WATER GUIDANCE NOTE

Wastewater? From Waste to Resource in a Circular Economy Context

Latin America and the Caribbean Region

Insights for World Water Week 2019

The World Bank with contributions from the CAF - Development Bank of Latin America, is promoting a paradigm shift in the sector, moving away from considering wastewater as a waste and recognizing its inherent value. Through the initiative "Wastewater: from Waste to Resource," the World Bank is raising awareness among decision makers regarding the potential of wastewater as a resource.

Source: Acciona

WORLD BANK GROUP

GWSP
GLOBAL WATER SECURITY & SANITATION PARTNERSHIP

In a world where demands for freshwater are continuously growing, and where limited water resources are increasingly stressed by over-abstraction, pollution and climate change, neglecting the opportunities arising from improved wastewater management is nothing less than unthinkable in the context of a circular economy.

– UN World Water Development Report (WWAP 2017)

The World Bank with contributions from the CAF - Development Bank of Latin America, is promoting a paradigm shift, moving away from considering wastewater as a waste and recognizing its inherent value. To kick start the joint effort, an event was co-organized at the World Water Forum (WWF) 2018 in Brasilia promoting dialogue among governments, international organizations, and the private sector.

As a result, the World Bank launched an initiative "Wastewater: from Waste to Resource," focusing on the Latin America and the Caribbean (LAC) region, to raise awareness among decision makers regarding the potential of wastewater as a resource. The initiative has involved a participatory process, including multiple consultations and workshops with key stakeholders working on wastewater management projects in the LAC region. The main report of the initiative *From Waste to Resource. Shifting paradigms for smarter wastewater interventions in Latin America and the Caribbean* contains the findings from case studies[1] and technical reports developed by the initiative as well as from the feedback received during the workshops and seminars. The purpose of the initiative is to encourage a paradigm shift in the sector, recognizing the new value proposition of wastewater and its potential in a circular economy context.

CAF - Development Bank of Latin America, as a partner of the World Bank in the initiative "Wastewater: from Waste to Resource", has analyzed and evaluated the institutional, regulatory and financial challenges in the region to achieve the SDG 6.3. Success cases in the region have been studied to show the potential of the circular economy approach and innovative financial instruments to ensure the sustainability of wastewater management projects. CAF is also working on the development of a conceptualization guide for wastewater treatment projects, promoting the vision of water basin and the circular economy approach.

As part of this collaboration, both organizations have co-organized sessions with key stakeholders at the World Water Forum and Latinosan, to encourage the water community to move towards a circular economy model.

This joint note summarizes the main findings of this collaborative work.

A Growing Global Challenge

Population and economic growth have driven a rapid rise in demand for water resources (WWAP 2015). Competing demands for water are adding pressure to the allocation of freshwater resources. Governments around the world face an array of water policy options for managing structural water scarcity, droughts, and floods; improve water quality; and protect ecosystems and their services. Careful planning promotes long-term water security and resilience to climatic and nonclimatic uncertainties. Water, importantly, connects to wider policy goals of mitigating poverty and ensuring social equity, public health, and macroeconomic performance, among others.

Rapid urbanization, especially in low- and middle-income countries, has created a host of water-related challenges. These include degraded water quality and inadequate water and sanitation infrastructure, particularly in expanding peri-urban and informal settlements. As cities continue to grow rapidly, and climate change impacts water resources' availability and distribution, it will become increasingly difficult and energy intensive to meet the water demands of populations and economies. Combined, these problems present a challenge for policy makers and municipalities in providing services to their citizens; ensuring that there are enough resources such as food, water, and energy; and protecting public health—all while protecting the environment. In this context, wastewater becomes a valuable resource from which water, energy, and nutrients can be extracted to help meet the population demands for water, energy, and food (WWAP 2017).

Wastewater can be treated up to different qualities, to satisfy the demand from different sectors, including industry and agriculture. It can be processed to promote environmental health, to be reused in irrigation or even to be reused as drinking water. Wastewater treatment is one

solution to the water scarcity issue, and also to the problem of water security, freeing water resources for other uses or for preservation. The diversification of water supply sources is critical for enhanced security and resilience and may be considered a key factor when estimating water balances. Meanwhile, the by-products of wastewater treatment can become valuable for agriculture and energy generation, making wastewater treatment plants more environmentally and financially sustainable. Treating wastewater as a valuable resource can contribute to the sanitation and major economic sectors in the region.

The Sanitation Sector in Latin America and the Caribbean: A Call for a New Vision

Population and Sanitation Coverage

In 2017, the population of Latin America and the Caribbean (LAC)[2] reached 644 million, 80 percent of which lived in urban areas. Between 2012 and 2017, the population increased by around 34 million, or by approximately 5.4 percent. During the same period, rural communities' population dropped by 1 percent (WDI 2019). According to the 2018 Revision of World Urbanization Prospects (UNDESA 2018), by 2030, the total population in the region will be 718 million, with an urban concentration of 84 percent.

Regarding access to water supply and sanitation, historically, countries in LAC have prioritized investments in water supply, achieving good coverage in the past years. According to WHO/UNICEF (2019) data of 2017, around 97 percent of households had access to an improved source of drinking water, although this average hides the gap between rural (88 percent) and urban (99 percent) coverage and does not reflect the sustainability and quality of the level of service. The share of the population with access to safety managed water services was only 74 percent. About 87 percent of the region's population had access to some form of basic sanitation, with an important difference between rural (70 percent) and urban (91 percent) areas. However, only 31 percent had access to safely managed sanitation services.[3] Moreover, it is estimated that only about 66 percent of the population is connected to a sewage system (18 percent in rural and 77 percent in urban areas) and only about 30–40 percent of the region's wastewater that is collected is treated (FAO 2017) - this value, however, does not reflect the quality of the discharged water or whether it complies with the regulation. This is surprisingly low, given the region's levels of income and urbanization, and has significant implications for public health, environmental sustainability, and social equity. In comparison, in the countries of the Organisation for Economic Co-operation and Development (OECD), 81 percent of the population is connected to a sewage system and 77 percent of people benefit from wastewater treatment by being connected to a wastewater treatment plant (WWTP) (OECD 2017). As shown in Figure 1, wastewater management and treatment levels vary significantly across LAC countries, and regional averages mask this significant variation.

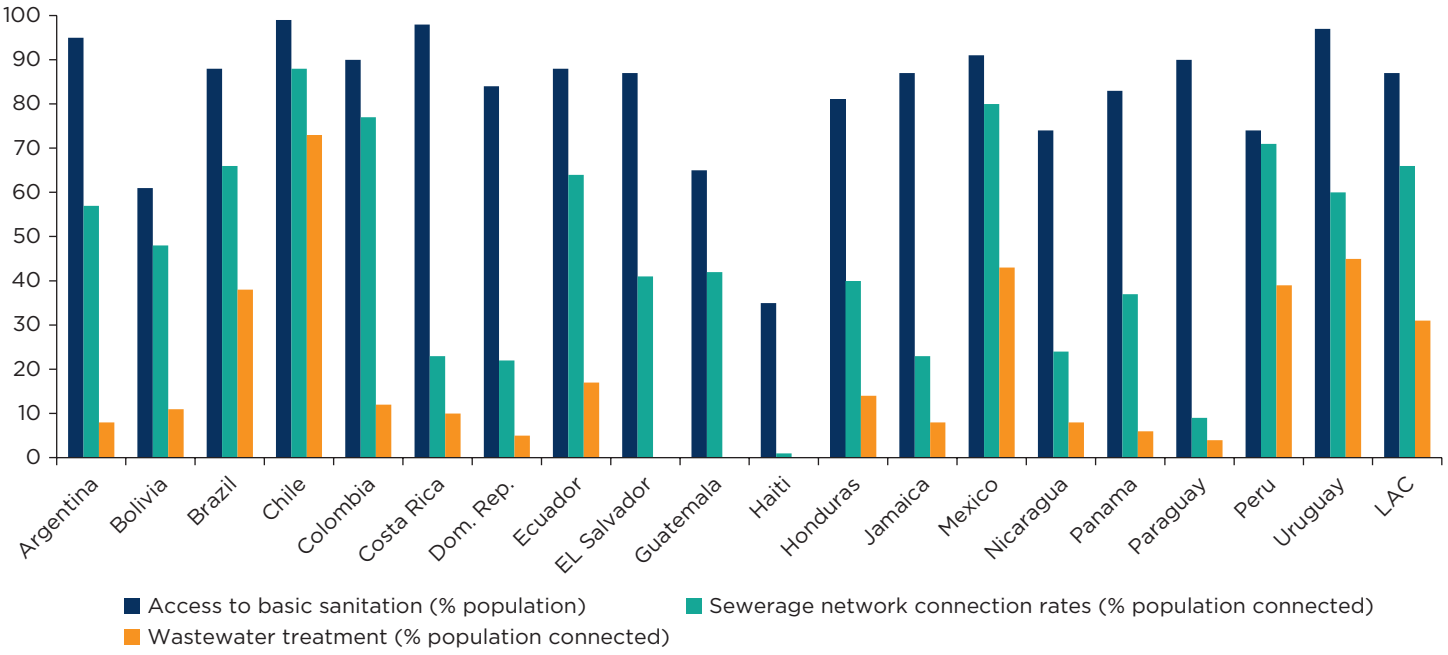
According to the CAF study (2018) on the current status of Wastewater Treatment in Latin America, the total annual flow of treated urban effluent is 390 m3/s, from which an estimated of 67 m^3/s were being reused (mainly concentrated in Mexico and Brazil).

The Potential for Better Investment

To reach universal coverage of basic and safety managed sanitation services by 2030, the region will have to reach a total of 307 million of as-yet-unserved people.[4] Hutton and Varughese (2016) estimated that the level of investment in the LAC region (excluding Chile, Uruguay, and most of the Caribbean countries) needed to meet the UN Sustainable Development Goals (SDGs) for sanitation ranged between $3.4 and $11.8 billion per year for the period 2016–30, of which approximately 95 percent would be devoted to urban areas. It is worth noting the challenge added by SDG target 6.3: "by 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally."

The investment needs in the sector are important, and to improve the wastewater situation in the region, countries are indeed embarking on massive programs to collect and treat wastewater. There is a huge opportunity to ensure that these investments are made in the most sustainable and efficient way possible. As lessons learned in LAC and other regions indicate, investment in technology alone will not guarantee meeting the SDGs. There is a need in the region to invest better. Efficiently investing in wastewater and other sanitation infrastructure to achieve public health benefits and environmental objectives, and to enhance the quality of urban life, is a major challenge for the region. As stated by a recent World Bank report (2017) on infrastructure in Latin America: "dismal wastewater performance is a real emergency, and one that epitomizes the potential for

FIGURE 1. Access to Sanitation Services in Selected Lac Countries, 2017



Source: WHO/UNICEF 2019.
Note: LAC = Latin America and the Caribbean. Data for Argentina is from WHO/UNICEF 2017.

spending better." As described in this summary note, the revalorization of wastewater as part of a circular economy process can contribute to an improved investment efficiency.

The Opportunities Presented by Circular Economy Principles

Wastewater: An As-Yet-Untapped Resource

The challenges mentioned above present an opportunity to plan and invest in sanitation services—and, in particular, the processing of wastewater—in a new way. The long-standing, linear approach of abstracting freshwater from a surface or groundwater source, treating it, using it, collecting it, and disposing of it is not sustainable anymore.

Future urban development requires demand approaches and focus on resource recovery under circular economy principles (Box 1). At its core, a circular economy aims to design out waste to achieve sustainability. Waste does not exist; products are designed and optimized for a cycle of disassembly and reuse. In line with this, wastewater should not be considered a "waste" anymore, but a resource.

However, in most LAC countries, sanitation and wastewater treatment services are still thought out and planned in a linear way. Furthermore, very often water supply is planned first, sewerage systems are planned next, and energy inputs for both are sometimes only considered once the systems have been designed and constructed. In order to change how institutions approach wastewater, a paradigm shift is required in the region. Wastewater should not be seen as a burden to governments and society, but as an economic opportunity that can be turned into a valuable resource (Figure 2).

One of the key advantages of adopting circular economy principles in the processing of wastewater is that resource recovery and reuse could transform sanitation from a costly service to a self-sustaining and value-adding system.

Improved wastewater management offers a double-value proposition: in addition to the environmental and health benefits of wastewater treatment, financial returns that partially or fully cover operation and maintenance (O&M) costs are possible. Resource recovery from these facilities in the form of energy, reusable water, biosolids, and other resources (such as nutrients and microplastics) represent an economic and financial benefit that contributes to the sustainability of these systems and the water utilities operating them.

BOX 1. The Principles of a Circular Economy

The A circular economy is an industrial system that is restorative or regenerative by intention and design. It is an economic system aimed at minimizing waste and making the most of resources. The traditional approach is based on a linear economy with a "make, use, and dispose" model of production. The circular economy approach replaces the end-of-life concept with restoration, shifts toward the use of renewable energy, eliminates the use of toxic chemicals which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems, and business models. Such an economy is based on three main principles: (i) design out waste and pollution; (ii) keep products and materials in use; and (iii) regenerate natural systems.

Sources: Ellen MacArthur Foundation undated; WEF 2014.

For example, WWTPs can, among other innovative solutions:

- Dispose of biosolids at no cost as in the case of Cusco, Peru (World Bank 2019) and Brazil (Box 3).
- Generate energy for self-consumption, save energy costs, or generate revenues by selling energy as in the case of Atotonilco, Mexico (World Bank 2018) Santiago, Chile (World Bank 2019) and Ridgewood, United States (Box 4).
- Sell recovered phosphorous for fertilizer as in the case of Chicago, United States (ASCE 2013).
- Sell treated water for reuse to industry and potentially cover all O&M costs as in the case of San Luis Potosi, Mexico (Box 5) and Durban, South Africa (Box 7)
- Partner with the private sector to cover capital and operating costs completely as in the case of Cerro Verde (Box 6).

Cost-saving and environmental considerations are among the main reasons to consider resource recovery and to incorporate circular economy principles in WWTPs in LAC and elsewhere in the world. The challenge remains one of scaling up the successful experiences and projects.

Fostering these new business models with extra revenue streams would in turn attract the private sector to close the funding gap. The private sector is often reluctant to invest in the sanitation sector given the low return on investment and the high risks. There is a need for an enabling environment that fosters business models that promote shifting from waste to resource and that enables private investment in infrastructure in tandem with improved efficiency in public financing to promote sustainable service delivery, especially in the poorest countries.

This new approach is also necessary to achieve the SDGs, which are adding a new dimension to the challenges in the sector by considering sustainability. The SDGs focus not only on the provision of sanitation services but also on improving water quality, implementing integrated water resource management, improving water use efficiency across sectors, reducing the number of people suffering from water scarcity, and restoring water-related ecosystems, among several relevant targets. Sustainable wastewater treatment and management will be crucial to achieve SDG 6, and can also contribute toward meeting several other goals. For example, electricity generation in wastewater treatment plants, using the biogas produced, can contribute toward SDG 7 (regarding energy) and SDG 13 (climate action); treating wastewater and restoring watersheds also contributes to SDG 3 (good health and well-being), SDG 11 (sustainable cities), and SDG 14 (life below water), among others.

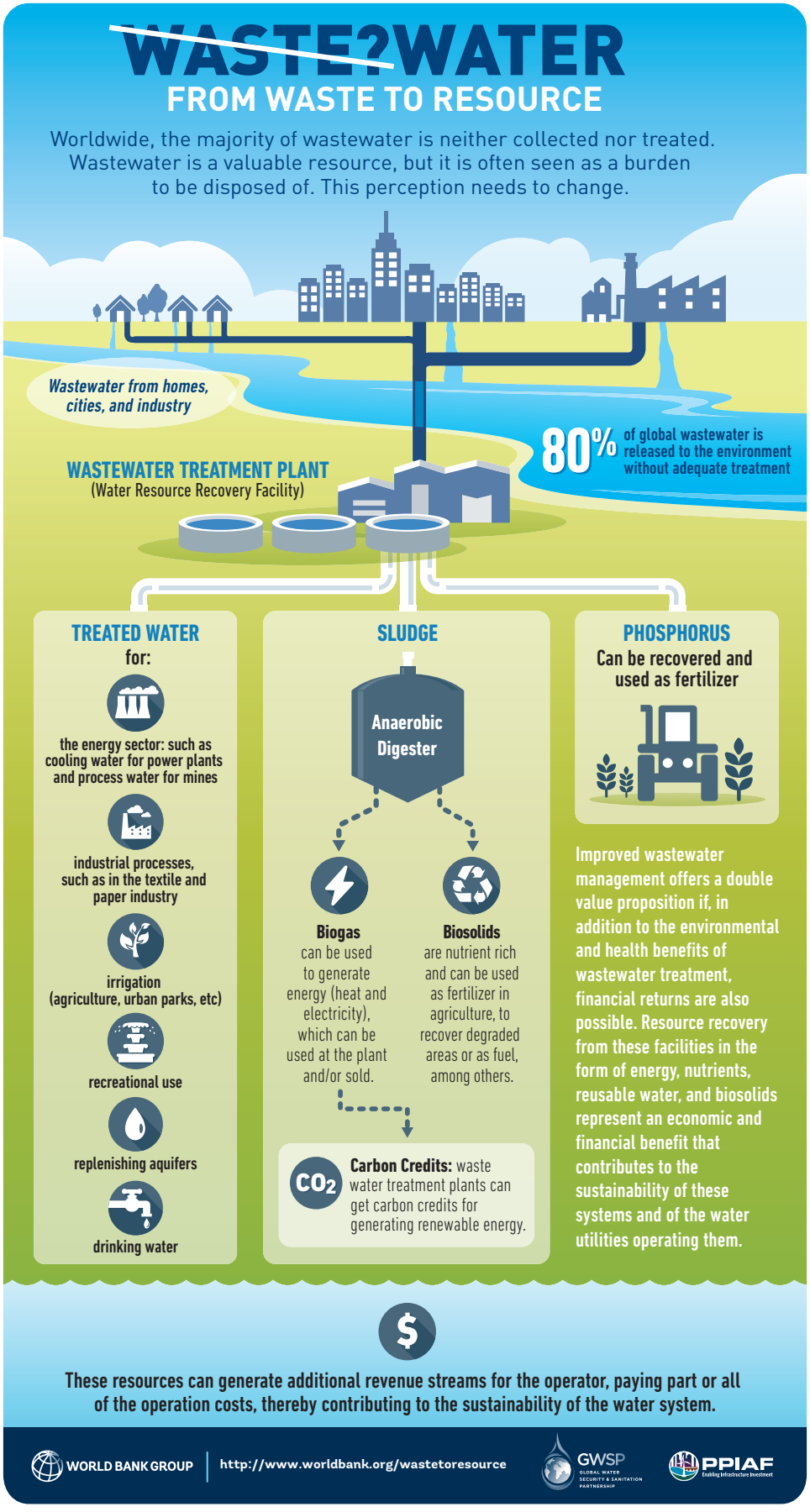
Resource Recovery is not New: Why hasn't this Approach Caught up in the Region?

Numerous challenges—institutional, economic, regulatory, social, and technological—will need to be overcome to achieve the needed paradigm shift:

Institutional

Knowledge gap and lack of political will. There is a general lack of understanding regarding the concept of water resource recovery and how to implement it in practice. Wastewater is still considered a hinderance or a substance to be dealt with and disposed of, rather than a resource. This results in a lack of political will in developing policies

FIGURE 2. Resource Recovery in Wastewater Treatment Plants



and regulations that support and incentivize wastewater reuse and resource recovery.

Weak long-term and mid-term planning. Pressure on increasing water, sanitation and hygiene (WASH) service coverage has postponed focus on long-term and mid-term planning. As a result, master plans and feasibility studies are usually outdated and there is a generalized lack of final designs for infrastructure. This situation delays the implementation of projects according to the investment needs.

Lack of coordination across institutions, regulations and sectors. In most countries in the region, regulations in the water sector are not aligned with the energy, health, industrial (including mining), and agriculture sectors, and therefore limit resource recovery and reuse from wastewater (energy, irrigation water, nutrients, preservation, etc.). Moreover, responsibilities for the provision of wastewater services are often fragmented across different levels of governments. The national government sets policies and targets, while service provision, including investment, O&M, and monitoring, is usually delegated to municipal governments, which in many cases lack the technical and financial capacities to adequately provide services (Trémolet 2011). There is also a lack of coordination between water resource management institutions and those responsible for sanitation service delivery. As a result, sanitation plans are usually not incorporated in river basin planning efforts, leading to inefficient and costly systems.

Economic

Water is undervalued. Unless water resources are properly valued, it will be difficult to promote resource recovery initiatives. The lack of value for water also leads to improper pricing of water resources and water services, which is also a deterrent for resource recovery projects. For example, if industries pay a very low fee to withdraw freshwater, they have limited incentives to pay for treated wastewater unless there is a significant short-term water shortage or long-term water scarcity resulting in very low freshwater availability.

Excessive emphasis on promoting and financing new infrastructure, without sufficiently considering the life-cycle of a plant or sustainability of the system (e.g., coverage of O&M costs) and without evaluating the real capacity of existing infrastructure and maximizing its use.

Reliance on conventional/public financing of WWTPs without taking advantage of market conditions and incentives to enhance sustainability. There is a need for innovative financing mechanisms that can encourage the development of and investment in wastewater systems to promote the sustainability of operations and also the health of local ecosystems.

Regulatory

Current regulatory standards are often too restrictive and/or inconsistent. Countries adopt internationally accepted regulatory standards for water quality that are not tailored to the specific needs of the country. Often regulations are designed without considering the financial implications of their implementation (especially their operation costs). More flexible standards that can be introduced gradually and that are suited to the objective of wastewater investment, will encourage innovative solutions needed to provide wastewater services as well as create value from water reuse and resource recovery.

Lack of adequate control over industrial discharge. Inadequate legislation, enforcement, regulation, and/or monitoring of industrial discharge mean that excessive pollutants are released untreated into the environment or left to an already overburdened WWTP. In the case of the direct release of untreated industrial discharge into receiving water bodies, the result is deterioration in water quality, with all its economic, social, and environmental implications. Where the effluents are left to the WWTP, customers end up paying with their tariffs for industrial treatment.

Lack of regulatory frameworks and guidelines for water reuse, beneficial use of biosolids, and energy generation in WWTPs. In the LAC region there are even regulations that limit or forbid resource recovery at WWTPs. For instance, in some countries, the reuse of wastewater might be permitted only for a specific set of activities, such as restricted irrigation, or the use of biosolids might be forbidden in the agriculture sector. There is a need for clear regulations and guidelines to ensure the safe use of human-waste-derived products and to widen the market potential. Moreover, a lack of regulation on the pricing of resources recovered from wastewater deters utilities and the private sector from investing in resource recovery projects due to uncertainty regarding the return on their investment. There is a need for new regulatory mechanisms that allow the clear and fair pricing of reclaimed water, biosolids, and energy.

Lack of incentives for wastewater reuse and resource recovery. There is a need for new regulatory mechanisms that specifically provide incentives to all stakeholders to consider wastewater systems as resource recovery facilities. There is also a lack of incentives for water utilities to innovate and recover resources from wastewater, given that in many countries the benefits and extra revenue reaped from those interventions would go only toward tariff reduction. The existence of perverse incentives such as the low price of freshwater abstraction is also a barrier to resource recovery initiatives.

Social

Negative perceptions of reclaimed water and reuse products. A major challenge to the development of the resource recovery market is the low social acceptance of the use of recycled products from human waste. Also, among farmers already using untreated wastewater, many are against treating it because they have the perception that wastewater nutrients will be removed and that their crop yield will diminish. Public awareness and education campaigns are needed to build trust and change negative perceptions.

Technological

Technology selection criteria biased toward expensive technologies without considering all potential possibilities that better suit the local conditions.

Countries still focus in the development of water infrastructure rather than on the service provision. Issues such as the quality of the receiving water body, sludge management, operational costs and technical capacities are usually not taken into account to select the most suitable technology, which results in unsustainable services.

What Must be Done to Overcome these Challenges and Achieve the Needed Paradigm Shift?

In order to achieve a paradigm shift in the sector, and based on the case studies analyzed, the workshops with key stakeholders and the lessons learnt in the LAC region, four key actions have been identified at different levels. First, at the country or regional level, wastewater initiatives need to be planned within a river basin framework to ensure that the most cost-optimal and sustainable solution is achieved. Second, there is a need to build the utility of the future by moving from the concept of WWTP to one of water resource recovery facility. Then, at the country level, develop the right Policy, Institutional and Regulatory Frameworks that will help promote the paradigm shift. Finally, at the project level, design and operate WWTPs in an efficient and effective way, considering resource recovery opportunities and exploring innovative financing and business models that leverage the circular economy principles.

Action 1. Develop Wastewater Initiatives as Part of a Basin Planning Framework to Maximize Benefits, Improve Efficiency and Resource Allocation, and Engage Stakeholders

There is the need to move from ad hoc and isolated wastewater solutions, such as one treatment plant per municipality, to integrated river basin planning approaches that yield more sustainable and resilient systems. Basin planning is a coordinating framework for water resources management that focuses public and private sector efforts to address the highest-priority problems within hydrologically defined geographic areas, taking into consideration all sources of water. By planning and analyzing water quality and quantity at the basin level, integrated solutions that are more financially, socially, economically, and environmentally sustainable are possible. Basin planning allows the identification of the optimal deployment of facilities and sanitation programs, including the location, timing, and phasing of treatment infrastructure (See Box 2). It also enables decision makers to set priorities for investment planning and action. The basin planning framework also allows the design of effluent standards to consider improvements to a specific receiving water body instead of uniform or arbitrary water pollution control standards, allowing for more efficient investments. Basin planning is, therefore, an iterative process that allows decision makers to move from the traditional approach of being reactive to a serious environmental problem to a proactive approach of managing available resources in any given basin through a structured, gradual process. Moreover, by including wastewater in the hydrological system as a potential water source, it is possible to account and plan for wastewater reuse. This shift must be reflected in the water policy framework.

Action 2. Build the Utility of the Future: Move from the Concept of WWTPS to One of Water Resource Recovery Facilities, Realizing Wastewater's Value

The practice of wastewater treatment continues to evolve, not only technologically but functionally as well. Traditionally, treatment is focused on removing contaminants and pathogens to recover water and safely

BOX 2. The Use of a River Basin Approach to Plan Wastewater Treatment Promotes More Efficient Outcome and Reduces Investment Needs

The municipality of Guayaquil, Ecuador, has promoted the creation of a water fund (Fondo de Agua) to clean and preserve the Daule River Basin (Santos, undated). The action plan includes monitoring and control of water quality, treatment of wastewater, erosion and sediment control, and reforestation, among other actions. The municipality has also developed an integrated plan for wastewater management that includes a hydraulic modelling of the receiving waterbody (Daule Basin) to understand its characteristics and assess the needed level of treatment to meet the existing regulation. The modelling showed that the treatment needed in the wastewater treatment plants to be built was lower than initially designed for since the waterbody had a higher capacity of absorption than thought. This resulted in the more efficient and effective investment in wastewater treatment plants.

BOX 3. The Beneficial Use of Biosolids in Agriculture Leads to Higher Crop Yields and at the Same Time Saves Significant Transport and Landfill Costs for the Water Utility

For several years, the Companhia de Saneamento Ambiental do Distrito Federal (CAESB), the water and wastewater utility of Brazil's capital district, has been reusing biosolids from its wastewater treatment plant operations to recover degraded areas in its railway operation areas (*patios ferroviarios*) and in agriculture. The effects on corn production of using biosolids as compared with a mineral fertilizer mixture consisting of equivalent amounts of nitrogen, phosphorus, and potassium, were evaluated in a series of studies in Brazil (Lemainski and da Silva 2006a). All grain yields were higher than average for Brazilian standards for corn. The biosolids were on average 21 percent more efficient than mineral fertilizers. Similar studies performed on soybeans have shown that biosolids were, on average, 18 percent more efficient than mineral fertilizers.

Source: Lemainski and da Silva 2006a, 2006b.

discharge it to the environment. Today, WWTPs should be considered water resource recovery facilities (WRRFs) (NSF, DOE, and EPA 2015). This comes with the realization that many components in wastewater can be recovered for beneficial purposes (see Box 3), starting with the water itself (for agriculture, the environment, industry, and even human consumption), followed by nutrients (nitrogen and phosphorus) and energy generation. These resources can generate revenue streams for the utility that would potentially transform the sector, from a heavily subsidized one to one that generates revenues and is self-sustained (see Box 4).

To move toward the ideal utility of the future, first utilities have to be properly run and perform adequately. Second, treatment facilities need to be designed, planned, managed, and operated effectively and efficiently, taking the basin as the unit of analysis. Finally, countries need to recognize the real value of wastewater and the potential resources that can be extracted from it, incorporating resource recovery and circular economy principles in their strategy and investment planning and infrastructure design, moving forward. Infrastructure is a long-term investment that can lock in countries into inefficient and unsustainable solutions. This highlights the importance of having resource recovery in mind when planning for wastewater investments.

Action 3. Explore and Support the Development of Innovative Financing and Sustainable Business Models in the Sector

Financing sanitation infrastructure and recovering associated costs pose a challenge throughout the region. Many utilities do not collect adequate sanitation tariffs to cover the costs of O&M, not to mention capital investment

BOX 4. The Village of Ridgewood Leveraged the Potential of Resource Recovery, Attracting the Private Sector to Fully Finance the Retrofitting of their WWTP for Co-Digestion Under a PPP Agreement, Implying Zero Investment Costs and Minimum Risk for the Village of Ridgewood

The case of Ridgewood shows how a well-designed public-private partnership between the village of Ridgewood's water utility and a co-digestion technology provider and engineering company (Ridgewood Green) led to a successful co-digestion project. The project allowed the wastewater treatment plant to generate enough biogas to meet all the plant's power needs, becoming energy neutral and decreasing CO_2 emissions. Ridgewood Green made all the up-front capital investment needed to retrofit the plan for co-digestion. In return, Ridgewood purchases the electricity generated by Ridgewood Green for the operation of the plant at a lower price than it used to pay for electricity from the grid. The power purchase agreement includes a fixed increase rate of 3 percent per year for inflation, establishing the village's price and Ridgewood Green's revenue for the duration of the contract. Therefore, this agreement benefits both parts. Since Ridgewood Green invested in the co-digestion infrastructure, it owns this new equipment, and the village of Ridgewood owns and operates the plant with technical support from Ridgewood Green. Ridgewood Green expects to get a reasonable return on its investment through an innovative revenue model that leverages different revenue streams: (i) selling electricity to the village of Ridgewood; (ii) selling all the renewable energy certificates (RECs) to 3Degrees, a leader in the renewable energy marketplace under an agreement of several years; and (iii) tipping fees for the organic matter collected for the anaerobic digesters. The full case study can be found here.

BOX 5. The Sale of Treated Wastewater Covers all Operation and Maintenance Costs of the Tenorio WWTP in San Luis Potosi, Mexico

New water reuse regulations and a creative project contract incentivized wastewater reuse in San Luis Potosi. Instead of using fresh water, a power plant uses treated effluent from a nearby wastewater treatment plant in its cooling towers. This wastewater is 33 percent cheaper for the power plant than groundwater, and has resulted in savings of $18 million for the power utility in six years. For the water utility, this extra revenue covers all its operation and maintenance costs. The remaining treated wastewater is used for agricultural purposes. Additionally, the scheme has reduced groundwater extractions by 48 million cubic meters in six years, restoring the aquifer. The extra revenue from water reuse helped attract the private sector to partially fund the capital costs under a public-private partnership agreement (40 percent government grant, 36 percent loan, and 24 percent private equity). See full case study here.

or future expansion. Hence, there is considerable agreement that more efficient subsidies are needed for sanitation, at least during a transition period. The existence of subsidies, however, does not mean that the sector has to rely on conventional financing without taking advantage of market conditions and incentives to enhance sustainability. Given the potential for reuse and resource recovery in WWTPs, the sector should pursue innovative financial and business models that leverage those potential extra revenue streams (see Boxes 5, 6, and 7).

BOX 6. In Arequipa, Peru, a Mining Company, Cerro Verde, has Financed, Built and is Operating the WWTP Enzolada-Cerro Verde, in Exchange for Being Able to Use Treated Wastewater for Its Mining Operations. Under this PPP Agreement between Sedapar, the Municipal Water Utility and Cerro Verde, Sedapar has Avoided the Cost of Construction and Operation of the System thus Resulting in a Net Saving of Over US$ 335 Million

Cerro Verde was planning a large-scale expansion which would require access to additional water supplies in a water scarce area. The mine explored several options such as using desalinated sea water, water from far away aquifers but the cheapest option was to build a WWTP to treat and use wastewater from Arequipa. The mining company agreed with SEDAPAR to design, finance and build the wastewater treatment plant, and in exchange, be able to use a part of the treated water for its mining processes. Under this agreement, the industry partner (and end user of treated wastewater) – Cerro Verde, provided all the needed investment for CAPEX and OPEX not only for wastewater reuse system but of the whole WWTP. The municipal authorities provided the land and permits for the plant. After 29 years in private ownership by the mine, the WWTP will be transferred to SEDAPAR. This win-win solution has allowed the mine to expand its operations and has resulted in significant savings for the municipality.

BOX 7. In Durban, South Africa, the Private Sector Provided all the Capital Needed to Implement a Wastewater Reuse Project for Industrial Purposes Under a PPP Agreement With the Local Water Utility, Which Resulted in a Sustainable Solution with no Extra Cost for the Municipality and the Taxpayers

Durban's sanitation capacity was reaching its limits. Instead of increasing the capacity of the existing marine outfall pipeline to discharge primary treated wastewater to the ocean, Durban explored the possibility to further treat it and reuse it for industrial purposes. Mondi, a paper industry, and SAPREF, an oil refinery, expressed interest in receiving the treated wastewater. Given the technical complexity, cost, and risk of the project, the municipal utility opted to implement the project under a public-private partnership. After an international bidding phase, Durban Water Recycling (DWR), a consortium of firms, was chosen to finance, design, construct, and operate the tertiary wastewater treatment plant at SWTW under a 20-year concession contract. The municipal utility would still be in charge of the preliminary and primary wastewater treatment, and the effluent would be sent to the plant operated by DWR to be treated and then be sold to industrial users. The private sector provided the entire funding needed for the project. DWR also undertook the risks of meeting the water quality needs of the two industrial users. The guaranteed demand for treated wastewater from the two industrial users made the project economically attractive and allowed DWR to undertake the investment risks. The sale of treated wastewater to the industry has freed enough demand of potable water to supply 400,000 extra people in the city. Moreover, as a result, the need for investment in new infrastructure for water treatment has been postponed. See full documented case study here.

Action 4. Implement the Necessary Policy, Institutional, and Regulatory Frameworks to Promote the Paradigm Shift

Finally, for this paradigm shift to happen, policy, institutional, and regulatory (PIR) incentives are needed to encourage sustainable wastewater investments that consider reuse and resource recovery that promote circular economy principles. The case studies analyzed show that this kind of project usually happens in an ad hoc fashion and with no national or regional planning, with the enabling factors many times being physical and local: water scarcity, distance to nearest water source, etc. To enable the development of these innovative projects, changes in the PIR environment and valuing of water resources are also needed (see Box 8). Wastewater treatment technologies for reuse and resource recovery have been progressing much faster than the enabling environment. Weak policy and governmental systems are among the key constraints to scaling up wastewater treatments that foster technologies for reuse and resource recovery. Current basin planning efforts in the region also need to be strengthened: governments need to support basin organizations so they can improve their technical expertise and exert oversight powers to enforce the implementation of planning instruments. Additionally, interventions prioritized in basin plans should be aligned with municipal and regional priorities. Regulations and standards also need to be tailored to the needs of the region and the current trends in the sector. The vast majority of the existing legislation in LAC was created with the sole purpose of meeting environmental standards and are copycats of instruments from Europe and/or the United States, which have very different capacities and financial means. However, the changes in the sector call for new legislation and regulation that embrace and promote gradual compliance, are flexible, and foster reuse and resource recovery. Finally, countries in the region need to ensure they have the required institutional capacity to enforce environmental regulations such as water pollution control standards.

The Way Forward

Wastewater reuse and resource recovery will soon become key aspects of wastewater management strategies worldwide. The scarcity of freshwater in the face of population growth and rapid urbanization, the challenge of meeting the Sustainable Development Goals (SDGs), and the logic of the circular economy have created a compelling incentive to reuse and recover wastewater.

The linear approach to wastewater as something to dispose of must give way to a more circular conception of wastewater as a potentially valuable resource. In the past, the incentives for reuse and recovery were diluted by inconsistent policies, and institutional and regulatory structures focused solely on wastewater treatment and disposal. The necessary paradigm shift is well under way: wastewater policies in many countries already include reuse and resource recovery. As more join them, the new paradigm will boost the sanitation sector and contribute to the achievement of the SDGs.

BOX 8. New Cairo, Egypt: a Successful PPP to Increase Wastewater Coverage and Foster Wastewater Reuse

As the first public-private partnership (PPP) in Egypt, initially the project faced significant governance issues, since there were no legal or regulatory structures to handle PPPs. The solution was to use the process of the New Cairo wastewater treatment plant to design a model for future PPPs in Egypt and eventually approve a PPP law in 2010. To ensure that the first project was a success, outside advisors were enlisted to assess and evaluate broad options for PPP structuring. The Government of Egypt worked with the International Finance Corporation and the World Bank Group's Public Private Infrastructure Advisory Facility to create a conceptual framework and transaction model. To facilitate the PPP process, a PPP Central Unit was created to act autonomously within the Ministry of Finance. Following the success of the project, the government has created a set of laws and regulations that will govern future PPP projects in the country, drawing on lessons learned from the New Cairo project. The establishment of a PPP central unit enabled coordination within the government. The full case study can be found here.

Basic Rules for Planning and Financing Wastewater Treatment Plants

When planning and financing WWTPs, priority should be given to projects that meet the following criteria:

- The project is a prioritized component of a larger integrated water-resource management program.
- The project sponsors have adequately analyzed capital and operating costs across the life cycle.
- They have conducted life-cycle evaluations of the project's environmental, social, and financial aspects. Climate resilience considerations and contributions to climate change mitigation are built in. The project will have a measurable contribution to the SDGs.
- The potential for the use of existing infrastructure has been analyzed and integrated into project planning.
- Sponsors have chosen a technology based not only on its suitability for the specific application and initial capital costs but also on its long-term operating costs to ensure that the project can cover operating costs under viable tariffs, taking into account income from sale of water for reuse, biosolids for beneficial use, and energy generated by the facility (through biogas or hydropower) as demonstrated by the life-cycle analysis.
- The project promotes resource recovery (water reuse, beneficial use of biosolids, and energy generation from biogas or hydropower) in a sustainable way.
- Planners and sponsors have explored innovative and sustainable business and financial models, weighing the benefits of private sector participation in investment and operation while retaining regulatory control (preferably by an independent regulator). If the private sector is to be involved, the project must clearly indicate how it will contribute to the sustainability of the project.
- Clear effluent limits are based either on the loading criteria of the receiving water body (best option) or regulatory requirements based on scientifically/economically sound legislation.
- Industrial discharges are identified and specified in adequate monitoring and control systems. Industries will either pay for treatment (e.g., $/kg treated) or will reduce their discharges to agreed concentrations through in-house treatment.
- The project contributes to the development of the sector by assisting in the training of government employees, local university students, operators from government-run utilities, and other professionals in the region who can gain from the experience
- There is public and stakeholder awareness and acceptance on the need to implement a WWTP. A communication strategy has been developed that clearly explains the benefits of resource recovery and debunks the misconception around wastewater reuse.

Important efforts are needed to align policy, institutional, regulatory, and financing frameworks to encourage and incentivize the development of wastewater resource recovery projects. The frameworks need to also enable collaboration among different sectors and different government tiers. Although policy and regulatory reforms are context specific and linked to the political economy of each country, a clear policy statement of the reason for resource recovery as part of a broad policy on water is a good first step. Around it, commitments from high-level political leaders can coalesce and public support can be built. A set of policies to create incentives for resource recovery from wastewater comes next, accompanied by complementary institutional, regulatory, and financing frameworks that can be improved over time. In fact, flexibility and adaptability may well be more conducive to progressive adoption of resource recovery practices. The policies and frameworks then need to be cascaded down from the national or federal levels to lower levels.

Private sector involvement in wastewater (including resource recovery projects) has proven to be key for the promotion of waste-to-resource projects. Private sector participation brings technical expertise and technology,

as well as investment in infrastructure and technology. Moreover, early on private sector participation has led to the successful identification of resource offtakers from wastewater treatments plants. Nevertheless, effective private sector participation depends on a conducive enabling environment for investment and a clear policy and regulatory framework.

Various forms of public-private partnerships will be needed for the financing of waste-to-resource projects, especially since the up-front investment requirements of reuse and recovery projects are beyond what many national governments can afford. Blended finance is typically necessary, with subsidies from governments or donors combined with private equity and debt financing that is recovered through user tariffs and resource recovery revenues. The level of subsidy warranted should be determined by economic and financial analysis at the basin level. To provide incentives for efficient performance, subsidies should be disbursed based on achieved results.

Technical standards for water reuse and biosolids are important in building public confidence and creating a market that makes resource recovery investments viable. Standards must be flexible and well adapted to local conditions, as standards that are too strict may disincentivize resource recovery. They must also be consistently enforced.

Cross-subsidies from tariffs on fresh water may be needed to allow the price of reused water to be set low enough to allow the market to grow. Moreover, water tariffs should reflect the real value of treated water. Economic regulation can also be used to stimulate and create competition in the bioresource market. There is also a great need to align regulatory frameworks from other sectors relevant to wastewater resource recovery, as overlapping regulations can create negative incentives.

Finally, it will be important to raise awareness of the reuse and resource recovery potential and benefits in the region at all levels. Through project design that ensures that those involved in resource recovery projects face appropriate incentives, including measures to mitigate risks, there can be confidence that the resource recovery projects will be sustainable.

A Global Vision

The challenges faced in the LAC region are not unique. The final report summarizing all the findings of the initiative will be published so countries in the region but also around the world can learn from best practices in the sector and can promote this paradigm shift towards a circular economy, fostering resource recovery and ensuring sustainable wastewater management.

Given the increasing interest and importance of the issue, the World Bank aims to expand this regional initiative into a global one, providing on-demand solutions to implement circular economy principles in wastewater projects worldwide.

NOTES

1. As part of the initiative, several case studies have been developed, highlighting innovative approaches on wastewater planning, management and financing. The case studies mainly focus on innovative designs that promote resource recovery such as wastewater reuse or energy production and that enhance the financial and environmental sustainability of wastewater treatment plants. The case studies can be found in the webpage of the initiative: www.worldbank.org/wastetoresource

2. The LAC region refers to all countries in the Latin America and the Caribbean.

3. Improved sanitation facilities are those designed to hygienically separate excreta from human contact (excreta are safely disposed of in situ or transported and treated off-site) and that are not shared with other households.

4. Approximately, 233 million people who currently do not have access, plus 74 million additional people.

REFERENCES

ASCE (American Society of Civil Engineers). 2013. "Chicago to Add Nutrient Recovery to Largest Plant." Civil Engineering, November 5. https://www.asce.org/magazine/20131105-chicago-to-add-nutrient-recovery-to-largest-plant/.

CAF (Corporación Andina de Fomento). 2018. "Diagnóstico rápido base. Tratamiento de Aguas Residuales en América Latina". Documento interno.

Ellen Macarthur Foundation. n.d. "Concept: What Is a Circular Economy? A Framework for an Economy That Is Restorative and Regenerative by Design." https://www.ellenmacarthurfoundation.org/circular-economy/concept.

FAO (Food and Agriculture Organization). 2017. "Reutilización de aguas para agricultura en América Latina y el Caribe: Estado, Principios y Necesidades." FAO, Washington, DC.

HLPW (High Level Panel on Water). 2018. *Making Every Drop Count. An Agenda for Water Action: High-Level Panel On Water Outcome Document*. March 14, 2018. https://reliefweb.int/sites/reliefweb.int/files/resources/17825HLPW_Outcome.pdf.

———. n.d. "Value Water." https://sustainabledevelopment.un.org/content/documents/hlpwater/07-ValueWater.pdf.

Hutton, G., and M. C. Varughese. 2016. "The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water Sanitation, and Hygiene (English)." Water and Sanitation Program technical paper, World Bank Group, Washington, DC. http://documents.worldbank.org/curated/en/415441467988938343/The-costs-of-meeting-the-2030-sustainable-development-goal-targets-on-drinking-water-sanitation-and-hygiene.

Lemainski, J., and J. E. da Silva. 2006a. "Utilização do biossólido da CAESB na produção de milho no Distrito Federal." *Revista Brasileira de Ciência do Solo* 30 (4): 741–50.

———. 2006b. "Avaliação agronômica e econômica da aplicacção de biossólido na produção de soja." *Pesquisa Agropecuária Brasileira* 41 (10): 1477–84.

NSF (National Science Foundation), DOE (U.S. Department of Energy), and EPA (U.S. Environmental Protection Agency). 2015. *Energy-Positive Water Resource Recovery Workshop Report: Executive Summary*. Workshop on April 28–29, 2015, Arlington, VA. https://www.energy.gov/sites/prod/files/2015/11/f27/epwrr_workshop_executive_summary.pdf.

OECD (Organisation for Economic Co-operation and Development). 2017. "OECD Environment Statistics." ISSN: 18169465 (online). Accessed March 2019. https://doi.org/10.1787/env-data-en.

Trémolet, S. 2011. "Identifying the Potential for Results-Based Financing for Sanitation." https://www.cseindia.org/static/mount/recommended_readings_mount/09-Identifying-the-Potential-for-Results-Based-Financing-for-Sanitation.pdf.

UNDESA (United Nations, Department of Economic and Social Affairs), Population Division. 2018. *World Urbanization Prospects: The 2018 Revision, Online Edition*. https://esa.un.org/unpd/wup/Publications.

WDI (World Development Indicators). 2019. "Latin America and the Caribbean Dataset (online)." https://data.worldbank.org/region/latin-america-and-caribbean.

WEF (World Economic Forum). 2014. *Towards the Circular Economy: Accelerating the Scale-Up across Global Supply Chains*. World Economic Forum, Geneva, prepared in collaboration with the Ellen MacArthur Foundation and McKinsey & Company. http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/.

WHO and UNICEF (United Nations Children's Fund). 2017. *Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines*. Geneva: WHO and UNICEF.

———. 2019. *Progress on Household Drinking Water, Sanitation and Hygiene 2000-2017. Special Focus on Inequalities*. New York: United Nations Children's Fund (UNICEF) and World Health Organization.

World Bank. 2017. *Rethinking Infrastructure in Latin America and the Caribbean Spending Better to Achieve More*. Washington, DC: World Bank.

———. 2018. *Wastewater : from waste to resource. The Case of Atotonilco de Tula, Mexico.* Washington, DC: World Bank.

———. 2019. *From Waste to Resource. Shifting paradigms for smarter wastewater interventions in Latin America and the Caribbean*. Washington, DC: World Bank. Upcoming publication.

WWAP (United Nations World Water Assessment Programme). 2015. *The United Nations World Water Development Report 2015: Water for a Sustainable World*. Paris: UNESCO.

———. 2017. *The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource*. Paris: UNESCO.

WWD (Water and Wastes Digest). 2011. "Brilliant Water Reuse in Brazil." WWD Magazine (online), September 12. https://www.wwdmag.com/water-recycling-reuse/brilliant-water-reuse-brazil.

Connect With the Water Global Practice

www.worldbank.org/water worldbankwater@worldbank.org @worldbankwater blogs.worldbank.org/water

SKU W19009