developed and the data collected by each cannot be cross-processed. A fundamental need in all water-related domains is the promotion of integration and the development of intersectoral systems. Professionals in each sector need to know more and understand the thinking and methods applied in other sectors in order to continue innovating in a more collaborative and operational way (UNESCO and UN-Water, 2020a).

There is also a latent need to promote the openness of information on data, technology, and processes through the raising of awareness, policy formulation and training, with the aim of expanding access to information, knowledge and technologies. Free and open-source software is becoming increasingly popular in low- and middle-income countries, where licensing costs for paid software are very high. These tools contribute to greater transparency and accountability in the sector. Visualization tools are also useful to make data more understandable, both for decision makers and the population. The transparency of information contributes to the efficiency and effectiveness of IWRM and the implementation of new tools.

In the face of climate change, inclusive approaches can empower water users to participate in the collection, sharing and use of information for mitigation and adaptation purposes. For example, citizen science and crowdsourcing have the potential to contribute to early warning systems and can provide data to validate flood prediction models. Citizen science is the involvement of citizens in the scientific process, where the degree of involvement can range from tasks such as data collection to full involvement in the research project. Crowdsourcing is the outsourcing of tasks to a crowd, which would be unfeasible to be performed by a single organization, and covers a wide range of purposes, including data collection (See, 2019; UNESCO and UN-Water, 2020a).

Free and open-source software for knowledge management encourages participation from civil society in the collection, provision, and use of information. Access to information and knowledge has the capacity to empower users, including young people, women, and the most vulnerable groups, to manage water resources and contribute to decision-making (See, 2019).

Engaging citizens in science contributes to accelerating scientific discovery while democratizing research and potentially improving or influencing stakeholder decisions. For example, ordinary people can support scientific research by observing and recording changes in ecosystems and natural phenomena, such as climate, behavior of animals and plants, or the prevalence of certain species. Citizen science data can also support the calibration of meteorological instruments and the collection of data on cloud cover, temperature, and precipitation to improve understanding of microclimatic variations (UNESCO and UN-Water, 2020a).

Innovation in the water sectors is highly diverse. On one hand, new technologies can improve existing methods and processes and make them more efficient and cost-effective. On the other hand, disruptive technologies can profoundly change the way water is used, and this field will require significant investments in Research and Development (R&D). These technologies often bring about a transformation of the current paradigm of forecasting and control in water resources into a more adaptive and flexible approach which is characterized by self-organization, adaptation, heterogeneity in scales, and distributed control (Pahl-Wostl et al., 2011; WWAP, 2016).

However, even with a clear understanding of the need for innovation to face water challenges and the fact that it will transform the sector in the coming years, it is recognized that the adoption and dissemination of new technologies and water policies are still slow. Every year millions are invested in R&D, but much of this research is not commercialized and developed into products and technology, which means it does not make its way onto the marketplace. The success rate of most water technology start-ups is still relatively low (O'Callaghan et al., 2020). This slow adoption of new technologies and policies is due to several factors that are characteristic of the sector. This includes, for example: the useful life and replacement cycle of installed assets, which can be from 10 to 15 years for mechanical and electrical equipment and more than 25 years for infrastructure; the engineering project cycle itself, which, between bids and acquisitions, can take several years; and the different local regulatory environments, which require different levels of treatment (O'Callaghan et al., 2020).

In order to face challenges related to water, it is important to understand that technology is an area in which innovation adds value, but requires that water policy, in turn, also undergoes an innovation process so that these innovations can have an effect. This means that there is a need to develop new laws and regulations that will create the space needed for water innovation, as well as the creation of new financing models and mechanisms and business models (O'Callaghan et al., 2020), which we have already highlighted in item 1.2.2. The importance of innovation in terms of how the value of water is communicated to the public is another relevant factor and cannot be overlooked. In this manner, we can see that everything is connected in a systemic way and that regulatory gaps and misdirected policies delay the adoption of innovative technologies.

1.3 Water on the Global Agenda

The World Water Forum is an event held every three years in a city that has been previously selected. It is organized by the World Water Council, together with institutions in the country and in the city in which the event is held.

To promote a broad discussion, the Forum seeks to bring together different segments of society around the topic of water. Entities interested in participating in discussions mainly include water management agencies and organizations, municipal governments, state and national governments, public policy makers and legislators, representatives of the judiciary, civil society organizations, education and research institutions, companies operating in the sector or who depend on this resource for the development of their activities – agriculture and livestock, energy, sanitation, industry, tourism, among others. The event's structure aims to promote qualified discussions of interest to these specific audiences as well as dialogue between these different segments.

From among the various topics covered at the 8th World Water Forum held in 2018, this publication focuses on debates related to the theme "Water and Development". More specifically, discussions and experiences involving water as an input to economic development, the water-energy-food nexus, financing, technologies, water infrastructure and the integrated management necessary for water security were explored.

2. Methods

2.1 Organization of the 8th World Water Forum

The 8th edition of the World Water Forum took place in Brasília, from March 19th to March 23th, 2018, under the theme of Sharing Water. The 2018 edition of the Forum included a thematic matrix aimed at guiding the discussions, which was organized by session.

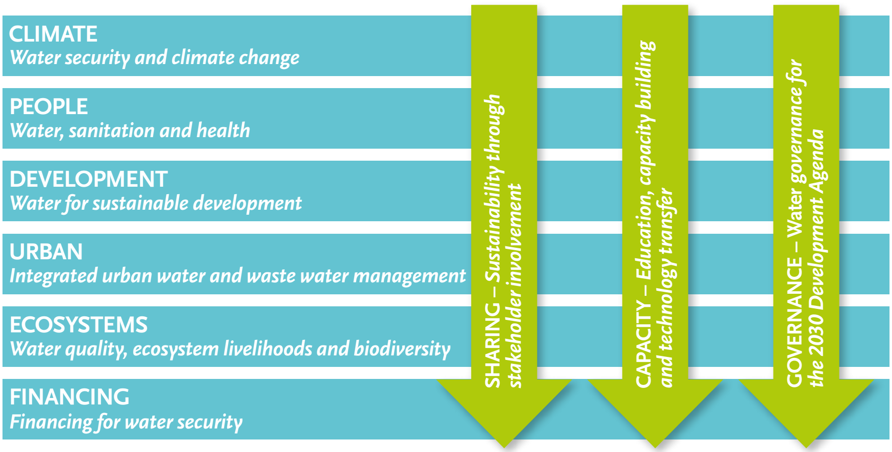

Figure 2. Thematic structure of the 8th World Water Forum

The sessions of the 8th World Water Forum were organized by five committees responsible for specific processes, namely the Thematic Process, Political Process, Regional Process, the Sustainability Focus Group, and the Citizens Forum. Each process organized discussion sessions in accordance with their respective objectives and the specific audiences involved. Table 1 shows the sphere of action for each process in the organization of the 8th World Water Forum.

Table 1. Role of each process in the organization of the 8th World Water Forum[1]

Acronym	Process	Objectives
TP	**Thematic**	To discuss the topics to be addressed in the Forum
PP	**Political**	To involve government at the local, regional, and national levels, members of legislative bodies, focusing on the establishment of memoranda of understanding, agreements, and cooperation treaties for integrated water management.
RP	**Regional**	To discuss different issues and guidelines for cooperation and integrated water management for each continent or in geographic region
SFG	**Sustainability Focus Group**	To discuss adherence to public policy and initiatives and principles of sustainable development (economic, social, and environmental) in a general manner, participating in other processes
CF	**Citizens Forum**	To promote the participation of organized civil society in discussions, exchanges of experiences, and the Forum's other activities

As previously mentioned, the six themes defined for the 8th Forum were climate, people, development, the urban environment, ecosystems, and financing. Three overarching themes were also taken into consideration: capacity building, sharing, and governance.

The forum's sessions were grouped according to their specific characteristics, and their acronyms were created using their titles in English (Table 2).

Table 2. Types of sessions held at the 8th World Water Forum

Acronym	Title	Objectives
HLP	**High Level Panel**	Participation of authorities and representatives from organizations relevant to the water debate
OS	**Ordinary Sessions**	Promotion of debate and the sharing of experiences within the scope of each Forum process
SS	**Special Sessions**	Discussion between more than one process, provided by organization or the opening/ completion of a series of sessions
PP	**Political Process**	Conferences that meet the specific demands of the following subprocesses:
		National Governments (NG)
		Local and Regional Authorities (LRA)
		Judges and Prosecutors (JP)
		Parliamentarians (PAR)

[1] Adapted from http://8.worldwaterforum.org/pt-br/estrutura-organizacional

About 300 sessions were held, totaling more than 400 recorded hours of discussions held during the 5 days of the 8th World Water Forum (an average of one and a half hours per session). Most of the discussions and presentations were recorded through means of synthesis documents, videos, audios, statements, reports, and photographs. The material was organized into a database (Table 3), which constituted the main source of information for this publication[2].

Table 3. Summary of the 8th World Water Forum database by session[3].

Category	Audio	Presentations	Rapporteur (Portuguese)	Rapporteur (English)
HLP – High Level Panels	**81%**	**63%**	**100%**	**94%**
OS – Ordinary Sessions				
Citizens Forum	83%	100%	100%	0%
Regional Process	92%	100%	100%	100%
Thematic Processes	95%	100%	98%	100%
PP – Political Process				
Judges and Prosecutors	88%	13%	100%	100%
Local and Regional Authorities	93%	100%	93%	93%
National Governments	89%	0%	89%	89%
Parliamentarians	100%	0%	0%	0%
SS – Special Sessions				
Citizens Forum	100%	67%	100%	0%
Collaborative	83%	83%	92%	83%
Partners	93%	100%	93%	93%
Regional	71%	93%	100%	100%
Sustainability	100%	100%	100%	100%
Thematic	100%	65%	100%	100%

2.2 Methodology used to Analyze the Forum Content

Taking into account the thematic delimitations of this volume and the extensive material available, it was decided that sessions would be selected based on a thorough investigation of their content after an analysis was carried out through code mining with the use of an automated tool.

2 An example of a session title would be OS-TP-01, being the first ordinary session of the thematic process of the event, or even SS-J-SFG+TP-02, which means the second special joint session from a sustainability focus group and a thematic process.

3 Videos, photos, agendas, and attendance lists were not considered.

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The text coding analysis was performed using the MaxQDA software [4] which, in addition to helping speed up the session selection process, offers other attributes that help in the analysis of the available material, such as:

- facility in storing comments that can be linked to index words or text segments;
- properties used to define links between index words;
- the use of variables, codes and filters to restrict the search to specific text segments.

In addition to analyzing the content of the sessions using software, another step was carried out to identify the most relevant sessions to the proposed theme through the analysis of the summary of each session that took place at the Forum. There were 100 sessions identified as relevant to the theme 'water and development' through an analysis of abstracts. The result of the coding analysis was applied to this universe of sessions and, based on the number of codes identified in each session, the sessions were ordered by relevance.

Below is a description of the stages of the content analysis work performed on sessions. A more detailed explanation of the mining and analysis methodology employed is presented in the volume "Water and the Environment".

1. *Import and organization of research base documents in the MaxQDA program from the database provided by Adasa.* Due to the large volume of information involved, only Word, PDF, and PPT files were imported.
2. *Structuring a series of codes.* Codes were created using specific keywords that allow the identification of recurring themes in the text documents through means of a lexical search;
3. *Coding of imported documents.* The codes generated in the previous step were used to identify the text excerpts (text data mining) in the documents inserted in MaxQDA.
4. *Cleaning of the codified database.* Removal of keywords outside the given context for the code.
5. *Quantitative and qualitative analysis of the coded database.* Quantification of the frequency of topics of interest in available texts was carried out by cross-referencing the set of pre-defined codes.
6. *Identification of focal sessions.* Focal sessions are those in which the largest number of codes was identified in documents.
7. *Updating of the session summary worksheet.* Based on the summary worksheet for sessions organized before the Forum, an update was carried out according to the actual schedule that was used.

[4] MaxQDA is software used in qualitative analysis and mixed methods research. https://www.maxqda.com

8. *Analysis of abstracts and classification of sessions.* Through means of the respective summaries, sessions were classified into four categories: i) sessions relevant to 'water and development', ii) sessions with evidence of relevance to 'water and development', iii) sessions that apparently do not relate to the theme 'water and development', and iv) sessions that do not relate to the theme 'water and development'.
9. *Prioritization for analysis.* The sessions identified as relevant to the topic in the analysis of the abstracts were ordered and prioritized according to the number of codes related to 'water and developments' they presented.
10. *Development of a model for annotating documents.* An electronic spreadsheet was formulated to systematically record in-depth content analyses of the prioritized sessions. Considering the amount of material available – audio, PowerPoint files, reports – the objective was to gather, in a single place, relevant information for each session.
11. *More in-depth analysis of the contents.* Since sessions are composed of a series of lectures containing a wide range of approaches, it was decided to pay a closer attention to the lectures. Audios were the basis of the analysis and many of them were subject to transcription due to the need to revisit the contents heard during the analysis. The analysis process involved: i) listening to and / or making the transcription of the audio along with the presentation slides, when available, ii) summarizing the relevant aspects related to the subject of the work carried out, iii) analyzing the information and populating the electronic spreadsheet, and iv) performing additional research related to the topic addressed in the lecture.
12. *Analysis and construction of the analytical matrix*. Based on the information listing from each lecture and on the prior analysis of the respective contents, it was possible to build the analytical matrix in which the findings, innovations and opportunities could be registered and analyzed from the perspective of recommendations for: water as an input to economic development, the challenge of the water-energy-food nexus, financing and technologies for water infrastructure, integrated water resources management, and water security, as well as for the overarching theme of education and training.

According to the criteria of relevance, 34 sessions were investigated and prioritized in the analytical matrix, resulting in 108 findings, innovations or opportunities. The analytical matrix was prepared with the aim of maintaining the reference of each finding with the corresponding session, the title of the lecture and the respective speaker, in addition to identifying the sphere, whether global, national or local. Annex I of this volume presents a simplified version of the analytical matrix prepared for the topic "Water and Development".

The sessions were very rich and participatory, some with more than 12 speakers presenting relevant content. In some sessions or lectures, the analysis of the information was slightly compromised due to the quality of the recordings or a language barrier. In these cases, the presentations were crucial to contextualize the debate and facilitate the interpretation and analysis of the content. At the end of the study, it was possible to provide a solid overview of lessons that are presented in this volume and identified in the analytical matrix.

2.3 Delimitation of the Theme "Water and Development"

The theme "Water and Development" involves a complex universe of information and approaches. This volume focused on the findings identified and listed in the analytical matrix and are therefore not intended to address the entire breadth of discussions on the topic.

The conceptualization of some topics goes through specific regulations in different countries, as is the case with public-private partnerships. For this publication, topics are considered as they were presented by speakers.

The data and information in this publication originate from recorded lectures and materials made available during the 8th World Water Forum.

3. Discussion of the theme "Water and Development"

3.1 Water as an Input to Economic Development and the Water-Energy-Food Nexus

3.1.1 Local Solutions for Water Supply and Sanitation

Local solutions for water supply and sanitation are at the base of global sustainable development. The supply of good quality water and adequate sewage treatment are directly linked to the health of the population, which, in turn, is directly related to the ability to work and generate income and tax revenue, as well as the reduction in demand for the health system, contributing to a self-perpetuating cycle of economic development.

There are many solutions for providing water for low-income populations or in isolated areas shared during the 8th World Water Forum. Several were highlighted, such as the rainwater harvesting and treatment project at a school in India (OS-TP-37, CHAKRABORTY, Debarati) that relieves pressure on water by capturing and treating water locally, and reduces contamination risks, in addition to system implementation and maintenance costs compared to conventional treatment and distribution (Box 1), the fresh water program, which seeks to provide desalination technologies in Brazil's semiarid regions (OS-RP-32, FERREIRA, Renato) with the incorporation of technical and environmental care into desalination systems, and the actions of the National Department of Works Against Drought – DNOCS (OS-RP-62, GUERRA, Angelo J.N.), also located in Brazil, which involve dams, well drilling, cisterns, and fish farming associated with the fight against drought.

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As a solution for small-scale sanitation, the Mandalpara experience (OS-TP-37. CHAKRABORTY, Debarati), India, shows the additional benefits of a sanitation arrangement in a case in which planned direct reuse generates employment and strengthens nutrition (Box 1). On a larger scale, the case of Senegal (OS-TP-37. GUEYE, Mouhamadou), in which the need to collect, transport and treat fecal sludge from on-site sanitation facilities in a region led to the structuring and regulation of the sanitation market with the integration of the private sector in the management of Fecal Sludge and Wastewater Treatment Plants and research for the use of sludge by-products (Box 2).

BOX 1. LOCAL SOLUTIONS IN INDIA

Debarati Chakraborty, Center for Built Environment – Kolkata, India, OS-TP-37

About 67% of wastewater is discharged into the environment without treatment, which means water sources are extremely contaminated with chemical and biological pollutants. More than 21% of the country's diseases are related to water quality. Around 67% of India's population do not have access to traditional sanitation. Consideringt this issue from another perspective, a great amount of water is being wasted in all areas.

Rainwater Harvesting - "Bhoroshar Borosha" (the promising rain).

The project implemented structures in schools capable of supplying 85,000 liters of water per year, based on the collection and treatment of rainwater. The project involves structures for storing and treating rainwater to drinking water quality.

Mandalpara (Chandipur).

The project, which is aimed at low-income communities, was developed in an area of 8 ha, involving approximately 1,700 people (400 families), most of them embroiderers and sellers of vegetables and poultry. The few sources of drinking water were contaminated and the families lived in precarious sanitation conditions. Effluents were released directly into water bodies and canals. The project's intervention was based on the introduction of new systems of toilets, implementation of a sewage and drainage system in the area, and reconnection and remodeling of water bodies for the introduction of the water purification system and development of aquaculture based on traditional techniques .

The project mobilized the entire community, especially women, and promoted improvements in hygiene conditions in the community. It provided training in traditional techniques for aquaculture, poultry, swine, horticulture, and agriculture. The project also involved the installation of an educational unit, a recreational unit, the development of an income generation program and the incorporation of the project into an urban planning process.

Aquaculture fed by wastewater from the Mudialy Fishermen's Cooperative Society (MFCS).

The fishermen's cooperative has transformed the swampy wetlands of Mudialy, often flooded with polluted wastewater from the city and the local industrial complex, into an urban fishing and waterside recreation area. It is a system composed of six ponds connected by tunnels populated by fish that serve as indicators for the level of water pollution. In the first stabilization pond, quicklime is sprinkled on the water. In subsequent ponds, the water hyacinth absorbs oil and grease. At the end of the process, water quality is tested before it is drained into the fishing ponds.

BOX 2. FECAL SLUDGE CHAIN RECOVERY PROGRAM

Mouhamadou Gueye, Director of the Fecal Sludge Management Program in Dakar, Senegal, OS-TP-37

The Senegal National Sanitation Office, through the Fecal Sludge Management Program, sought to structure the local sanitation market with the objective of making it a profitable sector capable of meeting the demands of users at viable costs. The program implemented actions to meet two main objectives: to provide quality service for mechanical emptying of on-site sanitation facilities at an affordable cost and to increase the income of service providers. Some of the highlighted initiatives included the creation of a call center to connect residents with service providers; the certification of pit emptying companies (license for emptying septic tanks), a communication program for stakeholder ownership of the program, and the delegation of wastewater treatment plants to the private sector through a public-private partnership model, with the objective of controlling illegal sewage disposal and encouraging the use of modern technologies for the use of by-products from wastewater treatment, thereby making the operation of the plants financially viable.

Technologies and financing aimed at serving residents in isolated areas or low-income populations were also discussed. It is also worth mentioning the wastewater-fed aquaculture project, which is carried out by the Mudialy Fishermen's Cooperative Society, India - MFCS (OS-TP-37. CHAKRABORTY, Debarati), based on natural solutions (Box 1), the provision of microfinancing for residential water and sanitation installation that *Water.org 's Water Credit* program (OS-TP-59.

THORSTEN, Richard. OS-TP-60. PORIES, Lesley) provides through working with financial institutions (Box 3), and funding the business plans of Swiss start-ups, small and medium-sized enterprises (SMEs) and social entrepreneurs that provide technologies for sustainable access to water and sanitation for low-income communities in developing countries (OS-TP-60. RUPPANNER, Violette).

A common feature of the solutions presented for low-income populations or in isolated areas is the implementation of simple systems and the training of the community itself for the operation and maintenance of these systems, in addition to raising awareness about the rational use of water and safety regarding water originated from reuse.

BOX 3. ACCESS TO FINANCIAL RESOURCES FOR LOW-INCOME AREAS

Richard Thorsten, water.org, OS-TP-59 / Lesley Pories, water.org, OS-TP-60

Water.org is a global non-profit organization working to bring water and sanitation to the world. It promotes access to safe water and sanitation through the facilitation of financing, such as small loans. The organization offers a portfolio of smart solutions that break down the financial barriers between people living in poverty and access to clean water and sanitation; one such solution is *Water Credit*. *Water Credit* is a pay-it-forward system *that* provides microfinance tools in the water and sanitation sector, providing affordable financing. How it works:

- Partnerships are formed with institutions that establish loans for water and sewage systems in their portfolio of offerings. Water.org supports projects by providing technical assistance, connections and resources to get them started.
- People in need use these small and affordable loans to install a faucet or a toilet in their homes, for example.
- Every loan paid can be loaned to another family that needs clean water or sanitation.

3.1.2 Water in Companies

Industries and other production sectors have come to realize that water is an essential factor for their businesses and that water risk takes on a collective dimension when it affects an entire value chain (SS-SFG-02. SOARES NETO, Percy). During the Forum, several reports from companies were presented regarding water management, with the topics of circular economy and especially water reuse subject to a great amount of discussion.

Denmark stood out with two cases of circular economy with economic benefits and incentives for infrastructure maintenance. These include the collaborative project between the city of Kalundborg and several companies, called Kalundborg Symbiosis (Box 4) and the Billund BioRefinery, in which residential, industrial and agricultural organic waste is treated in order to generate organic fertilizers, biogas and allow the return of clean water to the environment (OS-TP-40. LARSEN, Carl-Emil).

BOX 4. COLLABORATION BETWEEN COMPANIES - CIRCULAR ECONOMY

Carl-Emil Larsen, Danish Water and Wastewater Association (Danva), Denmark, OS-TP-40

Kalundborg Symbiosis is a collaborative circular economy project between the city of Kalundborg and several nearby private companies. It began in 1962 with a partnership between the municipality and the company Esso (currently Statoil) aimed at supplying water. Companies benefit from their partners' waste in which one partner's disposal becomes a resource for another partner. This model, developed over 40 years ago, was based on economic interests, and only later were the environmental benefits of the Symbiosis project recognized. In Kalundborg, industrial wastewater is used for the production of biogas, for heat pumps for district heating, and there is still discussion about the possibility of evaluating or studying the recovery and production of phosphorus and nitrogen from wastewater.

What facilitated the development of such cross-sector governance in Kalundborg was the physical proximity between the companies, simplified by the small size of the system (compared to large metropolitan areas). Currently, more than 30 exchanges of water, energy and other by-products are identified between the municipality and 7 other entities (Novo Nordisk, Novozymes, Gyproc, Dong Energy, Statoil, Kara/Novoren, Kalundborg Forsyning A/S).

In Brazil, the *Aquapolo Ambiental Project* (OS-TP-41. SILVA, Fernando Gomes da.) also seeks, through means of the recycling of wastewater, to contribute to the reduction of pressure on water. In the case of the Brazilian experience, in São Paulo, the technological solution found was developed specifically for the project, taking the specificities of the waste to be treated and disposal of the reused water into consideration. In the vast majority of cases of treatment and use of wastewater, infrastructure management takes place through a partnership between the municipality and the private sector.

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In addition to the experiences of treating and reusing wastewater jointly by a group of industries, the awareness of different business segments has been encouraged. It was in this same vein that the Swiss Agency for Development and Cooperation – SDC (OS-RP-32. ORJUELA, Diana Rojas) shared, during the Forum, its work in disseminating ISO 14046, which focuses on assessing the water footprint of products, processes and organizations based on LCA - Life Cycle Assessment (Box 5).

BOX 5. CORPORATE WATER RESOURCES MANAGEMENT: REDUCING WATER IMPACTS AND MANAGING RISKS – COLOMBIA, PERU AND CHILE

Diana Rojas Orjuela, Latin American Advisor, Global Water Program, Swiss Agency for Development and Cooperation (SDC), OS-RP-32

The Swiss Agency for Development and Cooperation operates in Colombia, Peru and Chile, and will start working with Brazil and Mexico through the SuizAgua Project, as part of its Global Water Initiatives Program. The proposal is aimed at the private sector, public institutions, and research centers in order to promote responsible and committed water management.

The agency's lines of action are based on:

- Water footprint (based on ISO 14046): assessment, reduction and management of internal impacts in production chains for goods and services;
- Commitment to the value chain: participation of suppliers and customers in reducing their impacts on water;
- Collective actions in watersheds: commitment of stakeholders to develop joint actions for the sustainable management of water and the protection of ecosystems.

The corporate water footprint is approached in accordance with ISO 14046 through the application of a methodology developed specifically for this purpose.

The initiative involved more than 30 projects in the five countries where it has been developed.

It is worth noting that, despite the understanding of the importance of water accounting and its use in management, as presented, in general, during the Forum discussions, the water footprint methodology was also criticized, especially when it involves agricultural products and communication, indicating the need for further discussions on the topic.

Another essential factor related to the incorporation of water management in companies' strategies is the need for data sharing (SS-TP-10. SOUZA, Marlos de.) related to internal and external water management in order to enable sectoral benchmarking (SS-SFG-02. SOARES NETO, Percy).

Experience in working with the respective sector is identified in Spain, which presents the report of a company in the food and beverage sector (OS-TP-40. SANTERO, Juan Francisco Ciriza.) that supported the process of identifying performance standards related to water consumption and the transition to a circular economy for an entire segment.

Likewise, in Brazil, the Sebraetec program (OS-TP-32. SOUZA, Suênia) works with micro and small companies in the identification and framing of innovative solutions related to sustainability, including the issue of water in the preparation of content aimed at training this segment. It is important to highlight the importance of working with the micro and small business segment, which represents, in Brazil, 98.5% of companies and is responsible for 54% of formal jobs, according to the speaker.

It is essential, for both cases above, that sectoral dialogue and the identification of limiting factors to the desired advances, whether legal or regulatory, occur.

On Business Water Day (SS-SFG-02, SOARES NETO, Percy), a broad debate was held, which resulted in the launch of the Brazilian Business Commitment to Water Security. The document indicates that the signatory companies of the document will have to work towards the fulfillment of goals that seek to establish best practices for water resources management. The commitment involves, among others, the following actions: support for local communities with regards to WASH (Water, Sanitation, and Hygiene) and water availability, water risk reduction, benchmarking, investments, and the circular economy.

In all cases related to water management in the business sector, it is observed that the sector is committed to the search for solutions and expresses the desire for a more active participation in the integrated water resources management (SS-TP-10. SOUZA, Marlos de.).

3.1.3 Water-Energy-Food Nexus and Economic Development

The topics that stood out the most during the 8th Forum, within the scope of the water-energy-food nexus, were: intersectoral dialogue, transparency, technology, knowledge sharing, and governance. The approach to water management in the territory was observed in the sessions that dealt with reservoirs for multiple uses, water reuse, and public policies associated with the use of water in irrigation. Finally, experiences of technologies associated with local irrigation systems were presented.

Dialogue between different sectors is essential in approaching the water-energy-food nexus, which seeks to optimize the use of the natural resources involved using strategies in which all parties are benefited. The language and specific terms used by professionals from different areas, mainly in the water and electricity sector, were pointed out as factors that make this dialogue difficult (SS-TP-10. CAMPANA, Michael).

Another point identified was how transparency and technological development become relevant factors for allowing the monitoring of demand and consumption of water and energy so that users can participate in the management of these resources. (SS-TP-10. CAMPANA, Michael).

The United Nations' Food and Agriculture Organization (FAO) provided an example of how technology can help water management in agriculture (Box 6). It has developed a database accessible to the public in near real time, using satellite data that allows the monitoring of agricultural productivity of water and land and the absorption of carbon dioxide by vegetation known as WaPOR - remote sensing for water productivity (OS-TP-32. HOOGEVEEN, Jippe).

BOX 6. MONITORING LAND AND WATER PRODUCTIVITY IN AGRICULTURE BY REMOTE SENSING.

Jippe Hoogeveen, Land and Water Division, Food and Agriculture Organization (FAO), OS-TP-32

The United Nations' Food and Agriculture Organization (FAO) is developing a publicly accessible database (beta version) provided in near real time using satellite data, which allows monitoring of agricultural productivity from water and land and the absorption of carbon dioxide by vegetation. Known as WaPOR – Remote Sensing for Water Productivity – this portal covers Africa and the Near East with remotely sensed data.

The purpose of the data portal is to:

- Assist countries in identifying gaps in water productivity, proposing solutions and contributing to a sustainable increase in agricultural production;
- Contribute to the general reduction of water stress; and
- Provide subsidies to modernize irrigation schemes and promote and increase the efficient use of natural resources.

Water productivity assessments and other computationally intensive calculations are based on the Google Earth Engine.

> The productivity of water and land is evaluated in a different manner at three spatial levels:
>
> - the continental level - ground resolution of 250 m;
> - national and subnational level - ground resolution of 100 m;
> - irrigation scheme and sub-basin - ground resolution of 30 m
>
> The portal's services are directly accessible through dedicated APIs (application programming interface), which are gradually being published and documented on the FAO website. All data on the portal is open access, as are the models and methodologies.

Knowledge sharing is also essential to ensure the dissemination of best practices and innovations. The International Commission on Irrigation and Drainage (ICID) is a knowledge-sharing platform dedicated to issues that span the full spectrum of agricultural water management practices, ranging from rainfed agriculture to supplemental irrigation, land drainage, deficit irrigation, and total irrigation. It is a professional, scientific, technical and international, non-profit organization made up of experts from around the world in the areas of irrigation, drainage, flood management, and other knowledge related to water management in agriculture (OS- TP-53. REINDERS, Felix).

The Inter-American Institute for Cooperation on Agriculture - Caribbean Region (IICA Caribe) encourages knowledge sharing through the Torneo de Sequía - adaptation of The Invitational Drought Tournament, a methodology created by the Canadian Department of Agriculture. It is a participatory methodology that, through simulation, seeks to increase the preparation of public and private sector actors for a drought event and promote the ability to identify prevention measures, make decisions and manage climate risks. (OS-RP-32. RASER, Erin)

Governance, in turn, is a prominent factor, especially when talking about water and energy in the context of water stress. In order to manage water and energy together, common governance structures must be developed, in which the issue of soil must also be considered. The integrated water resources management system must therefore consider energy management (SS-TP-10. CAMPANA, Michael).

This integration has guided the discussion about water and energy security and the construction of new accumulation reservoirs for hydroelectric plants in Brazil. Currently, the configuration of hydroelectric power plants in Brazil has followed the trend of run-of-river projects, impacting the energy reserve of the National Interconnected System - SIN, which can harm water security due to the lower availability of water and deepen conflicts over water use. The electric sector has invested in wind generation combined with reserve capacity. It is believed that the construction and operation of multipurpose reservoirs, under an institutional model that ensures sectoral integration, from the planning stage, in order to meet the interests of different sectors and multiple uses, can be a solution in the face of socioeconomic growth and increased demand for water, energy, and food (OS-RP-08. RIBEIRO, Igor).

An example of a multipurpose project is the experience of the Columbia and Yakima Basins (OS-RP-08. CRISTENSEN, Wendy), in the United States, which shows how Integrated Water Resources Management brings together different sectors (water-energy-food nexus approach) and technologies for different purposes. This example involves a series of multipurpose reservoirs, which are arranged along the flow of the river, and canals that divert water in sloping areas for agriculture and collect water from agricultural processes, which is treated and returned to the river (Box 7).

BOX 7. MULTIPURPOSE PROJECT: RECREATION, SUPPLY, IRRIGATION, POWER GENERATION, FISH CIRCULATION

Wendy Cristensen, Project Manager, Yakima River Basin Water Enhancement, US Department of the Interior, OS-RP-08

The Columbia and Yakima Rivers multi-use projects are located in the state of Washington, USA.

The Columbia River Project has 271,000 hectares of irrigated area where potatoes, wheat, alfalfa, cherry, hay and wine grapes are produced. There are two large reservoirs in the northern part of the basin that divert only the water needed for agriculture. The project generates 145 megawatts of energy and agriculture in the region contributes 4 billion dollars to the country's economy.

The Yakima River Project is responsible for the irrigation of an area of almost 188 thousand hectares. There are five reservoirs in the project, whose agricultural activity is responsible for approximately 3.5 billion dollars with production of cherry, peach, pear, apple, and almost 75% of the hops produced in the United States.

Irrigation water is often used more than once before returning to the river. A small power generation system in the canals is capable of generating 0.025 Megawatts per mile, with the goal of generating 1 Megawatt. The project generates 25 megawatts.

In addition to providing water for irrigation, producing electricity, controlling floods, providing recreation and regulating flow, the Columbia River Basin Projects also provide water for cities, industries and shipping, and ensure the conservation of endangered species.

In this case, energy is used along the water flow in the irrigation canals as well as in the reservoirs, which are still used for leisure activities. Specific canals serve Indigenous populations in the region in order to raise fish that help control water quality. Monitoring the quality and quantity of water is also indicated, in this case, as being strategic for water management.

The experience above shows the relevance of multipurpose reservoirs with regards to water consumption and energy generation. Territorial management, taking energy, water and the multiple uses of the reservoir into consideration, must also involve monitoring the quality and quantity of surface and groundwater. (OS-TP-32. KAMINSKI, Newton).

Applying the systems integration approach is one means of addressing the challenge of the water-energy-food nexus. During the event, technologies and solutions for the treatment of wastewater and waste from food production (agriculture and animal husbandry) through biological processes were presented. The result generates the recovery of treated water, energy production, fertilizers, and other chemical components (OS-TP-23. LIAO, Wei).

Itaipu Binacional presents its experience with the use of renewable energy sources, especially biogas produced from agricultural and livestock industries, agro-industry and urban wastewater in western Paraná, Brazil. The technological arrangement developed for the region, in partnership with CIBiogás - International Center for Renewable Energy–Biogas (a scientific, technological and innovation center), develops and supports projects related to renewable energy. The implementation of these biogas production systems, in addition to generating energy and producing biofertilizers, prevents contamination of water in the watershed (OS-TP-32. KAMINSKI, Newton).

The management of water in the territory and water security were also the object of the report of the experience of Spain, which made it possible to increase the synergy between water and energy production (OS-RP-08. MENENDEZ, Manuel). The search for optimization in the use of water resources, with the replacement of open canal systems by piped systems, and the implementation of services oriented according to demand, resulted in an increase in energy consumption and, consequently, in the cost of production. As a way of minimizing the impact of these costs, different water sources were interconnected for distribution so that it was feasible to choose the most suitable water depending on the time of year: surface water, groundwater and desalinated water. More modern desalination systems have also allowed for a reduction in the energy cost of desalination plants. This is a case in which new technologies associated with irrigation and desalination systems have made it possible to optimize the use of water and energy as part of a positive strategy for the water-energy-food nexus. The nexus is so complex and with so many socio-environmental implications that the technical approach alone is not enough. Political and stakeholder involvement is essential (OS-RP-08. MENENDEZ, Manuel).

In addition to the experiences of water management in the broader aspect of the basin, food production can benefit from local technological solutions associated with irrigation projects that are strategic in providing energy efficiency, savings in operating costs and the efficient use of water. Therefore, the modernization of irrigation systems is necessary and provides more efficiency in the use of water, as demonstrated in the experiences shared below (OS-RP-10. CHRISTOFIDIS, Demetrios).

The experience of the Nilo Coelho Irrigation District, in Brazil (OS-RP-10. ARRUNATEGUI, Humberto), is one of the cases that demonstrates how technological factors and the monitoring of consumption data, both for water and energy, enable a more efficient management of resources. Located between the municipalities of Casa Nova/BA and Petrolina/PE, the Nilo Coelho Irrigation District is a non-profit private institution, managed by more than 2,000 producers represented by a Board of Directors. The institution implemented an energy efficiency plan that involved actions in water conduction and distribution, operations, and energy efficiency systems. The review and replacement of equipment, the adequacy of the period of operation of the equipment, and the review of indices and performance criteria for monitoring were carried out. A system was created to control the capture, distribution and supply of water at different levels and to maintain the daily replenishment of the network of reservoirs from upstream to downstream.

The Mandacaru Project (OS-RP-10. VIEIRA, Rodrigo) is another example of the benefits that updating irrigation systems can bring. The project, which had its methodology certified and inserted into the *Banco do Brasil* Foundation's Social Technologies Bank, provides detailed guidance on the steps and procedures for converting surface irrigation systems, by furrows, to pressurized irrigation systems using localized irrigation and sprinkling. This intervention thereby improves management, provides water and energy savings, reduces environmental damage, and increases producer competitiveness. It is interesting to highlight the premise adopted by the methodology of not changing the infrastructure: the conversion of systems is carried out using the available infrastructure. After the success of the Mandacaru Pilot Project, developed in Juazeiro, Bahia, in 2011, the 'Mandacaru Methodology' was expanded to the public irrigation perimeters of Maniçoba, Curaçá and Tourão, in Bahia, and Bebedouro, in Pernambuco, with results higher than those obtained in the Pilot Project (70% annual water savings).

In the Arroio Duro Irrigation Perimeter (OS-RP-10. VIEGAS, João Izidoro), in Rio Grande do Sul, Brazil, rice producers were organized around a project for the rational use of water in flood irrigated rice. Emphasis is given to the adaptation of the technological solution aimed at measuring the use of water in the culture by flooding with the installation of partial floodgates which, with other additional measures (Box 8), have reduced consumption by 2 thousand liters/ha since its implementation.

BOX 8. RATIONAL USE OF WATER IN RICE CULTURES

João Izidoro Viégas, Technical Consultant, Arroio Duro Irrigation Perimeter Users Association (AUD), Rio Grande do Sul, Brazil, OS-RP-10

The Arroio Duro Irrigation Perimeter Users Association (AUD) is responsible for the operation and maintenance of the Arroio Duro Irrigation Perimeter. It is an entity that brings together more than 400 rice producers, most of them with small properties. In addition to providing technical assistance for irrigation, AUD seeks to provide members with operational technology, meteorological information and new knowledge about rice cultivation. The rice produced is exclusively irrigated by flooding. There are 61 thousand hectares of rice and an irrigation perimeter of 21 thousand hectares, which makes the rational use of water mandatory. It is more complex to measure the use of water in the culture by flooding, unlike pressurized irrigation, for example. AUD has the challenge of serving all farmers with the rational water use project, which was developed almost exclusively with its own technology.

Key factors for the success of the project included:

- Normative provisions – definition of water distribution criteria (irrigation quota) according to the user's characteristics;
- Monitoring system of water levels in irrigation and drainage canals along the irrigated perimeter with transmission via telemetry in real time through proprietary software;
- Installation of a system of gates by stages. All properties were equipped with standard water intakes, calibrated in the UFRGS hydraulic laboratory, and staged floodgates, which allows for regulating the flow;
- Program to encourage the rational use of water. The program is voluntary and grants a monetary premium in tariffs for those who manage to maintain the pre-established volume of water consumption;
- Incentive for the systematization of areas, i.e. for reaching the same quota, reducing the water depth, and increasing the maintenance interval;
- Testing of shorter cycle varieties that optimize water use. Results are shared with the producers.

As a result, water consumption, which was previously 12,000 liters/ha, was reduced to 10,000 liters/ha and the AUD has a target of reducing consumption to 8,000 liters/ha in the coming years.

The expansion of irrigated agriculture, therefore, must consider technical, environmental, water availability and structural criteria in order to optimize investments and increase efficiency in water consumption (OS-RP-10. CHRISTOFIDIS, Demetrios).

The Ribeirão Pipiripau Basin Water Producer Project, in the Federal District, Brazil, was the subject of an official technical visit of the 8th World Water Forum, as a model of cooperation and governance between 17 institutions (government, users and NGOs), integration between urban and rural communities in the Integrated Management of Water Resources, implementation of green and gray infrastructure, training for the management and negotiated allocation of water, among others, which includes Payments for Environmental Services for around 200 rural producers who have adopted good agricultural and environmental practices on their properties, helping to minimize the impacts of the historic conflict over water use in the basin (Lima and Ramos, 2018) .

Finally, the Forum presented, as messages associated with the theme, that agriculture, as the main user of water, must increase its participation in discussions on the management of water resources. It was also pointed out that land, energy and water cannot be managed or planned independently (Closing of the Thematic Process of the 8th World Water Forum, 2018).

3.2 Financing, Technologies, Infrastructure, and Integrated Management for Water Security

3.2.1 Financing for Water Management

Global estimates show that current water infrastructure financing needs go beyond available financial resources (OS-TP-37. LECKIE, Hannah). There is a large gap between current levels of investment in the water sector and the amounts needed to meet the targets of the Sustainable Development Goals, in particular universal access to basic water and sanitation services (SDG 6). Challenges related to adapting to climate change, replacing old infrastructure and expanding existing infrastructure are likely to increase this gap in the future. Therefore, a transformation in the financing of the sector is necessary, either by increasing the efficiency in the use of public resources, or by encouraging private ownership or alternative funds (PP-NG-07, High Level Ministerial Session).

The capital of Namibia presented a case in which public-private partnership enabled improvements in the wastewater treatment and reuse system. In Windhoek, the Goreangab Water Reclamation Plant treats wastewater and provides drinking water to the population and, since 2001, has been managed by the Windhoek Goreangab Operating Company (WINGOC) consortium, between Veolia, Berlinwasser International, and WABAG (OS-TP-41 . HONER, Thomas).

In Senegal, another case that relies on public-private partnership for success is the Fecal Sludge Chain Enhancement Program (Box 2), which delegated wastewater treatment plants to the private sector, with the aim of controlling illegal disposal of sewage and encourage the use of modern technologies for the use of by-products of wastewater treatment, thereby making the operation of the plants financially viable (OS-TP-37. GUEYE, Mouhamadou).

In Brazil, the *Aquapolo* project, the result of a partnership between *BRK Ambiental* and the Basic Sanitation Company for the State of São Paulo (Sabesp), supplies 650 liters/second of reuse water to the Petrochemical Complex in the *ABC Paulista* region, which is equivalent to the supply of a city of 500 thousand inhabitants (OS-TP-41. SILVA, Fernando G.).

Debates on water financing are mainly focused on investments in infrastructure. However, the sector has performed poorly in turning these investments into sustainable services and there is a growing gap in governance funding. This is perhaps one of the most overlooked costs in the industry and one of the most important elements when designing funding mechanisms (OS-TP-61. FONSECA, Catarina). Therefore, good governance, efficiency, and water integrity are essential to securing increased financial resources in order to achieve universal access to water and sanitation. (OS-TP-61, Program Outline for session 6B1: Financing Governance).

The French Development Agency (AFD) used loan mechanisms as a tool to promote the efficiency and sustainability of public policies in WASH (Water, Sanitation and Hygiene) in Bolivia and Senegal (OS-TP-61. GILQUIN, Celine). The challenge of access to water and sanitation due to the absence of good governance guides AFD's 'Water and Sanitation' strategy. After having guaranteed a good governance structure, investments in infrastructure are carried out. (Box 9).

BOX 9. WATER GOVERNANCE AND FINANCIAL INSTRUMENTS: PERSPECTIVES OF A DONOR INSTITUTION IN BOLIVIA AND SENEGAL

Céline Gilquin, Head of the Water and Sanitation Division, French Development Agency (AFD), OS-TP-61

The promotion of good governance in WASH (Water, Sanitation and Hygiene) is supported by the definition of transparent, efficient, and inclusive sectoral structures. This involves technical

> and economic measures such as financial models, pricing, and resource allocation. Fighting corruption is also a relevant approach at this stage. To implement this strategy, AFD adopts the policy of granting loans to beneficiary countries. This process consists of linking a fixed portion of the disbursement to eligibility criteria in which the government's general policy and the manner in which the budget is managed (public finance management, microeconomic situation and budget transparency) are analyzed. The remaining resources are linked to a matrix of sectoral indicators. As the indicators are reached, additional portions of the resources are released. The entire process is defined together with the authorities from the country receiving the support.

In order to optimize management, improve the quality of services and ensure greater investment, Portugal presents an example of how it restructured its entire governance system. The process began in 1993 with the national reform of the country's water supply and sanitation service and the creation of a public business group, *"Águas de Portugal"* ("Portugal's Waters"), formed by public companies with commercial privileges (OS-TP-62. SERRA, Alexandra). The multi-municipal governance model divided the sector into segments. The operations of abstracting and treating water and supplying it to the municipal reservoirs, as well as the collection of sewage from the municipalities, followed by treatment and return to the receiving water bodies were the responsibility of *Águas de Portugal*. The customer service segment, with water distribution and sewage collection at the households, was the responsibility of municipalities, municipal operators, public-private partnerships, or public partnerships.

In Latin America, a study showed that about 10% of investments are lost due to corruption (OS-TP-61. CATHALA, Corinne). The Inter-American Development Bank (IDB) takes action in supporting the fight against corruption, in the implementation of transparency mechanisms in the provision of public services, and in improving the level of water regulation. The Bank also provides technical assistance and institutional strengthening measures in relation to public utility companies.

In this context, the IDB developed, in partnership with the International Water Association (IWA), an international standard – the AquaRating. It is a methodology used to strengthen the management of companies providing water and sanitation services, through the review of strategic indicators and best practices throughout the value chain. The process begins with a company self-assessment phase to verify the status in 8 strategic areas: service quality, planning, operations, management, finance, access to services, environmental management, and corporate governance. Subsequently, the validation of the results generates a mapping of the evaluated elements that guides the company in the identification of focus areas, strengths, and improvement opportunities. Certification is also available, which verifies the information to ensure the quality and compliance of the process, through an independent audit.

In addition to the state's role in ensuring good governance for the management of water resources, proper management by operators is essential for investments in the sector in order to remain attractive and enable universal access to water and sanitation services.

The United Nations Development Program (UNDP) GoAL Wash Program prepared a methodology for a new approach to the financial and general management of companies that provide water and sanitation services, thereby making it sustainable for consumers (OS-TP -59. Film: Every drop of water has to find its way to consumers). The objective is to guarantee the supply of water through good management, with a clear definition of roles and responsibilities, in a spirit of partnership between municipalities and supplying companies. The methodology was piloted in companies in the cities of Tešanj and Teslić, in Bosnia and Herzegovina (Box 10).

BOX 10. FILM: EVERY DROP OF WATER HAS TO FIND ITS WAY TO CONSUMERS

GoAL WaSH Programme, United Nations Development Programme (UNDP), OS-TP-59

The population of Bosnia and Herzegovina has been provided with deficient water supply and wastewater treatment services. The supply network is outdated and the water quality is questionable. The cause of these problems in the water supply sector is that those responsible for the supply do not invest in the maintenance of the system. There is a lack of qualified teams, a lack of clarity in the definition and distribution of responsibilities, in addition to the tariff charged not being adequate. All this puts the supply service at risk over the long term. Therefore, a new approach is needed in the financial and general management of the companies that provide the service to make it sustainable for consumers.

Through the *GoAL WaSH* Programme, the UNDP is committed to supporting the accountability of companies by setting goals for sustainable water supply and sanitation. The program prepared a methodology to facilitate the process of setting appropriate tariffs for water supply and sewage treatment.

> The tariff must ensure full coverage of the service provider's costs, investments in maintenance and working capital, in addition to respecting the principle of service accessibility to consumers.
>
> In 2017, the methodology was tested by companies in the cities of Tešanj and Teslić. The intention is to extend the methodology to the majority of companies in Bosnia and Herzegovina as an effective mechanism for assessing the financial cost of supply services and the long-term sustainability of the system. In addition to increasing the level of transparency of companies, it will be possible to establish an appropriate regulatory framework for water supply services, and wastewater collection and treatment.

Losses in the water distribution system also represent costs. The average for water treated but lost before reaching the user worldwide is 35%. In São Paulo, it is 37% and in some cities, this rate can reach 70% (OS-TP-32. LEMOS, Flavio). The Basic Sanitation Company for the State of São Paulo (Sabesp) fights against losses in the water distribution network (OS-TP-37. LEMOS, Flavio).

In 2013, the *RE São Luiz* Consortium was hired to carry out studies and to distribute water more efficiently in the *Jardim São Luiz* Supply Sector, in the city of São Paulo. The performance contract, the type of contract used, allows for reducing implementation deadlines for works and improvements, seeking innovative and long-term solutions, attracting the market with success stories, and optimizing management processes. The savings that Sabesp obtains from the reduction in losses is used to pay the consortium for providing the service. The studies indicated the potential for water savings of 680 thousand m^3/month. More than 1 million m^3/month was saved, converted into remuneration for the improvements implemented, such as the extension of the distribution network and connections.

There are different financing arrangements available in public-private partnerships aimed at building infrastructure projects. The cost of these projects is high and a great deal of time is needed to recover the capital invested. These two aspects represent some of the risks that raise project interest rates. Funds from development institutions, which are usually made available at lower interest rates or on a non-refundable basis, can be associated with financing/financial arrangements, in what is called blended finance. From the investors' point of view, this financing system reduces the risks associated with the capital invested – whether financial, social or environmental risks – and encourages the contribution of private capital to ensure the financial sustainability of the projects. (OS-TP-62. ALEXANDRE, Jean-Luc)

Jordan presents an interesting blended finance experience for a 25-year-old BOT (Build, Operate and Transfer) public-private partnership project for the construction of the wastewater treatment plant "As-Samra" (OS-TP-62. ALEXANDRE, Jean-Luc). The project received resources from the Swedish International Development Cooperation Agency (Sida) for the preparation of the project. The United States Agency for International Development (USAID) and the Millennium Challenge Corporation (MCC) provided non-refundable funding, for stages I and II of the venture, respectively. This capital was essential to ensuring the financial sustainability of the project, which also benefited from investments from consortium companies, through the issuance of participation shares and a consortium of local banks with favorable interest rates (Box 11).

BOX 11. OPTIMIZING EXISTING FINANCIAL RESOURCES TO IMPROVE THE SUSTAINABILITY OF WATER SERVICES - JORDAN'S CASE

Jean-Luc Alexandre, Chief Operating Officer - Treatment Infrastructure, SUEZ, OS-TP-62

The water situation in Jordan is critical. The amount of water available per person, per year, is 150 m^3 when worldwide, levels below 500 m^3 are considered an emergency. The "As Samra" water treatment plant was built to replace the old and overloaded wastewater stabilization ponds in Amman and treats 30% of the country's wastewater for reuse.

The infrastructure was built through means of a 25-year BOT (build-operate-transfer) public-private partnership. The first phase involved the signing of the BOT contract with the Jordanian government in 2003, the construction of the plant, completed in 2008, with a capacity of 267 MLD (million liters per day), and the planned O&M (operation and maintenance) period expected to continue to 2030 (22 years). The second phase involved the expansion of the plant with a 37% increase in capacity (to 365 MLD) and extension of the O&M period to 2037. The third phase is currently being prepared, which will increase capacity to 500 MLD.

As for funding, phases I and II received resources from the United States Agency for International Development (USAID) and the Millennium Challenge Corporation (MCC), respectively, making the project financially sustainable. A consortium of local banks led by Arab Bank provided cheaper financing for the project. The consortium contracted to develop the enterprise entered with participation shares (equity) in order to form the Special Purpose Company. This combination of financing sources, capable of mobilizing additional financing for sustainable development in developing countries, is called blended finance. (source: https://www.oecd.org/dac/financing-sustainable-development/blended-finance-principles/). In addition to lower interest rates, the arrangement enabled lower rates for users.

Other highlights of the project include:

- Groundwater protection – The treatment plant replaced the ponds that polluted the Amman-Zarqa Basin with wastewater infiltration;
- Water reuse – The Samra treats water for reuse in irrigation, serving 4,000 producers in an area of 10,000 ha;
- Power generation – The plant's turbines and biogas generate 80% of the energy required for its operation;
- Job creation – More than 1,000 jobs created during construction and 165 jobs for O&M. 99.5% of employees originating within the country and 70% local workforce, providing training and knowledge transfer; and
- Community involvement – Strong political support at the state level, involvement of local financial institutions, management of local environmental challenges such as the need for water for irrigation, and consideration of the concerns of local communities.

Finally, issues related to water directly affect the well-being of the population and the economy. Floods and water scarcity, lack of access or inadequate access to water and sanitation are examples of how water, if poorly managed, poses a risk, including an economic one. Water management implies the proper performance of institutions, investments for maintenance, expansion and adaptation of water infrastructure aiming at greater efficiency, the creation of policies and strategies that consider water efficiency as a principle in other sectors, and financial mechanisms to encourage the changes needed in the industry (OS-TP-37. LECKIE, Hannah).

3.2.2 Technologies for Integrated Water Management

Technology plays a key role in achieving the goals of SDG 6, not only in terms of engineering technology in the delivery and maintenance of water and sanitation facilities and systems (such as faucets, toilets and pipes), but also in the wider use of information and communication technologies (ICTs) to help manage water itself (UNESCO and UNESCO i-WSSM, 2019).

Technological development can be seen in most of the cases presented, and not exclusively in those that sought to discuss this specific theme. Technological advances appear to be associated with the need for improvement, whether in seeking out greater efficiency in water management processes or ensuring water quality. Technology is also playing a significant role in preventing water-related disasters, as well as within the circular economy. New methods, techniques, equipment and solutions are appearing, from local solutions for supply and sanitation to water management at the national or transboundary level, through solutions inspired by natural processes – Nature-based Solutions (NbS) – and by digital advances in a general manner.

Social technologies – initiatives that promote solutions for effective social transformation – were also identified for water supply and treatment. The *Semear Internacional* ("International Sowing") Program (OS-RP-32. VITERBO, Fabiana) aims to increase the impact and efficiency of rural development policies and programs and reduce rural poverty in northeastern Brazil. The publication "Sowing Knowledge, Inspiring Solutions - Best Practices for Living in Semi-arid Areas", in the "On the water's path" session, presents the systematization of seven experiences related to water saving, water withdrawal, or increasing water availability in semi-arid regions, where the resource is extremely scarce (Box 12).

BOX 12. KNOWLEDGE MANAGEMENT FOCUSED ON WATER SUSTAINABILITY IN RURAL AREAS OF THE BRAZIL'S SEMI-ARID REGIONS

Fabiana Dumont Viterbo, Coordinator of the Semear Internacional Program, IICA, OS-RP-32

The International Fund for Agricultural Development's (IFAD) *Semear Internacional* Program, which is executed in partnership with the Inter-American Institute for Cooperation on Agriculture (IICA), develops work that identifies, monitors and evaluates, implements and disseminates the best practices and social innovations that are being adopted in rural areas of northeastern Brazil. Often developed by the residents themselves, these initiatives have helped to transform their reality in order to successfully coexist with the Brazil's semi-arid regions.

The publication "Sowing Knowledge, Inspiring Solutions - Best Practices for Living in Semi-arid Areas" dedicated a section to initiatives related to water: "No curso das águas" ("On the water's path"). Some of the experiences systematized in the publication included:

- **Gray water filtration process.**
  System that collects water from the shower, kitchen sink, laundry area basin, and washing machine. After passing through the grease trap and through a filter, the water is stored in a cistern. By pumping the water to an elevated water tank, it can be used to irrigate the garden using a drip system.

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- **Spring recovery and protection.**
  Interventions for the recovery of a spring area which was previously degraded and contained brackish water. Measures to protect the area ensure a clean source, free from the presence of dead animals, waste, or decaying plants. This intervention increased the availability of water, and the spring became a source of water for animals and families throughout the year.

The presence of technological solutions can also be observed in the aforementioned rainwater harvesting and treatment project located at a school in India (OS-TP-37. CHAKRABORTY, Debarati), which associates a water filtering and treatment system to the reservoir, thereby allowing it to be consumed. Also in India, the case of Mandalpara (OS-TP-37. CHAKRABORTY, Debarati) introduces new sanitary systems, with a double pit that ensures improved hygiene standards (Box 1).

The Mudialy Fishermen's Cooperative Society (MFCS) wastewater-fed aquaculture project, the third case from India presented, is a nature-based solution (OS-TP-37. CHAKRABORTY, Debarati). Sewage is channeled through six different ponds. In the first stabilization pond, wastewater is treated with quicklime sprinkling. In others, the water hyacinth absorbs oil and grease. The connecting tunnels between the ponds are populated with exotic fish like tilapia and nycotica that can withstand toxic stress, and other air-breathing varieties like singi, magur and koi. These are indicator fish as they provide an early signal if the water is contaminated with chemicals. When fish jump out of the water to breathe too often, the fisherman is told that the dissolved oxygen in the water is low. In each pond, the water is cleaned through sedimentation and absorption and is subsequently channeled into the fishing ponds (Box 1).

The desalination of seawater has been a common practice in several countries, either for human consumption or for use in food production. But its use is no longer restricted to coastal countries. The practice has also been used in arid regions or areas with low availability of potable water, for the treatment of brackish water. This technology has been continuously advancing, expanding the alternatives for water supply.

The use of desalinators with technology that optimizes energy consumption has been reported by Spain (OS-RP-08. MENENDEZ, Manuel) in the use of seawater.

The Fresh Water Program (OS-RP-32. FERREIRA, Renato), in Brazil, incorporates technical, environmental and social care into the recovery, implementation and management of desalination systems, primarily in rural communities in the Brazil's semi-arid regions. It aims to establish a permanent public policy for access to good quality water for human consumption. The program involves 10 Brazilian states and more than 200 institutions and uses reverse osmosis technology.

Whether for economic reasons, or because of concerns about water scarcity and the consequent impact on business, the business segment continually seeks technological solutions to optimize the use of water and other resources in its processes. Research and the development of technologies allow the treatment of water for reuse, in addition to the use of other by-products of the production processes.

Special mention can be made of cases of circular economy presented above: the *Aquapolo Ambiental* Project (OS-TP-41. SILVA, Fernando Gomes da.), from São Paulo, which uses a technological solution for wastewater treatment in order to meet the specific water quality requirements for companies that use the system, the Kalundborg Symbiosis (OS-TP-40. LARSEN, Carl-Emil), which enables the use of water, energy and other by-products between the municipality and companies (Box 4), and Billund BioRefinery (OS-TP-40. LARSEN, Carl-Emil), which adopts environmental technologies in water treatment and biogas generation.

Marselisborg ReWater (OS-TP-40. LARSEN, Carl-Emil), another case from Denmark, is a learning plant for wastewater treatment that adopts an innovation strategy with the aim of being 150% self-sufficient in energy. "The ambition is not to build a factory that will remain unchanged for the next hundred years. We are building a factory that will constantly expand our knowledge and therefore can be constantly improved. We build for the needs we know and make room for flexibility in terms of what we don't know. We think of short life cycles for areas that undergo rapid technological development or meet new demands," reports Larsen.

The search for production efficiency in agriculture – the sector that consumes the most water in the world – has also led to the development of solutions both in water management and in the development of agricultural varieties that require less water.

The case of the Rational Use of Water in Rice Culture (OS-RP-10. VIEGAS, João Izidoro), highlighted in Box 8, shows how the partnerships between producers and universities can generate interesting technological solutions, such as the system of regular floodgates to control the use of water in rice cultivation by flooding. In addition to the engineering technology implemented, a real-time telemetry water monitoring system using software was adopted.

It is widely agreed that the modernization of irrigation systems has allowed for the optimization of water use while increasing energy consumption. There-

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fore, energy efficiency appears as a concern in all irrigation cases presented, with the adoption of monitoring systems for both water efficiency and energy efficiency.

Rivers are the main source of water in Malaysia, providing 97% of the water used. The country's water management strategy involves Integrated Water Resources Management (IWRM) at the watershed level, governance of water resources, and water demand management based on water availability. NAWABS – National Water Balance Management System (OS-RP-13. ISNIN, Abdullah) is a comprehensive Decision Support System focused on IWRM, designed to monitor the fulfillment of SDG 6 targets (Box 13).

BOX 13. DECISION SUPPORT SYSTEM (SSD) FOR WATER RESOURCES MANAGEMENT: WATERSHED STRATEGIES IN MALAYSIA

Abdullah Isnin, Malaysia Department of Irrigation and Drainage, OS-RP-13

The National Water Balance Management System - NAWABS is a system for water resources management by basins and sub-basins developed by Malaysia based on SDG 6 targets. Through data collection and based on models and decision support tools, information is made available for watershed management.

The system consists of the following components:

1. Study of the basin's water balance, basin ecological flows, demand management options, water resources conservation plans, and the water-energy-food nexus.

2. Numerical model of surface water resources and related infrastructure.

3. Numerical model of groundwater resources.

4. Database of model results, as well as links to external data sources.

5. Management and decision support system, and associated SSD tools.

6. Web portal for disseminating the NAWABS's main results.

NAWABS's results involve:

- **Water accounting**
  (SDG 6.1.1, 6.4.1 and 6.5.1.)
- **Water availability**
  (SDG 6.4.2.)

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- **Water quality**
  (SDG 6.3.2, 6.4.2 and 6.5.1.)
- **Water storage**
  (SDG 6.4.2 and 6.5.1)
- **Water resources and drought index**
  (SDG 6.4.2 and 6.5.1)
- **Water audits**
  (SDG Indicator 6.4.2)
- **Water allocation**
  (SDG 6.5.1 and 6.5.2)
- **Alternative Demand Options**
  (SDG 6.5.1)
- **Priority-based water recommendations**
  (SDG 6.5.1 and 6.B.1.)

Big cities promote new projects to bring more water to the urban supply system, usually through transfers or very expensive works. Before bringing more water to the system, demand must be reduced and one of the ways to reduce demand is to combat water loss. Energy consumption is also a concerning factor for water operators. It is estimated that the drinking water sector is responsible for 4% of the energy consumed in the world, according to the speaker who presented the WatEner platform (OS-TP-32. PASTOR, Jordi J.).

WatEner is a web platform that helps to improve the operation and daily management of drinking water networks, considering the water-energy nexus, based on artificial intelligence and the availability of information in real time. In addition to the early detection of leaks and demand forecasting, the tool allows energy efficiency to be improved through intelligent operation, by adjusting pumping schedules according to energy prices, for example. The city of Karlsruhe, Germany, has reduced energy consumption and its carbon footprint, as well as improved daily grid operation and management and leakage control using this platform (Box 14).

BOX 14. OPTIMIZATION OF URBAN SUPPLY NETWORKS IN KARLSRUHE, GERMANY

Jordi J. Pastor, Regional Director for South America, Inclam Group, OS-TP-32

Stadtwerke Karlsruhe (SWKA) is a German municipal water supply company that serves a region with 400,000 inhabitants and distributes around 24 hm^3 of water per year. Water is supplied by four main pumping stations and distributed over more than 900 km of pipeline.

In this context, the WatEner platform was developed, with the objective of improving the operational management of the network and reducing the energy consumption of the water distribution system. In a supply system composed of modern and up-to-date infrastructures managed by a highly qualified technical team, WatEner provided added value with a global solution for network management.

The tool allows for:

1) *Increased water savings*
Anomaly detection to identify leaks in the global water network, demand forecast, and hydraulic model;

2) *Reducing energy costs*
Improved energy efficiency through smart operation (e.g. adjusting pumping schedules according to energy prices);

3) *Short term profitability*
Investment Paybak Period of 3 to 5 years, based on energy savings alone;

4) *Greater Accessibility*
Role-based and multi-device access;

5) *A strategic business vision*
Indicators and control and monitoring panels;

6) The maximization of in-house expert advice;

7) A Web Platform; and

8) A reduced carbon footprint.

The results of implementing WatEner in SWKA show a reduction in energy consumption of 5 to 7%, and energy cost savings of up to €50,000 per year.

Additional research source: http://waterer.com/#casestudy

Combating water loss is also a topic that is related to new technologies. Accuracy in measuring water consumption is essential for measures to combat the loss of unbilled water (OS-TP-32. NAITO, Koji). In water supply services, the water used by the customer is measured with the hydrometer and charged accordingly. Leaks, clandestine connections, and inaccurate water meters give the system operator a distorted view of the real demand for water. Adequate measurement of consumption allows the use of water and the system's financial resources to be optimized.

3.2.3 Integrated Water Management in Cities

UN reports indicate that two-thirds of the world's population will live in cities by 2050 (PP-LRA-00. CAMARA, Paulo). Financing and technologies for water infrastructure and for the integrated water resources management, in moving towards water security, is a mandatory topic in urban management.

Water management in cities was one of the highlights at the 8th World Water Forum. The theme 'Urban Environment' mobilized more than 30 institutions to organize 9 sessions that focused on water in cities, the circular economy, treatment, and reuse. In addition, water management in cities was also addressed by the 'Regional' and 'Political' Processes (SS-TP-11. BRIKKE, Francois).

The main development frameworks agreed upon internationally – such as the 2030 Agenda, the New Urban Agenda, the Sendai Framework for Disaster Risk Reduction, and the Paris Agreement on Climate Change – were considered as a backdrop to the discussions that took place during the 5th International Conference of Local and Regional Authorities on Water, organized by the Political Process within the scope of the 8th Forum. The objective of the conference was to strengthen the capacity of decision makers to overcome local water challenges (PP-LRA-00. CAMARA, Paulo). The launch of the guide "Start with Water – Including water in local action agendas to promote global change" adds to initiatives such as the Istanbul Water Consensus *("Istanbul Water Consensus - For Local and Regional Authorities,"* 2009) and the Daegu-Gyeongbuk Water Action for Sustainable Cities and Regions (*"Daegu-Gyeongbuk Water Action for Sustainable Cities and Regions,"* 2015) aiming to contribute to the mobilization and coordination of local and regional authorities in the implementation of these international frameworks through concrete actions.

The document resulting from the conference "Brasília Local and Regional Governments Call for Action on Water and Sanitation" (PP-LRA-13. ALMEIDA, Débora) aims to place the theme 'water' at the center of urban management through the following recommendations:

1. Promote sensitive integrated water practices, taking into account basic human rights and services and gender approaches, putting sanitation and access to quality water at the top of the water agenda;
2. Bring forward legislation that enables fair, efficient and sustainable use of water resources, promote integrated urban water practices and energy efficiency, making use of technology when possible;
3. Strengthen and increase decentralized funding and innovative finance mechanisms for water and sanitation projects;

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4. Promote urban water resilience through planning out risk and climate change adaptation and mitigation and protection of sensitive areas; and
5. Strengthen the capacity of local governments and citizens in water sensitive governance."

To support cities in developing sustainable management of the urban water cycle, the International Water Association (IWA) has developed principles for 'water-wise cities' (OS-TP-37. REUTER, Stefan) that aim to encourage collaborative action, supported by a shared vision, in order to actively involve local governments, urban managers and individuals in approaching and finding solutions for the management of city waters (Box 15).

BOX 15. THE PRINCIPLES FOR WATER-WISE CITIES FROM THE INTERNATIONAL WATER ASSOCIATION (IWA)

Stefan Reuter. Director General, Bremen Overseas Research and Development Association (BORDA), Germany, OS-TP-37

The principles for water-wise cities support the development and implementation of sustainable management of the urban water cycle, in addition to equitable and universal access to safe drinking water and sanitation. These principles seek to encourage collaborative actions, supported by a shared vision, so that local authorities, urban professionals and other individuals actively commit to addressing and seeking solutions for urban water management. The principles are supported by 5 pillars: Vision, Governance, Knowledge and Capacities, Planning Tools, and Implementation Tools. They are divided into the four following action levels:

1 - Regenerative Water Services

- Replenish water bodies and their ecosystems
- Reduce the amount of water and energy used
- Reuse, Recover, Recycle
- Use a systemic approach integrated with other services
- Increase system modularity and ensure multiple options

2 - Water Sensitive Urban Design

- Enhance Regenerative Water Services
- Design urban spaces that reduce flood risks
- Improve the quality of life with visible water
- Modify and adapt urban materials to minimize environmental impacts

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3 - Basin Connected Cities

- Plan to secure water resources and mitigate droughts
- Protect the quality of water resources
- Prepare for extreme events

4 - Water-Wise Communities

- Empowering citizens
- Professionals aware of the mutual benefits of water
- Multidisciplinary planning teams
- Policy makers who leverage conscious actions in water management
- Committed and trust-inspiring leaders

Additional research source:
<https://iwa-network.org/wp-content/uploads/2016/10/IWA_Brochure_Water_Wise_Communities_SCREEN-1.pdf Accessed on 12/26/2020.>

It is important for decision makers to consider the role of natural hydrological systems and, where appropriate, integrate green and gray infrastructure in ways that increase overall water system performance and climate resilience at lower costs (OS-TP-50. OZMENT, Suzanne).

South Korea presented its effective and sustainable design initiatives for water-wise cities (OS-TP-37. KIM, Lee-Hyung). Water scarcity in South Korea led the country to seek out new sources of water and find a solution in the readjustment of cities so that they were sensitive to the hydrological cycle and, thus, benefit from supporting, provisioning, cultural and regulatory ecosystem services. Adopting low-impact development principles, green infrastructure, and the decentralization of water treatment plants, the urban environment was changed in order to provide better use of rainwater and treated water, promote aquifer recharge, as well as prevent negative impacts related to floods, droughts and pollution. The leading cities in water circulation in South Korea are: Gwangju, Daejeon, Gimhae, Ulsan, and Andong.

In China, in order to address the problems that have arisen because of rapid urbanization, the government conceived the Sponge Cities Program (OS-TP-40. ZHU, Yongnan). The program includes a strategy for the integrated management of urban water. The concept is rooted in the laws of natural and social water cycles and their associated processes. The objective is to mitigate urban waterlogging, control urban water pollution, and use rainwater resources, as well as reverse the ecological degradation of urban water. Its possible measures, including engineering (green and gray) and non-engineering measures, respect the principles of natural ecological regulation of the urban hydrological cycle,

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in order to build benign interactions between the socioeconomic system and the urban water cycle. This enhances the resilience of cities in the face of changing environments and natural disasters. The main technical measures are classified into six categories (infiltrate, detain, store, cleanse, use, and drain) according to their main functions. These categories are seen as the sponge city's "six-word principle", which forms the basis for the program's guidelines.

Reuse, once again, stands out as a great promise to help minimize the impacts that possible water crises may bring. It appears both as a solution to sanitation problems and as an alternative to solving growing problems related to water stress. A study by the Ethiopian Civil Service University (OS-TP-40. TAREKEGN, Mekonnen Maschal), on reuse and recovery of resources in urban water management, analyzed the production of vegetables by urban farmers and the amount of water that is wasted in this process compared to the amount of water that is recycled in treatment plants in the city of Addis Ababa, Ethiopia. The following conclusions were reached:

- Wastewater generated by the city can be a resource to alleviate urban food insecurity and balance the ecosystem functions of the urban environment;
- The problems generated in the city system were mainly caused by the lack of policies and strategies for the wastewater-food nexus;
- The poor quality of recycled wastewater causes contamination in cultivated food. Thus, it is necessary to adopt good wastewater treatment technology to remove contaminants;
- The reason for the low efficiency in the use of water is the lack of techniques and qualified technicians to promote and train urban agriculture in the country, which makes it important to establish international cooperation agreements; and
- The negative attitude of consumers towards consuming products that use recycled water in irrigation is one of the main challenges to be faced.

According to Lauriat (OS-TP-41. LAURIAT, Alexandra), water recycling goes beyond reuse for agriculture. Recycling considers water according to the purpose of use, including industrial, urban or recreational uses, underground recharge, and even the recovery of water for potable use. In regions with high water scarcity, this solution is essential for social, economic, and environmental sustainability by reducing stress on water resources. The recycling of water also promotes productivity in several sectors and consequently mitigates economic and environmental impacts. It reduces the exploitation of rivers and other water sources by allocating optimal quality water for human supply, and avoids conflict by introducing a sustainable cycle.

Some reuse experiences have already been mentioned in this volume, both in agriculture and in companies, such as the case of *Aquapolo Ambiental* in São Paulo (OS-TP-41. SILVA, Fernando), the cases of Denmark (OS-TP-40. LARSEN, Carl-Emil), and Windhoek, Namibia (OS-TP-41. HONER, Thomas).

Japan also shared interesting experiences on water reuse during the 8th World Water Forum. Water reuse has been ongoing since 1978 and has quadrupled in the last 40 years (OS-TP-43. YAMASHITA, Hiromasa). The main purposes for reuse are distributed in the following manner: Landscapes - 30%, Increase in river flow - 28%, Snow melt - 20%, and Planned industrial use - 10%. Different technologies are used for water treatment depending on the origin and purpose of reuse. As an example, highlights among the reuse technologies adopted in Tokyo included: increase in the flow of the Meguro River (68,000 m^3/day) with the use of a UV Filter system – which kills the most fragile bacteria by exposing them to ultraviolet light; feeding toilet flushes using a system of biological filters, ozone and filtering membranes, as implemented in West-Shinjuku, Nakano Sakaue and the surrounding region, in which 9,300 m^3/day are recycled; supply water for recreational purposes using reverse osmosis filters, as seen in the Ochiai Water Treatment Center, through which 16,000 m^3/year are used; and to clean the Yurikamome train, where ozone is used to treat 1,800 m^3 of recycled water a year.

With a focus on water safety for reuse, Singapore shared its experience (OS-TP-41. MENG, Pang Chee). With limited area to collect and store rainwater, Singapore faced droughts, floods and water pollution in the early years of its nation building process. These challenges inspired the government to strategize and pursue innovative ideas, build capacity, and ensure a sustainable water supply. The water collected from rivers, streams, canals and drains is stored in 17 reservoirs. With pipelines connecting the various reservoirs, excess water can be pumped from one reservoir to another, thereby optimizing storage capacity. The collected water is treated and further purified using advanced technology known as NEWater. To facilitate the implementation of NEWater, an appropriate regulation was developed in which the transparency of the entire process is mandatory, with the publication of online monitoring reports. The NEWater treatment system ensures water for indirect potable use and direct non-potable use. Today, Singapore has a robust and diverse water supply known as the "Four National Taps", which consists of water from the local basin, imported water, highly purified reuse water (NEWater), and desalinated water.

3.3 Education and Training for Integrated Water Resources Management

Seeking out water security requires interdisciplinary collaboration across sectors, communities, and political boundaries to ensure that the potential for competition or conflict in water resources between sectors and users is properly managed (Zeitoun, 2011). In this context, training for the integrated water resources management must be broad and aimed at all citizens. In line with the approach of "Water-Wise Cities" (OS-TP-37. REUTER, Stefan), training for integrated water resources management should encourage collaborative action by citizens supported by a shared vision of responsibility for water.

In many of the analyzed sessions of the 8th World Water Forum, examples of the relationship between capacity building and the experiences and innovations presented can be extracted. When it comes to training for integrated water resources management, four major target audiences for training actions can be identified:

- *Citizens who use water.* This group includes everything from environmental education and awareness actions for the water user population in general to training for participatory action in water management. Emphasis is given to actions to raise awareness of the population for the rational use of water, including the reduction of losses and the acceptance of the utilization of reuse water or food produced from it. It is worth mentioning the community training action carried out in San Francisco in the United States of America, which involves the distribution of kits and is aimed at the implementation of water reuse systems to water household gardens (OS-TP-43. KEHOE, Paula). Community training in the maintenance of local water supply or sanitation systems was also covered in more than one session.
- *Workers in the water sector.* The constant training of water system workers, associated with technological updating, allows water to be made available with better quality and at lower maintenance costs. The importance of practical training and the need to retrain these workers was highlighted (OS-TP-77. TARDIEU, Eric).
- *Water managers and researchers.* Managers and researchers in the water sector must be permanently updated on best practices and technologies for the management of water resources. The need to share with these professionals the vision of water use as perceived by other sectors, including understanding the challenges that water represents was reiterated throughout the Forum's sessions (OS-TP-77. SALLES, Paulo).

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Understanding the specific technical language and concerns of other sectors is essential for a systemic and comprehensive view of water management. It is also essential to encourage the exchange of experiences between managers from different countries or spheres of activity (OS-TP-77. ZIGANSHINA, Dinara R.).

- *Managers and workers from other sectors.* As part of a vision for integrated water resources management, the training of sectors that use water as an input (energy, agriculture, industry) and that dispose of water in natural bodies is also essential.

4. Conclusions and recommendations

From the various analyzed sessions of the 8th World Water Forum, a series of recommendations were extracted and subsequently systematized. Below are the main recommendations related to the theme of "Water and Development" obtained from this analysis.

4.1 Water as an Input to Economic Development and the Water-Energy-Food Nexus

- As the main user of water, agriculture should increase its participation in discussions on water resources management;
- Soil, energy, and water cannot be managed or used independently;
- Water allocation must be more equitable and inclusive in order to encourage social and economic development;
- An integrated urban and rural approach should be used for the planning and management of water resources, including the integration of surface and groundwater;
- It must be ensured that policies and investments in water infrastructure take into account sustainable allocations and different water use objectives;
- Ecological services must be explicitly integrated with policy and planning and must include genuine community consultation, incentives to mitigate potential socio-economic impacts, and support for community engagement.

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4.2 Financing, Technologies, Infrastructure, and Integrated Management for Water Security

- Cities are the main actors in the implementation of agreed upon goals worldwide and in the use of integrated approaches through the involvement of stakeholders;
- The circular economy must be implemented, which encompasses the reuse of water and the recovery of resources. This can generate several benefits (environmental, social, and economic) and help to achieve the SDGs;
- Principles of 'water management awareness' should be integrated into urban planning, exchange of experiences for mutual learning should be promoted, and opportunities for dialog and sharing between different stakeholders should be encouraged;
- Decision makers should consider the possibility of integrating nature-based solutions (NbS) into water management and infrastructure planning in order to add to or parallel artificial infrastructure (gray);
- Advances in monitoring capabilities, decision analysis, and innovative policies and technologies are needed to ensure sufficient water quality;
- Consideration should be given to payments for environmental services (PES) or other forms of incentives to promote nature-based solutions (NbS), as well as financial and regulatory tools to provide inclusive services (in rural and peri-urban areas), in addition to attracting new actors, including the private sector;
- There is great synergy between the water-related SDGs and the climate change adaptation goals. To achieve them, investments in water governance (integrity, transparency, accountability) are essential and the environment must be favored at various levels (national and subnational). These are the key drivers in providing incentives for other financing tools, including domestic and climate financing;
- Clear regulations are a prerequisite for public and private investments in water security, which can be implemented effectively through public-public and public-private cooperation. Multipurpose infrastructure – including water storage solutions – can contribute to the SDGs and adaptation goals, and should be designed to maximize their social and environmental benefits;
- Financial support to the institutions responsible for water governance and its implementation is necessary, as part of a fundamental strategy to materialize the various actions necessary for water security.

4.3 Education and Training for Integrated Water Resources Management (overarching theme)

- Water education and training are not expenses, but rather investments. Education, at all levels, is the key to implementing change. International partnerships to fill capacity gaps must be long-term and develop ongoing collaborative projects;
- It is necessary to translate the Science & Technology / Policy interface. Water-related policies need to consider this resource as an overarching element throughout the 2030 Agenda;
- The water sector must welcome new developments in IT and monitoring. It is necessary to understand technology as a facilitating instrument that is effective and capable of adapting to training needs. Identifying and implementing ICTs or sensor technology can make a difference;
- Accountability and integrity are essential to improving the water sector. This requires a significant increase in investments in the training of public bodies, managers, operators, and civil society organizations;
- International cooperation and capacity building are the main means to address the relationship between water and climate and share knowledge about innovative technologies;
- Modern legislation and regulations are essential in enabling professionals to carry out effective and responsive work;
- Capacity building at different levels is essential to adapt to new situations and reflections, from governments to traditional communities.

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6. Annex 1

Sessions and lectures considered in the analysis of the Water and Development theme

The complete analytical matrix of these sessions is available at the following link: <https://www.adasa.df.gov.br/publicacoes-da-adasa>

LOCAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
OS-TP-37	The IWA Principles for Water-Wise Cities	Stefan Reuter	BORDA (Bremen Overseas Research and Development Association)
OS-TP-37	Urban Water for Sustainable Development	Debarati Chakraborty	Centre for Built Environment
OS-TP-37	Transitioning Megacities to the Circular Economy: New Synergies Through the Megacities Alliance	Alexandra Lauriat	Siaap - Greater Paris Sanitation Authority
OS-TP-37	Performance contract cases in Brazil	Flávio Lemos	SUEZ
OS-TP-37	Effective and Sustainable Design for Water-Wise Cities: Case studies of Korea	Lee-Hyung Kim	Kongju National University
OS-TP-37	Delegation of "STBVs": A successful PPP model - Faecal Sludge Treatment Plant	Mouhamadou Gueye	Director of the Fecal Sludge Management Program - Dakar
OS-TP-40	Water in the circular economy - From consumer to producer	Carl-Emil Larsen	DANVA
OS-TP-41	Waters Reuse Safety in Singapore	Pang Chee Meng	Industry Development Director - PUB (Singapore's National Water Agency)
OS-TP-41	Recycling Waters - Aquapolo	Fernando Gomes da Silva	*Diretor da Aquapolo Ambiental*
OS-TP-41	50 Years of Direct Potable Reuse in Windhoek	Thomas Honer	General Manager - WinGoc
OS-TP-43	Water Recycling for Non-potable and Potable Purposes on Multiple Scales	Paula Kehoe	Director of Water Resources - City of San Francisco
OS-TP-25	Providing Energy for the Abandoned Communities of Togo: A case of Yikpa	ALUORA, Annette Luttah	*Jeunes Volontaires pour l'Environnement*
HLP-04	Water management in the State of São Paulo	Geraldo Alckmin	*Governador do Estado de São Paulo*
HLP-04	Water Crisis in Brazilia	Rodrigo Rollemberg	*Governador do Distrito Federal*

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LOCAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
OS-TP-77	Training is an investment - Capacity building for better water management	Claude Toutant	International Office for Water - IOWater and National Water Training Center - NWTC
OS-RP-10	Efficient use of water and the conversion of irrigation systems in Codevasf irrigation projects	Rodrigo Ribeiro Franco Vieira	*Codevasf*
OS-RP-10	Energy and Operational Efficiency in the Nile Coelho Irrigation District	Humberto Arrunátegui	*Gerente de Operação e Manutenção, Distrito de Irrigação Nilo Coelho*
OS-RP-10	Rational Use of Water in Rice Culture	João Izidoro Viégas	*Consultor Técnico da AUD*
OS-TP-61	The Water Route - Cordillera Apolobamba	Film	*Universidade Andina Nestor Caceres Velasquez*
OS-TP-62	Optimizing existing financial resources to enhance Water Services Sustainability	Jean-Luc Alexandre	Chief Operating Officer - Treatment Infrastructure, SUEZ
OS-TP-40	Integrated Urban Agriculture practices for resource recovery from Wastewater Management Case: Addis Ababa, Ethiopia	Tarekegn, Mekonnen Maschal	Ethiopian Civil Service University
OS-TP-32	Optimization in urban supply networks	Jordi J. Pastor	*Director para América del Sur del Grupo INCLAM*
OS-TP-59	Expanding access to financial resources to low-income areas around cities.	Richard Thorsten	water.org
OS-RP-62	Infrastructure for Water Security Assurance: Scenarios, Challenges and Perspectives	Cássio Ramos Peixoto	*Secretário de Infraestrutura Hídrica e Saneamento – Bahia*

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NATIONAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
OS-TP-37	Project to strengthen the National Strategy for Integrated Risk Management in Natural Disasters	Film / Celso Oliveira	*Ministério das Cidades*
OS-TP-37	Financing water for sustainable cities	Hannah Leckie	The Organisation for Economic Co-operation and Development (OECD)
OS-TP-62	Investments Financing and Sustainability of Water Services in Portugal: Aguas de Portugal role and achievements.	Alexandra Serra	*Membro do Conselho Executivo da Águas de Portugal Internacional SA e Presidente da Parceria Portuguesa para a Water Partnership*
OS-TP-40	Urban Storm & Sponges Cities in China	Yongnan Zhu	China Institute of Water Resources and Hydropower Research (IWHR)
OS-TP-41	WATER REUSE IN SPAIN – REGULATION AND EXPERIENCE	Concepción Marcuello	Deputy Director for Planning and Sustainable Water Use - Ministry of Agriculture and Fisheries, Food and Environment
OS-TP-41	Wastewater reuse in Bolivia: Policies and pilot projects	Martin LEMENAGER	French Development Agency - AFD
OS-TP-43	Water Reuse in Japan	Hiromasa Yamashita	National Institute for Land and Infrastructure Management (NILIM)
OS-TP-43	Policy Proposal for the reuse of treated sanitary effluent in Brazil – Technological aspects	Ernani Ciríaco de Miranda	*Ministério das Cidades*
SS-TP-10	Abstract "Efficient use of surface and groundwater – urban and rural environments"	Maria Eugênia	*Itaipu Binacional*
SS-TP-10	Abstract "Inclusive and sustainable growth, responsible water management, and the industry"	Marlos de Souza	Food and Agriculture Organization - FAO
HLP-04	Water Crises in Brazil	Ministro Helder Barbalho	*Ministro de Estado da Integração Nacional*
OS-RP-10	Irrigated Agriculture in Brazil	Demetrios Christofidis	*Ministério do Meio Ambiente*
OS-RP-32	Water for Food Security and Rural Development in the Americas - Current Issues, Opportunities, Actions and Experiences in Brazil.	Gertjan Beekman	Inter-American Institute for Cooperation on Agriculture - IICA
OS-RP-32	Managing for the future: sharing experiences to collectively work towards climate change resilience	Erin Raser	Inter-American Institute for Cooperation on Agriculture - IICA

NATIONAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
OS-RP-32	*PROGRAMA ÁGUA DOCE*: Empowering Brazilian Northeast Rural Communities to Desalinated Drinking Water Access	RENATO SARAIVA FERREIRA	*Ministério do Meio Ambiente*
OS-RP-32	Corporate water stewardship: reducing impacts on water and managing risks - Colombia, Peru and Chile	Diana Rojas Orjuela	Global Programme Water and the Swiss Agency for Development and Cooperation (SDC)
OS-TP-31	Surface and Groundwater Integrated Management and Governance	Oscar Escolero	Instituto de Geología - Universidad Nacional Autónoma de México
OS-TP-60	My story of the Swiss Bluetec Bridge	Violette Ruppanner	Swiss Bluetec Bridge
OS-TP-60	View of market-based mechanisms and policies in the United States and the role of the federal government in managing economic and biophysical risks.	Christopher Hartley	United States Department of Agriculture (USDA)
OS-RP-08	A (very preliminary) approach to the Water-Food-Energy Nexus in arid and semiarid regions in Spain	Manuel Menendez	Ministry of Environment - Spain
OS-RP-08	Columbia Basin Project and Yakima Project Water-Food-Energy Nexus in Washington State, USA	Wendy Cristensen -	Yakima River Basin Water Enhancement Project Manager and the U.S. Department of the Interior
OS-RP-08	São Francisco River Water Transfer Project and Energy: Challenges and Opportunities	Claudir Afonso Costa	*Ministério da Integração Regional do Brasil*
OS-RP-08	A future vision for multipurpose reservoirs - the importance of users and regulation	Igor Ribeiro -	*Ministério das Minas e Energia do Brasil*
OS-TP-61	Financing Water Governance	Céline GILQUIN	French Development Agency - AFD
OS-TP-30	Focusing on Korea's Experience on Water Allocation System: Progress & Challenges	Ju Hee Jeung	K-water
OS-TP-30	Comparative multiple case study of international experiences with water markets	Layla Lambiasi	*Fundação Getulio Vargas (FGV)*
OS-TP-30	Water Allocations Demand Management and Water Availability - Australian Perspective	Stefanie Schulte	New South Wales Irrigation´s Concil - NSWIC
OS-TP-32	Small Businesses in the Brazilian Economy - SEBRAE	Suênia Souza	*Gerente do Centro de Sustentabilidade do Serviço Brazileiro de Apoio à Micro e Pequena Empresa - SEBRAE*

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NATIONAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
OS-TP-32	ITAIPU and the territorial development	Newton Kaminski	*Diretor de Coordenação Itaipu Binacional*
OS-TP-59	Regulatory framework for risk reduction.	Percy Soares Neto	*Confederação Nacional da Industria do Brasil*
OS-TP-59	Every drop of water has to find its way to consumers.	Film	UNDP's GOAL WASH Programme
OS-TP-50	Why Invest in Natural Infrastructure: Engineering a 21st Century Approach to Human Water Security	Charles J. Vörösmarty	Water Future, Brisbane
OS-TP-50	The experience of the PCJ Watershed Committee Policy in the context of prioritizing programs and actions for investments	João José Assumpção de Abreu Demarchi	PCJ Committee
OS-TP-50	Socio-Economic Benefits of Natural Infrastructure – Ansan Artificial Wetland	Munhyun RYU	K-water Convergence Institute
OS-TP-53	Water producer program	Devanir Garcia dos Santos	*Coordenador de Implementação de Projetos Indutores*
OS-TP-53	Farming for ecosystem services: can farmers save rivers and still make a profit?	Jorge Werneck Lima	*Embrapa / ADASA*
OS-RP-13	Crisis Management: Strategies for river basins in Malaysia	Abdullah Isnin	
OS-RP-13	Water Crisis in Southeast Brazil – recent events	Joaquim Gondim	*Agência Nacional de Águas – ANA*
OS-RP-09	Water Crisis in Southeast Brazil – recent events	Joaquim Gondim	*Agência Nacional de Águas – ANA*
OS-RP-09	Water and Energy During Crises: Brazilian and French Experiences - "Management of water scarcity in the Durance and Verdon river basins (Provence, France) and shared experiences with Brazil"	Nicolas Bourlon	Project Manager for Latin America – International Office for Water (IOWater)
OS-TP-09	Water utilities - moving towards carbon neutrality: Planning locally, impacting globally	Astrid Michels	GIZ
OS-RP-62	The Brazilian Semi-Arid	Angelo José de Negreiros Guerra	*Diretor-Geral do DNOCS*
OS-RP-62	National Water Security Plan – strategic water infrastructure to Brazil	Sérgio Rodrigues Ayrimoraes Soares	*Agência Nacional de Águas – ANA*
OS-RP-62	Infrastructure for Water Security Assurance-Scenarios, Challenges And Perspectives	Liana Ardiles López	Ministry of Agriculture and Fisheries, Food and Environment (MAPAMA)

GLOBAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
OS-TP-40	Circular Economy Approach to Water Treatment and Stakeholder Engagement	Carolina Zoccoli	*Especialista Ambiental, Federação das Indústrias do Estado do Rio de Janeiro*
OS-TP-40	Water in the circular economy - From consumer to producer	Carl-Emil Larsen	DANVA
OS-TP-40	Circular Economy Approach to Water Treatment and Stakeholder Engagement	Juan Francisco Ciriza Santero	
OS-TP-41	Water Reuse: “Making Every Drop Count”	Miguel Angel SANZ	President of IDA and Director of Strategic Development of SUEZ
OS-TP-43	Water Reuse in Japan	Hiromasa Yamashita	National Institute for Land and Infrastructure Management (NILIM)
SS-TP-10	Abstract "Water and Energy"	Michael E. Campana	American Water Resources Association
SS-TP-10	Abstract "Infrastructure for sustainable management of water resources and service provision"	Cristine Smith and Elisa Marques	United States Department for Interior and *Departamento Municipal de Habitação de Porto Alegre*
SS-TP-10	Summary "Water and Food"	Christopher Neale	University of Nebraska
OS-TP-25	Thirsty Energy - A World Bank Initiative - “Optimizing the water-energy production value chain”	Diego Rodriguez	World Bank
OS-TP-77	Education and training on water are not costs but investments	Eric Tardieu / General Secretary	International Network of Water Training Centers
OS-TP-77	Education and training on water are not costs but investments	Carlos Hiroo Saito	University of Brazilia
OS-TP-77	Education and training on water are not costs but investments	Susanne Reitsma	Global Youth Hub for Water
OS-TP-77	Education and training on water are not costs but investments	Jean Antoine Faby	Director of the Water for All Chair at ParisTech
OS-TP-77	Education and training on water are not costs but investments	Pierre Victoria	Senior Vice-President for Sustainable Development at Veolia
OS-TP-77	Education and training on water are not costs but investments	Paulo Salles	*Presidente da ADASA*
PP-NG-07	High-level ministerial roundtable: Financing	Osward Chanda, Ramón Jiménez and Pio Wennubst	African Development Bank, Minister of Public Works and Communications (Paraguay), State Secretary for Foreign Business (Switzerland)
SS-SFG-02	Business Water Day	Percy Soares Neto	*Confederação Nacional da Insdustria – CNI*

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GLOBAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
OS-TP-60	Sustainable market-based mechanisms and national-regional economics and financing: Why microlending for water and sanitation is a good bet	Lesley Pories	Senior Analyst
OS-TP-45	One System Does Not Fit All! Navigating the Cost for Urban Water Management	Fabio Pereira de Carvalho	Dow Chemical
OS-TP-61	Water Governance: Is it possible to actually Finance it?	Corinne Cathala	Inter-American Development Bank (IADB)
OS-TP-61	Civil society engagement and financing accountability: lessons from South Asia	Snehalatha Mekala	Freshwater Action Network South Asia (FANSA)
OS-TP-62	Towards the Green Coast: Case of Slovenia	Filme	EUSAIR: EU Strategy for the Adriatic and Ionian Region
OS-TP-32	Efficient use of water as a development inductor	Koji Naito	Expert of JICA - Japan International Cooperation Agency
OS-TP-32	Monitoring Land and Water Productivity in Agriculture by Remote Sensing	Jippe Hoogeveen	Food and Agriculture Organization - FAO
OS-TP-50	Financing Natural & Engineered Water Solutions:The growing investment opportunity	Suzanne Ozment	World Resources Institute - WRI
OS-TP-50	Nature-based solutions for wastewater management	Suzanne Ozment	World Resources Institute - WRI
OS-TP-53	Farming and Ecosystem Services: Can farmers save rivers and still make a profit?	Felix Reinders	President of the International Commission on Irrigation & Drainagee (ICID)
OS-TP-53	Farming and Ecosystem Services: Can farmers save rivers and still make a profit?	Adriana Niemeyer Pires Ferreira	Volunteer rapporteur of the 8th World Water Forum
OS-RP-13	Disaster preparedness - Field drill for earthquake response in Asia	Tadashige Kawasaki	Network of Asian River Basin Organizations (NARBO)
OS-RP-13	Crisis Management: Watershed Strategies in the Americas and Asia-Pacific.	Volunteer rappourter: Ana Costa Marques Machado / Session coordinator: Ney Maranhão	*Diretor da Agência Nacional de Águas do Brasil*
OS-RP-01	Water Security and Climate Resilience for Africa's Sustainable Development – Climate Investment Planning at River Basin Level: Experiences from the Orange Senqu River Commission	Lenka Thamae	Orasecom

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GLOBAL SCALE

SESSION	PRESENTATION SUBJECT	SPEAKER	INSTITUTION
PP-NG-04	High Level Ministerial Roundtable - "Development"	Political Process Leader - Reinaldo Salgado	*Ministério das Relações Internacionais - Itamaraty*
PP-NG-05	High Level Ministerial Roundtable - "Urban"	Political Process Leader - Reinaldo Salgado	*Ministério das Relações Internacionais - Itamaraty*
SS-TP-11	Closing session of the Urban theme		
OS-TP-77	Panel: Education and training in water are not expenses, they are investments	Dinara R. Ziganshina	Scientific Information Center of Interstate Commission for Water Coordination in Central Asia

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