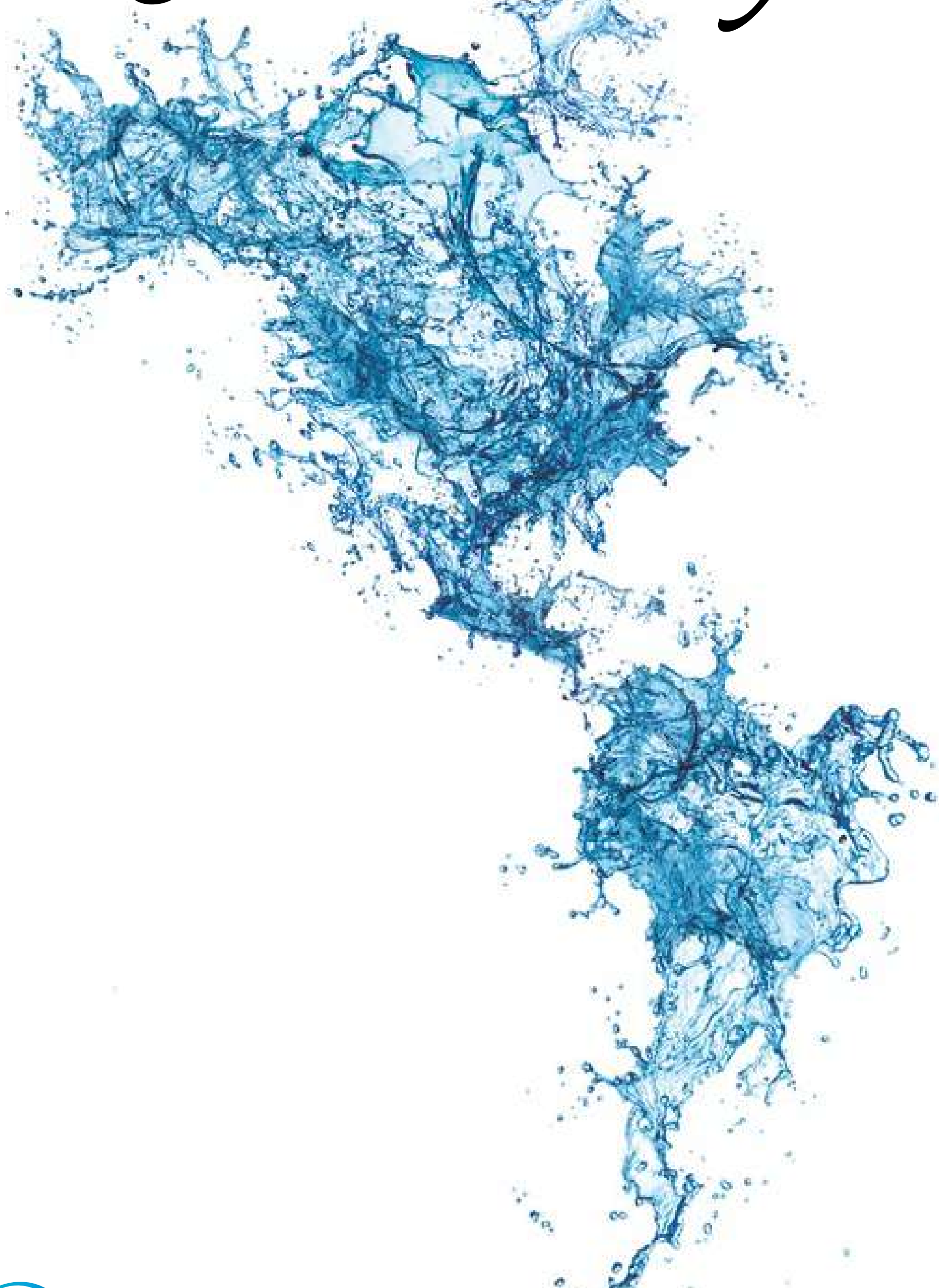
URBAN WATER CHALLENGES IN THE AMERICAS

A perspective from the Academies of Sciences

Summary



United Nations Educational, Scientific and Cultural Organization

International Hydrological Programme

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INTERAMERICAN NETWORK OF ACADEMIES OF SCIENCES

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The Inter-American Network of Academies of Sciences

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Ejecutive summary

Introduction

The countries of the Americas have the most urbanized regions of the world (> 80%). Urbanization goes hand in hand with intensification in the use of water resources for human needs; in turn, sources of water play a role in the development and growth of cities not only to supply drinking water but also for the transport and treatment of wastes. There is a growing need to find solutions for water management problems in urban centers where economic and population growth is frequently concentrated. The Academies of Science of 20 countries of the Americas have identified the problems of urban water management and the policy issues that must be addressed to resolve those problems. The discussions found herein summarize the more detailed country-by-country presentations contained in a much larger volume entitled Urban Water Challenges in the Americas, A Perspective from the Academies of Sciences, http://www.ianas.org/docs/books/Urban_Water.html and published by the Interamerican Network of Academies of Science (2016). The present edition was prepared specifically for decision-makers. It is brief and accessible and it identifies the policy priorities that are required to develop and implement solutions to urban water management problems that affect the countries of the Americas.

This unique examination of the countries of the Americas, each with different water resources characteristics, diverse levels of economic and social development, varying problems related to water quality and quantity and different experiences with water management, reveals that there are a number overarching themes that are universally pertinent in spite of the social, economic, physical and hydrologic diversity of the hemisphere. These themes are three in number.

1. Evidence from virtually every country shows that if water management is to be effective it must extend beyond urban boundaries and include the entire watershed(s) upon which the urban area depends for its water supplies.
2. Groundwater can be just as important as surface water and this means that the interactions between ground and surface water, the hydrologic connections, must be specifically addressed in water management plans. In addition, it should be recognized that contamination of ground water is almost always cheaper to prevent than to clean up after it has occurred.
3. Urban areas are especially vulnerable to extreme climatic events. Changing climate and its consequences should be addressed in water management plans and planned responses should be both flexible and adaptive.

In addition, the summaries of each of country chapters that follow emphasize such common topics as:

- Water resources in urban areas and the impacts on water from urbanization.
- The adequacy and accessibility of water supply services in urban areas.
- The adequacy of wastewater management in urban areas.
- The importance of appropriate urban water services for community health.
- The potential impacts of climate change on water resources and water services in urban areas.

The analyses herein offer the opportunity to draw lessons stemming from the commonalities and differences among the countries of the Americas. Also, they highlight the fact that a significant diversity of water management schemes will be required to manage water effectively.

Findings and Conclusions

Urbanization and water resources

Urbanization and increases in urbanization have been observed globally but are more pronounced in the Americas. Developed countries tend to have large and stabilized urban populations while developing countries exhibit patterns of urbanization that are steadily growing (UN, 2009). Urbanization concentrates competition for the use of water resources into a small space. This allows for efficiencies in water use, but it also imposes special demands associated with water transport, water quality maintenance and the management of excess water from storm events, among other challenges. In general urbanization requires more water per unit area while producing wastes, including wastewaters and solid wastes that tend to degrade water quality and that must be managed. Urbanization also tends to degrade local watersheds and their surrounding areas through deforestation and increases in impervious areas. If the human needs for healthful domestic living conditions are to be met and if economic development is to prosper, more efficient methods for the management of the urban water resources are essential.

Urbanization and impacts on water resources in urban zones

Urbanization has not been accompanied by adequate planning and foresight in most countries. Environmental impacts are accounted for in advance only infrequently with resulting adverse effects on the environment including water resources. Examples include: 1) Inappropriate land use and deforestation in watersheds in areas surrounding urban centers. This leads to erosion which then brings heavy sedimentation into the cities and contaminates sources of water; 2) Uncontrolled discharges of domestic and industrial wastewaters into surface waterbodies and coastal areas; 3) When segments of the population do not have appropriate hygienic practices and there is inadequate management of solid wastes which are frequently deposited into natural sources of water or open city drainage systems; 4) Contamination of ground and surface water from different sources: mining, hydrocarbon spills from industry and contamination from storage of fuel tanks at service stations as well as pesticide runoff from agricultural activities from the surrounding watershed; 5) Impairment of recharge to urban aquifers due to reduction of green cover (forests, wetlands, riparian forests) and impermeable infrastructure associated with urbanization and more.

Water supply services and sanitation

In the last decades the access to potable water and treatment of waste water in cities of the Americas has improved. The coverage of water supply systems in the majority of cities has reached levels that lead to the fulfillment of the Millennium Development Goals of the United Nations for improved drinking water sources and it is important to highlight that Latin America and the Caribbean have the highest drinking water coverage of the developing world. However, as observed in the analysis provided in each country´s chapter, there are still serious problems with the coverage for improved sanitation in cities. Coverage varies by country from 57 to 100% according to the WHO and UNICEF report on Drinking Water and Sanitation (2014). Chile is an example of one country where there has been rapid improvement in sanitation coverage in the last decade such that all collected wastewaters are treated. A combination of factors has made this possible, including Chile´s economic stability, institutional restructuring and significant investments in the context of utility privatization. Despite this success, important challenges remain, such as access to sanitation service in peri-urban unincorporated communities.

Adequate water supply services are generally available throughout the developing countries of Latin American and the Caribbean. The problems are centered more on the reliability of services, the need to repair massive leaks in the existing distribution systems and the need to regulate and enforce controls on illegal connections which affect the efficiency in delivery of water and the economic capacity of the water supply companies to make investments in improving services. Faulty distribution systems have also caused problems in Canada and the United States where there is a need to replace old systems and undertake new programs of renewal and innovation.

The lack of adequate monitoring of water quality for contaminants, together with new emerging sources of contamination, is identified as a major problem in both developed and developing countries. It is also important that the microbiological safety of water in most countries is not secure because the detection of viral and protozoan pathogens is not included in standard water monitoring protocols.

It is important to acknowledge that some improved sanitation systems still cause contamination of water sources originating from the same system. Many countries report examples of septic tanks from urban areas and new urban developments that contaminate groundwater sources used for drinking water.

Also the majority of developing countries reported massive problems due to the discharge of waste waters into rivers and the ocean without treatment. It has also been reported that 15% of waste waters do not receive even basic primary treatment. Some Central American countries report many cases where inadequate treatment and designed discharges of incompletely treated water from oxidation ponds. result in the discharge of domestic waste into waterways that are then subject to intensifying cultural eutrophication and loss of water quality for human consumption and irrigation.

The cities of Latin America and the Caribbean islands are affected by the informal growth of peri-urban areas (usually due to migration from rural areas or consequences of climate change crisis in rural areas) which have little or no water coverage or sanitation. These areas have the highest rate of water-borne disease and a significant incidence of contamination of water sources. These periurban areas will require special attention if healthful drinking water supplies and adequate sanitation services are to be provided to the local residents.

For the United States and Canada, urban water issues are focused on the need for improving maintenance and renewal of systems. The deterioration of quality in source waters and intensifying water scarcity require innovative financial, technological and "demand management strategies" to reduce loss of the resource and to maintain acceptable levels of reliable water availability.

Urban water and health

The increase in coverage of water and sanitation in urban zones has had a positive influence in reducing the incidence of waterborne diseases (bacterial and vector born) in developing countries of the Americas. Further improvements in the continuity of services, and the renewal and better maintenance of distribution systems would further reduce the probability of waterborne diseases. Where water supply and sanitation reaches only part of the population or is completely absent, the environment is ripe for the development and spread of waterborne diseases. Peri-urban and informal settlements are particularly at risk.

Climate change and impact on water resources in cities

Cities are more vulnerable to extreme climate events especially due to failures in planning for growth and modernization of water distribution systems. Similarly, inadequate storm drainage can be overwhelmed by intense precipitation events. All countries have reported changes in precipitation patterns accompanied by changes in land use in surrounding urban watersheds and changes in soil use from deforestation which creates increases in erosion and brings heavier sediment loads into cities. The geographical characteristics of Central America make it especially vulnerable to climate change and higher evapotranspiration rates have been observed due to the gradual increase in temperatures. There have been reports from many countries in North, Central and South America of droughts that have caused severe crises in the provision of potable water forcing authorities to ration irrigation and give priority to human consumption. Special examples of drought management and organizations of the water supply in cities are mentioned for the USA in California and northeastern Brazil. Also, most countries have documented the occurrence of extreme events of intensive rains causing flooding in urban areas, owing to inadequate drainage systems. Examples of better planning for the reform of urban drainage systems are presented in several country chapters.

Water reuse

Climate change and especially drought situations have made the reuse of waste water more important than ever for cities. New technologies to prepare waste water for reuse are described and these can also contribute to reduction in the deposition of raw sewage into receptor bodies of water in cities. The use of domestic sewage, liquid residues from industrial effluents, agricultural runoff and brackish waters could prove to be a viable alternative source of water for certain uses. The storage and reuse of rain water has been implemented in some countries. It was emphasized that the monitoring of the quality of water for reuse is fundamental in order to guarantee the appropriate quality.

Effectiveness of water institutions and legal aspects

In most countries, progress has been made with the establishment of governing bodies with responsibility for water resources management. These bodies have usually been authorized by appropriate legislation. For some countries the effectiveness of these institutions is not yet adequate. Corruption is sometimes a problem. The development and effective operation of governing institutions and well as appropriate laws and regulations is an essential pre-requisive for effective management of water resources Equitable enforcement of regulations is also required if the regulations are to be effective.

Recommendations for Improving water management and institutional planning and oversight

Most countries are conscious that the management of water in cities has been fragmentary and has not considered the infrastructure for urban water management in a holistic fashion. One proposal would entail incorporating, all elements of urban water management: supply of potable water, collection and treatment of wastewater, and storm drainage and urban flood control into a single agency. A watershed-based planning approach is also needed to mitigate the water quality and quantity impacts of wet weather flows, including water pollution, flooding, and stream erosion. Such an approach would also help to better direct urban growth away from high risk areas such as flood plains and embankments.

It was emphasized in all countries that proper urban water management must include watershed management within urban and surrounding rural areas.

Specific Recommendations to consider for policy-making endeavors

- Develop data and good measures of benefit to help guide investment programs for water, sanitation and drainage facilities. Data should be developed on a continuing basis to assess the effectiveness of such facilities over time.
- Strengthen regulation and control in water services in cities.
- Improve capacities for planning, design and installation of water services in cities. Improvements in infrastructure to deal with climate change in urban areas is badly needed to combat more intensive flooding and drought. New infrastructure should be both flexible and adaptive.

- Strengthen and amplify monitoring of water quality which include new contaminants.
- Improve the training, education and technical capacity of the pool of managers of water treatment and purification plants as well as water service and watershed managers.
- The national government needs to authorize and provide funding support for programs of evaluation and regulation of contaminants and potential emerging contaminants. Failure to accomplish this task will adversely impact both the safety and reliability of the urban water supplies in the future Although this recommendation emerges from the USA it applies to all countries in the Americas.
- Prepare risk evaluations and alert systems to confront problems: climate change events, water quality problems, water access, sanitation and health supervision to diminish vulnerability of population.
- Strengthen water management and governance institutions. Vest clear and effective authority to enforce water laws and regulations in appropriate institution. Some countries will require new and revised laws as part of a general overhaul of existing water laws and regulations.
- Development of special urban programs to engage in holistic management of surrounding watersheds and within cities themselves.
- Improve sanitation systems to assure no or very minimal further contamination of water resources.
- Establish reuse of waste waters that involve water quality monitoring for adequate use. This is a measure especially important to secure better adaptation for climate change impacts.

Obelisk of Buenos Aires, historic monument and icon of icon of that city, located in Plaza de la Republica, Buenos Aires, Argentina. Photo credit: ©iStock.com/dolphinphoto.

Argentina

Challenges posed by water management in urban areas

Raúl Antonio Lopardo[1], Jorge Daniel Bacchiega[2] and Luis E. Higa[3]

Argentina has an unequal distribution of its water resources, with two thirds of its territory consisting of arid and semi-arid regions and only a third with an abundance of bodies of water -mainly surface water- accounting for 84% of the country's water availability. Argentina has an average annual water supply of over 20,940 m3 per inhabitant, well above the water stress threshold determined by the UNDP. However, despite the significant overall supply of water, a number of negative balances can be observed between potential demands and water availability in certain parts of the country.

The uncontrolled growth of industrial and productive consumption with untreated effluents, coupled with the haphazard development of major marginal population settlements meant that at the beginning of this century, a considerable degree of water deterioration was observed as a result of inadequate water exploitation and the dumping and infiltration of polluting substances, which in turn has led to problems in the development of aquatic life, increased waterborne diseases, the deterioration of conditions for undertaking various recreational activities and an increase in water purification costs.

Although wet regions occupy 24% of the country, they concentrate approximately 70% of the total number of inhabitants, while arid zones, representing 61% of the total area, are only home to 6% of inhabitants. This match between water and population is exactly the opposite of what happens in most Latin American countries

Groundwater availability is linked to the contributions of rainwater and rivers in each region, and in most cases, is used when surface water is unavailable. Groundwater supply is sometimes limited by the low quality and power of aquifers, which, in turn, is progressively conditioned by the pollution of rivers, lakes and aquifers that cause diffuse and concentrated sources.

At the same time, urban residents-in other words, those living in centers with over two thousand inhabitants- account for 90% of the total population, mostly in the peri-urban areas of large agglomerates, particularly Greater Buenos Aires. Unaccounted for water constitutes one of the main problems of efficiency in drinking water services in major cities in Argentina. It is estimated that losses in the network and under-invoicing, due to clandestine connections and outdated user cadastres, account for between 35 and 45% of the water produced. This aspect must be taken into consideration by decision makers.

Although there is a high percentage of potable water coverage (over 90% in major cities), sewerage levels are uneven, with indices ranging from 35 to

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80%. The political actions underway regarding this last aspect must be sustained and encouraged. Since the provision of drinking water service is organized at the federal level, there are specific rules and regulations for each province, which in turn means that political consensus must be arrived at for the development of programs and projects in shared basins. The number of different water suppliers in the country is remarkable, amounting to 1,830, if one includes public limited companies (both national and provincial), provincial and municipal state companies, centralized entities, private corporations, cooperatives and neighborhood groups.

An analysis of the situation in the Greater Buenos Aires urban conglomerate, home to more than 12 million people, shows that it is essential to achieve 100% coverage of potable water, but also to concentrate efforts on wastewater treatment and reuse levels. This challenge, a successful example of which was the renovation of the Matanza-Riachuelo basin, will only be met if accompanied by the necessary investment and replicated in similar basins such as that of the Reconquista River.

The authorities should also ensure better water quality on the Argentine coast of Rio de la Plata, using the results of numerical modeling studies for various public works linked to the water uses the authorities wish to guarantee.

As noted earlier, much of the urban population in Argentina inhabits an area with a significant excess of water. Apropos of this, studies have recently been undertaken in which two significant impacts related to water management that should be taken into account by decision makers tasked with project selection are specifically analyzed: the uncontrolled increase of certain groundwater levels and the impact of excess rainfall on urban centers.

At the beginning of this century, several localities in the Buenos Aires metropolitan area have experienced the progressive rising of water tables, which has flooded basements even in high areas, and created foundation problems in various type of structures, an upwelling of water in low zones with flooded lands, the slumping of blind wells, contaminated water in contact with the population, the destruction of paving and, undoubtedly severely reducing the quality of life.

Although some preliminary explanations state that the phenomenon could be associated with an increase in rainfall and climate factors, it is largely the result of man-made actions, such as the lack of sewers in the affected areas, the importation of water through potable water pipelines from sources outside the basin, a sharp decrease in the provision of water through household wells, the elimination of the provision of industrial water through local wells and the systematic reduction of the public supply of potable water from underground sources.

Argentina faces a major challenge in the management, control and administration of excess water in urban centers. It has been proved that the presence of heavy rainfall recorded in nearby areas with periods of occurrence of under 20 years indicates that heavy flooding is not an uncommon problem. Moreover, growing urban expansion into floodplains of rivers and streams has led to increased vulnerability in most coastal cities.

Despite the use of advanced technologies, engineering works fail to provide absolute protection from all the flood processes that may occur in the future. That is why the great challenge in excess water management lies in the integral analysis of the problem, with the right balance of structural and non-structural measures. This is essential in the Buenos Aires agglomerate, home to a population of over 12 million inhabitants, most of whom are unaware of the risk of flooding to which they are exposed. Accordingly, the intrinsic vulnerability of urban centers must determine the protection schemes adopted, risk analysis and, therefore, the guidelines for decision making and the definition of comprehensive analysis schemes that seriously contemplate an appropriate combination of structural and non-structural measures. This aspect, which is difficult to achieve in most cases, constitutes the main challenge to achieving adequate risk reduction in the event of urban water surpluses.

In view of this problem, emphasis should be placed on studies of structural and non-structural actions that make it possible to offset the effects produced by excess water in densely populated urban areas, as a result of rising groundwater levels and above all, disasters caused by extreme rainfall.

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View of Sao Paulo, Brazil, from Ibirapuera Park. The Ibirapuera is one of Latin America largest city parks.
Photo credit: ©iStock.com/alffoto.

Brazil

Urban Waters in Brazil

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In Brazil, the accelerated urbanization process in the last decades has brought many challenges for municipalities, such as higher water demands for drinking and non-drinking uses, higher volumes of wastewater to treat and solid waste to dispose, besides the need of adequate water drainage systems in order to prevent floods. All these and many other challenges must be solved to improve human well-being and environmental conservation.

To achieve water sustainability in cities, Urban Master Plans should be guided by an Integrated Urban Water Management (IUWM) approach, which considers that water supply, solid waste disposal, sewage collection and water drainage must be managed by the integration of all tools that rule a municipality, such as legislation, urban planning and natural resources management. This approach should provide special attention to irregular and informal urban areas called slums, which generally lack sanitation facilities. As a result, groundwater is overexploited with inappropriate methods, resulting in pumping of contaminated or salty groundwater. Also, the increase of impervious areas (reduction of infiltration) and channelization of urban rivers have been the cause of frequent flood events in cities. Solid wastes that are not adequately disposed are carried with other pollutants by stormwater into rivers, worsening flood peaks, besides contaminating superficial waters.

The following steps are recommended to achieve an adequate governance of urban waters: **1) assessment of the urban sanitation issues,** to identify problems related to water supply and distribution, wastewater collection and treatment, storm water drainage, and solid waste disposal; **2) development of plans** for the solution of problems by the integration of the various institutions that manage water to create new urban development standards; **3) implementation of action plans and strategies** in due time, taking into account economic and financial aspects .

The assurance of quality and quantity of water demanded for multiple uses are challenges to be met constantly, as the urbanization processes take place. The preservation of water supply sources should take into account 1) the evaluation of the **water quality of sources;** 2) the relationships between **water availability** and **water demand;** 3) the **conservation** of surface and groundwater sources and **analysis of**

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future tendencies of urbanization; 4) new **legislation** at the municipal level in order to prevent excessive land use and occupation near water sources; 5) protection and development of **urban forests** and green spaces in order to maintain an adequate balance between urban and natural areas; 6) the implementation of **payment for ecological services** as a complementary measure for the protection of water sources; 7) inclusion of **projects** in the Master Plan of each town or city for the protection of water sources, control of urban drainage, and land use regulation; 8) mobilization of the population, schools and private initiative to develop a **participatory approach** for an integrated watershed management; 9) **capacity building** of managers, technicians and other participants of the municipal administration - the lack of a systemic view of the municipality and its urban region, its natural resources and the areas of expansion is one of the problems that impair an efficient management of the water supply services in many urban regions of Brazil; 10) **financial resources** to promote a better institutional organization in the urban regions of Brazil; 11) **integration** of several **administrative departments** such as housing, environment, science, and water services; 12) **wastewater treatment** with advanced methods, as well as new projects such as the use of wetlands to improve the process and lower the costs of treatment; 13) improvement and increase of the efficiency and frequency of **monitoring** at all levels (from the source to the tap); 14) **development of a Statistical Data Bank** for Human Health and Water Supply Quality in order to establish and consolidate an integrated policy for the urban areas; 15) **vulnerability assessment of urban populations** exposed to risks of water shortage and degradation of water quality; and 16) **implementation and execution of ideas, projects and plans** - there are sufficient financial resources, plans and projects, but the execution is not adequate, fails or is too slow.

Another challenge for water governance in Brazil is the water supply in dry regions. The driest area in Brazil, classified as semiarid, extends across eight states of the Northeast (Alagoas, Bahia, Ceará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte and Sergipe) in addition to the North of Minas Gerais, totaling a territorial extension of 980,133.079 km². In these areas, the quality of surface and groundwater is compromised due to human activities related to improper disposal of solid waste, indiscriminate use of agricultural inputs, deficient or absence of sewage treatment systems, carrying of inorganic fillers from mining and processing of ores and deforestation, and improper soil management. Projections for the year of 2025 showed that among the 1,256 analyzed municipalities, 26.8% will be adequately served by supply systems, 2.7% will be supplied by means of a deficit water source, 52.8% will be supplied through critical water production systems and 17.7% through production systems and water sources both classified as critical. The most appropriate solution to supply water for cities in dry zones is the **construction of pipelines** from larger reservoirs, wells, rivers, even those located in other watersheds, thus creating the so-called transpositions of water between basins.

Water reuse is an urgent solution that copes with the problems of limited availability of water sources and water pollution in Metropolitan Regions, and should be included in the Integrated Urban Water Management plans and strategies. To significantly enhance water supply systems in urban regions it is important to manage demands and to search alternative sources of provision, including treated domestic and industrial sewage water, harvested rainwater, besides managing the recharge of aquifers. The possible uses of water from reuse are, for instance, irrigation of parks and gardens; supply to extinguish fire; decorative aquatic systems, such as fountains and small shallow artificial lakes; vehicles washing; washing of floors, garages and parks; sanitary flushing; cleaning of sewer pipes and rainwater pipes; dust control; and in construction industry.

The following recommendations are important for the implementation of water reuse: **1) develop a realistic legal framework to regulate, guide and promote the practice of water reuse,** including norms, water quality standards, codes of practice and institutional responsibilities for the different means of reuse, especially for urban and agricultural use; **2) encourage reuse of water** by developing educational and awareness programs to promote public acceptance, creating research and development programs, implementing demonstration programs and projects, introducing specific credit lines, and establishing specific criteria for funding reuse projects; **3) sanitation companies** should develop studies and surveys with certified research centers to assess, technically and economically, operations and individual processes, as well as advanced treatment systems for direct potable reuse considering Brazilian conditions; establish certificates for the quality of reused water; overcome the self-protectionist and immediate procedures of the regulatory bodies that should be guided towards developing realistic norms, standards and codes of practices based on studies and research, and not through copying alien rules and guidelines that do not represent our technical, cultural, environmental and public health conditions.

The challenges related to water supply, water reuse and water governance, mainly in metropolitan regions, include the impacts of waterborne diseases as a consequence of low rates of sewage treatment and of a very deficient legislation and parameters for monitoring microbiological quality of water. In Brazil, the main threat to human health is gastroenteritis, which is characterized by vomiting and diarrhea. The current applied techniques to measure microbiological safety of water in Brazil do not include the detection of viral (or protozoan) pathogens. Also, technologies to treat drinking water are not effective to avoid the risk of viral contamination.

Considering the high rates of detection of these viral agents in water and the number of cases of diarrhea in Brazil, it is recommended **1) the revision of the Brazilian guidelines for the quality of drinking water** and **2) the improvement of the levels of sewage treatment** in Brazilian cities to minimize the discharge of contaminated wastewater into water bodies used for production of drinking water.

In summary, the solutions for Brazilian water-related problems must focus on integrating the roles of all municipalities' institutions that rule water issues, with a systemic view for plans and actions (Integrated Urban Water Management) regarding the location, availability and quality of water supplies; appropriate treatment for drinking water; distribution of water without losses; adequate disposal of solid waste; adequate collection and treatment of house and industrial sewage; reuse of treated sewage; restructuring of urban drainage systems; constant and adequate monitoring of water quality, adapted to the Brazilian reality of waterborn diseases; and transport of water to dry zones. Special attention shall be given to poor areas in cities, called slums, where sanitation infrastructure is deficient or inexistent.

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The Rideau Canal (1832) is a UNESCO World Heritage Site and connects the city of Ottawa on the Ottawa River to the city of Kingston on Lake Ontario. Ottawa, Ontario, Canada. Photo credit: ©iStock.com/Tonlylanioro.

Canada

An overview of water supply, use and treatment in Canada

Banu Örmeci[1]

Introduction

Canada is the world's second largest country and encompasses a wide range of climate regions and landscapes, which affect the supply, demand, use and treatment of water. Canada has access to approximately 20% of the world's stock of surface fresh water, and even though water is abundant at the national scale, there are strategic water problems and shortages at the regional scale due to the uneven distribution of population and water supplies.

1. Water resources and problems caused by development

Water supplies are increasingly under pressure from urbanization, economic, industrial and agricultural growth, and impacts of climate change. Eutrophication of Great Lakes, industrial activities in Southern Ontario and Southern Quebec, oil sands mining operations in Alberta, hydroelectric power developments in northern Quebec and Labrador, agricultural activities in Prairies, and overexploitation of groundwater are some of the main stresses on water resources in Canada (Hipel et al., 2013). Growing oil sands mining operations and hydraulic fracturing of shale gas are expected to increase the demand and threat to both surface waters and groundwater.

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2. Water use and supply

Canadians are one of the highest per capita water users in the world. The water consumption in households was approximately 300 litres per person per day in 2009. However, a decreasing trend in residential water use has been observed in Canada in the past decade, which indicates a change in consumer behaviour towards a more sustainable approach to water use. In addition, increasing use of residential (72%) and commercial (87%) water metering over the past decade has helped to decrease the water consumption (Environment Canada, 2011).

According to the 2011 Municipal Water Use Report (Environment Canada, 2011), 89% of Canadians are served by a water distribution system and 94% of them receive treated water. However, the percent of people who are connected to a distribution system drop substantially in smaller communities.

3. Treatment of wastewater

Over 150 billion litres of untreated or undertreated sewage is dumped into to waterways every year in Canada which poses a threat to the quality of water supplies and consequently human health.

Until recently, Canada did not have a national policy on wastewater treatment, which resulted in large differences among provinces and territories with respect to the level of wastewater treatment and effluent quality. The *Wastewater Systems Effluent Regulations* that came into force in 2012 created the basic treatment standards for wastewater treatment across Canada, requiring the use of secondary (biological) or equivalent treatment. The regulations also put in place additional requirements for monitoring, reporting and toxicity testing.

According to the 2011 Municipal Water Use Report (Environment Canada, 2011), 87% of people were connected to sanitary sewer system whereas 12% were using septic tanks and 0.5% were using holding tanks and sewage haulage. From large municipalities with a population of 500,000 people or more, 98% had sewer access, but municipalities containing less than 1,000 people had only 47% sewer coverage. The level of wastewater treatment varied from no treatment to preliminary treatment, primary treatment, secondary treatment and tertiary treatment depending on the size and location of the communities. Of approximately 24.5 million people connected to the sewer system, 55% received secondary-mechanical treatment, 7% had secondary treatment in sewage lagoons and 17% received tertiary treatment. However, 3% received no treatment or only preliminary treatment and 18% received primary treatment.

4. Aboriginal communities

The status of water and wastewater infrastructure is of particular concern in aboriginal communities and requires substantial investment to meet acceptable quality standards. The results of the National Assessment of First Nations Water and Wastewater Systems (Neegan Burnside, 2011) revealed that from the 807 drinking water systems inspected 39% were found high-risk, 34% medium risk, and 27% low risk. For the 532 wastewater systems that were evaluated, 14% were identified as high-risk, 51% as medium risk, and 35% as low risk. High, medium, and low risk water and wastewater systems were distributed throughout Canada and were not localized to particular provinces or First Nation communities. As predicted, the least accessible First Nations due to their remoteness had higher percentages of high-risk systems.

According to a Health Canada report (2009), the length of the boil water advisories in aboriginal and rural communities, which are issued as a preventive measure when there is suspicion of a risk to public health from drinking water, varied from 1 day to 13 years between 1995 and 2007. The average duration of the boil water advisories were 343 days and the median was 39 days, and the discrepancy was caused by the skewed average due to the years of ongoing boil water advisories in some communities.

5. Water and health

A comprehensive surveillance for the occurrence of drinking water related illnesses in Canada between 1993 and 2008 reported 47 waterborne disease events (WBE) in this time frame (Wilson et al., 2009). On average 5-6 WBE's per year occurred before 2001, and after 2001 there was a substantial drop down to 1-2 WBEs per year, which was likely due to the measures taken after the Walkerton (2005) and North Battleford (2001) waterborne outbreaks. Frequency of the WBE's was 6 times higher in communities with less than 1,000 people compared to communities with more than 100,000 people. The main factors contributing to waterborne disease outbreaks in small systems include lack of source water protection, inadequate water and wastewater systems, and limited trained personnel.

6. Summary

Canada has a well-established network of water and wastewater systems, and overall Canadians enjoy safe and high-quality drinking water. Waterborne outbreaks are rare, but they continue to occur particularly in rural regions and aboriginal communities where operation and maintenance of water treatment and distribution systems are difficult. The frequency of waterborne outbreaks has substantially dropped in the past decade mainly due to the investments made to the water and wastewater infrastructure and training programs put in place for small system operators. As well, cold climate conditions present unique challenges for the design, installation, and operation of drinking water and wastewater systems.

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Skyline of downtown Santiago, the capital of Chile, featuring 300-meter high Gran Torre Santiago, the tallest skyscraper in Latin America, and Mapocho River, which divides the city in two parts. Photo credit: ©iStock.com/Phototreat.

Chile

Water security in Chilean cities: progress and pending challenges

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In the past four decades, the urban water sector in Chile has seen great progress in terms of water coverage and quality, as well as in wastewater treatment levels in the past 15 years. This progress has been driven by the country's economic stability and public policies that have encouraged the decentralized management of sanitation services. Despite improvements in the efficiency of sanitation companies, the theoretical reductions in rates that this should entail have yet to materialize. The population with least economic resources receives cross subsidies that help alleviate the situation and have made the privatization policies implemented in recent years viable. Likewise, the robustness of the supply system of many cities has been favored by the possibility that sanitation companies have of acquiring water rights from other users, which in practice has meant transfers from the agricultural to the urban sector. Some features of the Chilean system worth noting are the regulation of companies to prevent concentration, the powers of the Sanitation Services Superintendence and the procedure for setting rates. All these elements have allowed the satisfactory functioning of the health sector, the sustainability of companies and the high levels of coverage and quality of service achieved in the urban sector.

Despite this progress, a number of significant challenges have yet to be addressed. In some regions, the emergence of the industrial and mining sectors has posed a threat due to the transfer of water to this activity, although in the case of major cities in the north of Chile, institutional agreements have made it possible to ensure domestic supply. In the central zone, companies such as Aguas Andinas and ESVAL

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have achieved high coverage and reliability, and even in situations of drought such as that experienced by Chile since 2011, there have been no supply problems for the vast majority of the population. One matter of concern is small peri-urban localities, which often have local supply systems not attached to large regional companies, which are much more vulnerable to droughts and other supply disruptions. In some cases, these localities have had to be helped by water trucks, severely affecting the population's quality of life. These extreme cases are due more to specific deficiencies in terms of the security of certain sources and the investment capacity of these peri-urban systems than to structural problems in terms of the current institutional framework. Regarding the quality of urban waters, there is currently concern about the micropollutants present in drinking water sources that receive discharges of treated wastewater. Although attention has traditionally focused on the presence of organochlorine compounds, the presence of pharmaceutical compounds and personal care products has recently gained interest. Mainstream literature does not contain systematic measurements of this type of compounds in drinking water in Chile, probably because the analytical methods for quantification are not sufficiently available.

Rainwater management in Chile continues to revolve around the construction of large infrastructure works for the evacuation of water, with less funds being invested in detention and infiltration works. Likewise, non-structural measures such as better territorial planning are underrepresented, partly due to conflicts and gaps in the definition of competencies of several government entities, such as the Ministries of Housing and Public Works, and city halls and municipalities. Ideally, the country should move towards an integral conception of urban hydrology that seeks the sustainability of infrastructure and environmental services. An integral drainage system should consider the following: (1) local household control, (2) local retention on public land, (3) slow surface transportation, (4) larger-scale storage on public land, and (5) controlled conveyance by transport vehicles and subsequent discharge into receiving courses and bodies. Rainwater system planning, design and management are integral activities that must be carried out at the basin level, transcending administrative divisions and addressing the process from downstream. This avoids transferring problems downstream and favors the sustainability of long-term solutions.

Lastly, the climate change envisaged for a significant part of Chilean territory suggest that we must decisively advance an adaptation agenda at the national level, in order to preserve current average supply levels and improve the robustness of systems during periods of drought. This adaptation agenda should obviously contemplate local realities, but also be guided by common principles of reliability and preservation of ecosystem services under the concept of increasing global water security.

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Panoramic view of Bogota, Colombia. In the background the volcano Nevado de Tolima.
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Colombia

Urban Waters in Colombia

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According to the UN Report "Water for People, Water for Life", Colombia ranks 24 out of 203 countries. This ranking makes Colombia appear to be a world water power. However, IDEAM studies confirm that, despite its relatively favorable status of supply and water availability, it is characterized by a high spatio-temporal variability in the distribution of its water resources. Moreover, the conditions of plant cover, soils, land use and geological and hydrological characteristics of Colombian basins are extremely varied, as a result of which the country has hydrographic basins with varying regulation capacities. Thus, regions with the greatest water supply contain the lowest percentages of municipal capitals in the country, whereas those with less water are home to the largest percentage of the population (approximately 70%).

This variability in the water supply has led to signs of concern, and even alarm in certain municipalities and urban areas. Most urban aqueducts, usually supplied (more than 80%) by rivulets and streams, do not have watershed protection programs, or systems for water regulation and storage, transport or treatment.

The Colombian urban system has developed with limited environmental planning or considerations, with serious consequences for this area, as a result of disorderly occupation processes, and the heavy demand for resources this entails (Ministry of Environment, Housing and Territorial Development (MAVDT), 2008).

Of the total water demand in Colombia, urban areas or municipal seats account for 82% of

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domestic use, and the remainder for 18%. Moreover, 30.7% corresponds to domestic demand in the country's five main cities (Bogotá 13.6%, Cali 6.4%, Medellin 5.9%, Barranquilla 2.8% and Cartagena 2.0%). In 2011, potable water coverage for urban zones was estimated at 96% compared with just 56.3% in rural areas (DANE, 2012). According to a study by Defensoría del Pueblo (2005), only 18% of 959 municipalities comply with safe drinking water regulations. In the case of small urban centers, it was found that only 64% have an aqueduct and sewerage master plan, only 46% of which actually implement them (CRA, 2013).

According to an estimate of the amount of wastewater produced by urban centers, nearly 67 m3/s are deposited into water bodies, with Bogotá accounting for 15.3%, Antioquía 13%, Valle de Cauca 9.87% and the remaining departamentos less than 5%.

The country's shortfall in wastewater treatment is due both to the lack of wastewater treatment infrastructure and the low coverage of existing plants. Only 354 (33%) municipalities in the country have treatment systems, 29% of which are inoperant. It has been estimated that of the 159 m3/s of water collected nationwide, the volume of wastewater that receives treatment is approximately 5 m3/s, equivalent to 3.1%. Some of this wastewater has been reused, mainly for crop irrigation with little or no treatment. However, although technical feasibility studies have been undertaken and proposals submitted to reuse it, there is a lack of clarity regarding the issue.

Flooding in urban areas is one of the problems resulting from urbanization with the highest impact on the population and its lifestyle. In 2010 and 2011, the country experienced an unprecedented rainy season. During this 14-month period, 1734 flood events were recorded, corresponding to 45% of the events that occurred in the 1998-2008 decade. The number and scale of these events in such a short time created consequences that exceeded previously recorded events, claiming hundreds of lives and affecting over three million people (UNGRD, 1998-2011).

Although early warning systems are used to forecast rapid floods, Colombia has seen limited progress in this regard. An Early Warning System (SIATA) was installed in Medellín, the first in the country.

Some progress has been made with sustainable urban drainage, such as the preparation of standards and guidelines for environmental management in construction, environmental recognition programs for ECO-efficient buildings (PRECO), productive green roofs for vulnerable populations, wetlands built to control contamination from urban runoff, the implementation of linear parks and the establishment of ecological networks to functionally link public green areas in the urban area and integrate them with the natural vegetation fragments of the rural area.

Progress has also been made in the need to have urban planning processes that incorporate the analysis of the problems and potentialities of the basin into its various components, with a strong emphasis on processes.

The priority action is to plan the use of watersheds and microwatersheds, especially those that are highly urbanized, in order to guarantee water in sufficient quantity and quality and to have better environmental planning and, therefore, clear environmental guidelines for territorial planning.

It is necessary to control deforestation, and pesticide and fertilizer use in a rational way and encourage sustainable agriculture. Likewise, wastewater treatment plants must be built in all cities and towns to avoid polluting water sources and therefore be able to reuse the treated water. It is essential to implement more and better sustainable urban drainage solutions and adopt a system with a comprehensive vision of water use and management, in which the basin is considered the source of the resource. The population must be taught to about rational water use and water saving, while municipal administrations must be tasked with wastewater treatment and land use with an environmental approach.

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View of Costa Rica's capital city, San Jose, from the lower slopes of Volcan Poas. Photo credit: ©iStock.com/pilesasmiles.

Costa Rica

Urban Waters in Costa Rica

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With the exception of certain cities that suffer recurrent problems, the potable water supply in Costa Rica is fairly good. However, sanitation (particularly in relation to sewage treatment) is an issue that is only just beginning to be addressed. For many years the percentage of treated water did not exceed 4% across the entire country. These numbers have begun to change slightly as a result of the entry into operation of the Los Tajos treatment plant, benefitting 1,070,000 inhabitants of the Greater Metropolitan Area; however, a great deal remains to be done. As for health, many of the reasons for its good rates are related to the social health system, although credit must also be given to the effect of the widespread availability of drinking water in urban areas.

It is essential to restore the rivers in urban areas. Although Costa Rica has prided itself on being a green country, it suffers from sharp contrasts in its environmental policies with respect to rivers. Greater awareness of the problem of sewage treatment is necessary and more resources must be invested in treatment plants in urban areas. Urban river pollution is perhaps the most serious problem related to water resources in urban waters.

Costa Rica is affected by several large-scale natural climatic phenomena such as El Niño-Southern Oscillation, Atlantic climate variations, the position of the Intertropical Convergence Center (a strip of large amounts of rainfall where the North and South winds converge) and the Trade Winds, represented by the Caribbean Low Level Jet. Likewise, in recent decades, Central America has experienced changes in hydrometeorological variables that suggest anthropic influences. Temperature trends towards warmer nights and days are fairly consistent, while trends in

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precipitation (rain) have been less consistent and unclear. Moreover, in the capital of Costa Rica (San José) and the capital of Honduras (Tegucigalpa), significant surface runoff reductions have been found since the 1980s. This translates into a growing reduction in water availability and an increase in aridity.

Although there tends to be a great deal of uncertainty about this part of the world, projections with climate models point to a drier Central America by the end of the century, especially in the north (Honduras), whereas in the southern part (Costa Rica) reductions are likely to be less severe. Recent analyses have shown that Panama could be wetter by the end of the century. This is related to the country's general positioning further south of the Intertropical Convergence Center. These changes become more significant when examined in light of the socioeconomic differences between northern and southern Central America, and when the vulnerabilities characteristic of countries in the region are considered, such as dependence on subsistence agriculture in certain regions or society's vulnerability to extreme hydroclimatic events. On this last point, Central America is expected to have a significant increase in extreme events such as droughts and floods. This could be exacerbated by the lack of investment in infrastructure and anthropogenic modifications to land use such as deforestation and those associated with inadequate urban planning.

As for urban flooding, more studies are required to provide a solution to these problems. Each basin has specific characteristics, making it difficult to find a "one-size-fits-all" solution. In some places, builders of new housing developments are being obliged to provide rainwater disposal systems. This is usually done through infiltration lagoons. Unfortunately, in some cases these lagoons are abandoned once building permits have been approved, meaning that better control is required through municipalities and ministries to ensure their proper functioning.

The risks of climatic variability associated with natural causes, such as the repercussions associated with El Niño or La Niña events, can be reduced by the preparedness offered by medium-term seasonal forecasts, which provide advance knowledge of future hydroclimatic conditions in many regions of the isthmus. Although the quality and certainty of these forecasts varies throughout the year, they are currently used by Central American countries to make decisions in several key sectors of society, with good results. Using the information from these forecasts can help prevent severe impacts on agriculture, hydroelectric generation, water supply, health and other aspects. Adapting to natural climate variability is a great step for adaptation to anthropic climate change, given that the dynamism of changes at the seasonal, inter-annual and inter-decadal level allows society to explore its resilience to different types of threats, which in principle should help to increase its adaptive capacity and reduce vulnerabilities. It is essential, however, to incorporate aspects related to the projected climate change into integrated water resource planning. Due to the uncertainty of climate change projections, a planning mechanism is needed that will includes adaptive water resource management in which long-term climate projections guide planning in the shorter term. It will also be necessary to consider the interaction of the various time scales. For example, a decadal oscillation associated with much higher than normal rainfall for a period of 10-15 years can effectively counteract a drought associated with climate change for that period. Climate projections and short-term planning are periodically reviewed in order to be able to continue advancing.

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Panoramic view over Havana. Down to the left it is possible to see the chamber of the groundwater grid, used to impede the entrance of objects and sands into the siphon through the tunnel which crosses the bay from one side to the other.
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Cuba

Aquifer Management in Islands in the Humid Tropics: The Urban Water Cycle in Havana, Cuba

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Potable Water System

The potable water supply system in Havana, the capital of Cuba, is distributed among four aqueducts supplying 99.7% of the population. A total of 99.1% of the population receive water that undergone adequate.

Water is supplied through nearly 4,000 km of pipelines and the main local networks. Some of these pipelines have been used for over 100 years, since the Albear Aqueduct was considered one of the Seven Wonders of Cuban Engineering and awarded the Gold Medal at the World Fair in Paris in 1878. It diverts the karst springs from the discharge zone of the Vento aquifer gravitationally, guaranteeing nearly 19% of demand in Havana since the end of the 19th century. The remaining systems require high-flow pumps, some of which are just over 50 km from the capital, including El Gato in the Jaruco basin. A common feature of the city's water supply is that all groundwater comes from karst aquifers (three inland ones, developed in karstic fields and a fourth in a coastal plain).

Improving the water supply system in Havana combines an engineering and sanitation program established within a price adjustment policy designed to achieve the following: 1) Modification of state and private sector tariffs, 2) Rehabilitation of the aqueduct system, including the restoration of 3,200 km over the next 12 years, and 3) Reuse of nearly 3 m3 per second of the wastewater to be used, until the assessment of the induced artificial recharge of the Vento basin has been completed. The aim is to provide a reliable water source that will guarantee the safe performance of the aquifer.

To date, 692 km of local water networks have been rehabilitated using HDPE technology, mainly in areas with low supply and low pressure. The construction and repair of 3,200 km of pipelines, including 2,422 km of networks in inadequate conditions, in addition to a

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235 km extension, remain pending. The rehabilitation/expansion of 20% (543 km) of sewerage systems is planned and a project to rehabilitate 898 km of the network is also being designed.

Sewerage works

The central wastewater network has a total length of 1,130 km. This network and its ramifications supply domestic wastewater through physical and mechanical treatment processes before being discharged into the ocean through a submerged tunnel at a depth of 10.7 meters and a distance of 147 meters from the coast. Havana's Sewage Tunnel, built between May 1911 and April 1912 and with a length of 375 meters, was built in the rocks under the bay and the city of Casablanca, on the east side of the bay. The tunnel gravitationally discharges nearly 110 Hm3 of wastewater per year to a pumping system by impulsion.

Cámara de rejas subterránea, destinada a evitar la entrada de objetos y arenas al sifón que a traves de un túnel atraviesa la bahía, de un lado a otro, Fuente: Juan de las Cuevas y colaboradores. Publicación de la Oficina del Historiador de la Ciudad de La Habana, Cuba, año 2012, pág. 38-56. Fotografía: Cortesía de Lissette Solorzano

Status of water-related diseases in Cuba (Havana)

Cubans have a high life expectancy at birth (77.97 years). The incidence of infectious diseases and mortality is low, and the infant mortality rate is extremely low (4.5/1,000 live births). Fifteen infectious diseases have been eliminated in Cuba and another eight occur so rarely that they do not pose a public health problem (fewer than 0.1/100,000 inhabitants).

The first cases of cholera outbreaks in Cuba were reported in July 2012. By January 14, 2013, a total of 51 cases had been confirmed, all characterized as *Vibrio cholerae* serogroup O1 biotype ElTor enterotoxigenic serotype Ogawa. The outbreak in Havana was the result of poor food handling.

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Doves flying over main square with Columbus statue, Santo Domingo, Dominican Republic.
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Dominican Republic

Urban Waters in the Dominican Republic

Eleuterio Martínez[1] y Juan Ramón Valenzuela[2]

Santo Domingo, the oldest of the capitals of the Americas and the largest in the Caribbean, is currently undergoing the largest urban metamorphosis in its history due to unprecedented vertical growth and exponential spontaneous growth on its periphery. The resulting pressure on drinking water facilities and sewage disposal is creating an unprecedented crisis in these services.

Of the 10.27 million inhabitants of the Dominican Republic (2018), 82.18% live in urban sectors and 18.6% in rural areas. Greater Santo Domingo is home to 3.5 million people, accounting for 42% of the urban population and 31% of the overall population, whereas 8% of the country's total population lives in Santiago de los Caballeros, the second largest city. Together they concentrate 50% of the country's urban population.

The Dominican Republic has an average annual rainfall of 1,500 millimeters, slightly less than that of South America (1,560 millimeters/year) and much higher than the world average (970 millimeters/year), which implies an annual inflow of 73 km3 of water, of which 47 km3 evaporate and 2.5 km3 reach the water table, leaving 23.5 km3 of runoff availability. The overall water supply is therefore 2,676 m3 per person per year.

The potable water supply systems for country's main urban areas provide the National District and the province of Santo Domingo with an approximate daily flow of between 18.0 and 22.0 m3/s, to supply a population of over 3.5 million inhabitants, which wastes between 54% and 60%, partly because of leaks due to obsolescence in the distribution network lines.

The volume of water actually used in this metropolis varies between 9.0 and 12.0 million m3 per day. All this indicates that, if Santo Domingo had a permanent policy of citizen education oriented towards the saving and responsible use of its waters, associated with an effective leak correction program, there would be no shortages, as is the case today, even in the worst scenario.

The Dominican Republic has complied with the Millennium Development Goals (2000-2015), achieving access to drinking water and sanitation. In 2015, approximately 93% of the population used improved sources of drinking water and 82% had improved sanitation services.

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The basic infrastructure in the sector comprises 399 drinking water systems, 314 operated by INAPA and 85 by CORAAS. There are also 56 sewage systems, 25 run by INAPA and 31 by CORAAS. INAPA is responsible for a greater share of service delivery to the rural population, while CORAAS covers a much larger sector of the urban population, particularly because of the importance of CAASD's catchment area.

INAPA's potable water systems benefit 1,111 communities (814 rural and 297 urban), 63% of whose systems are driven by pumping, 30% by gravity and 7% by mixed methods, while CAASD reports that only 5% of the capital city currently has wastewater treatment services. Approximately 18% of the streets - roughly 726 km - have networks out of a total of 4,279 km. In the rest of the country, the situation is as follows: only 21% of the population have sewage networks, 160 thousand homes have no waste disposal and only 14 of the 56 treatment plants operate in the country's 393 cities.

In order to comply with the 2030 Agenda for Sustainable Development Goals, Dominican Republic will focus on the emerging impacts of global climate changes on the country and, in particular, the main human settlements.

For the particular case of the city of Santo Domingo, CAASD has drawn up a Master Plan for Wastewater Treatment. On April 12, 2016, President Danilo Medina inaugurated the Río Ozama, Mirador Norte-La Zurza Wastewater Treatment Plant, which will benefit over 450,000 residents in the sectors located in the northern area of the National District and parts of the Santo Domingo Norte municipality. It is scheduled to begin operating in April 2018 and to operate fully as of October of this year. It will treat the waters of 54 industries that pour directly into the Isabela River, the main source of pollution in the Dominican capital.

This plant will treat 1.2 m3/s of sewage from sectors such as Cristo Rey, La Zurza, April 24, Simón Bolívar, Ensanche La Fe, Villa Juana, Villa Agrícolas, Villa Consuelo, Los Guarícanos, Sabana Perdida and Villa Mella. Work is also being carried out on the renovation of approximately 80 ravines and construction of 13 wastewater treatment systems in Greater Santo Domingo.

The Plan also includes the rehabilitation of 218 km of networks, the expansion of 3,340 km of secondary and tertiary networks and 535,700 residential connections, the installation of 306 km of main and trunk networks, and sanitary waste interceptors, the installation of 34 pumping stations, the rehabilitation of 12 treatment plants, the construction of seven new treatment plants and the installation of four more underwater emissaries.

As for the supply, the Potable Water and Sewerage Corporations cover 16% of the country, yet serve 54% of the Dominican population.

CAASD and CORAASAN, responsible for Santo Domingo and Santiago respectively, supply 45% of the national population and transport 39% of the total flow produced; while the other five CORAS (CORAABO, CORAAMOCA, COAAROM, CORAAPLATA and CORAAVEGA) supply 14% of the Dominican population, with 11% of the national flow of drinking water.

In the remainder of the country, INAPA covers 25 of the 32 provinces in Dominican Republic (80%), including rural areas and other communities served by other unregulated operators (community aqueducts). It covers 84% of national territory and supplies 41% of the population, 26% in urban areas and 15% in rural areas, through 116 aqueducts or urban and 252 rural potable water supply systems.

The Dominican capital, home almost half of the city's population, is built on stepped marine terraces that facilitate the drainage of residential and industrial sewage and rainwater by gravity. However, the inadequate and obsolete infrastructure of the sewerage system is driving water pollution to extremely critical levels.

Every year, during the cyclone season (June-November), drainage systems collapse and floods affect the city, exposing the population to numerous diseases and epidemics, showing that the challenge remains and addressing it requires ingenuity, resources and, above all, proper planning.

Lastly, it should be noted that Dominican Republic is awaiting the approval and passage of two laws that have been in the legislative chambers for 17 years: the Sectoral Water Law and the Potable Water and Sanitation Law.

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Distant view of Volcano San Vicente and Lake Ilopango near the city of San Salvador.
Photo credit: ©iStock.com/GomezDavid.

El Salvador

Overview of Urban Waters in El Salvador

Julio César Quiñonez Basagoitia[1]

From the perspective of urban waters, the hydrological-environmental problems in the Metropolitan Area of San Salvador (AMSS) -which concentrates 27% of the population of El Salvador- have mainly arisen as a result of the difficulties and obstacles caused by political and economic interests that have historically hampered efforts to achieve environmentally regulated and balanced urban development planning.

This situation, coupled with legal gaps and institutional weaknesses, has led to a significant change in land use and impacts due to urban growth and high intervention modalities, reflected in the gradual deterioration of forested areas essential for recharging the San Salvador aquifer, the maintenance of ecological and environmental protection areas, and the preservation of water sources, located mainly in the south-east of the capital and the basins to the south-west comprising the foothills of the Cordillera del Bálsamo as far as the coastal plain. This situation has resulted in a gradual decrease in the groundwater levels of the San Salvador aquifer by approximately 1m/year (Coto, 1994), with declines of 2.47m/year for San Salvador and 1.47m/year for Soyapango (Arévalo and Vásquez, 2005). The lower-middle zones of the Acelhuate River basin have experienced the greatest impact, reflecting the low productivity or disuse of some of the wells located in the municipalities of Soyapango and San Marcos (Barrera, 2010). In April 2016, the National Administration of Aqueducts and Sewers (ANDA) announced it was experiencing great difficulty in supplying sectors of the AMSS, due to the drastic reduction in the levels of the wells and the low productivity of the latter, which forced it to adopt emergency palliative measures. This situation is reflected in the fact that in 2009, ANDA reported water production for the AMSS of 192.9 mt3, which has been decreasing annually, with levels of 176.2 m3 being reported in 2015 (ANDA Statistical Bulletin, 2016). This hydric-environmental deterioration also affects and accentuates the hydrological risks due to flooding in the lower areas of the AMSS (MARN, 2013; Erazo, 2009), which in recent years has claimed human lives and caused material damage, as well as requiring a constant increase in the budgetary allocations to the Public Works portfolio, allocated for the construction of protection, regulation and mitigation works. According to the study, the waterproofed areas

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between 1998 and 2009, with an area of 5.53 Km2 in sensitive and protected zones, have lead to an increase of up to 98% in peak flows and a 40% reduction in the time of occurrence. At the same time, maintenance of surface flows and base flows in the dry season has also significantly declined at the national level, with some rivers at the risk of disappearing in the short or medium term (SNET-MARN, 2005).

Some hydric-environmental planning initiatives in the AMSS, which began to emerge in the 70s -such as METROPLAN-80, drafted in 1969, PLAMDARH-1982 and PLAMADUR-1996, describe attempts to steer development in a different direction, since they conceived of urban growth from an environmental sustainability perspective.

However, these were gradually modified, replaced or adjusted to the new economic dynamics imposed by Urban Land Markets (Lungo, 1998), which exponentially increased the price per square yard of land in the former coffee farms located in the southwest of San Salvador, and acquired the capacity to direct urban growth, outside any socio-environmental planning on the part of the state. Along the same lines, the municipal guidelines for Environmental Zoning and Land Use established by the MARN-2013 for the southwest zone of the AMSS undertook a recategorization, whereby major portions previously conceived in the PLAMADUR-96 as subject to “maximum protection” were presented as “continuous urban areas” and “areas to be rehabilitated” (parts of the El Espino estate), reflecting the adaptation and adjustment of current environmental planning plans to the logic of extensive urban growth and high intervention.

This situation, which is also mirrored in the AMSS, is projected and reproduced in the rest of the country, severely impacting the quality of river water. According to the Monitoring Program for Surface Water Quality at the national level, which MARN has been implementing since 2006, rivers have a very low water quality. The latest report, submitted in December 2017, reports a substantial decrease in the flows suitable for purification by conventional methods, for irrigation and recreational uses. At the same time, recent years have seen a steady increase in pollution in the San Antonio and El Jute rivers, located in the South-West zone of the AMSS, precisely in the vicinity of the urban sprawl that is spreading onto the Balsam mountain range, with the attendant deterioration of its basins that extend as far as the coastal plain. Until a few years ago, these rivers were considered clean, within a natural environment, carriers of local water resources and appreciated for their scenic and recreational value.

In general, the pollution of rivers and aquifers, mainly due to direct discharges into water bodies, widespread agrochemical use and a low level of wastewater treatment - reported as 8.9% for the country as a whole (FOCARD- 2013) -, is a fundamental issue that is becoming increasingly more complex due to its interrelation and growing impact on other key aspects of national life such as: water availability for human consumption and irrigation, health, food production, recreation and ecosystem maintenance.

Given the current situation of urban waters and their status in the rest of the country, and in order to chart a new course that will reverse this problem, the MARN implemented the National Plan for Integrated Water Resource Management (PNGIRH-MARN 2015). The Plan undertakes a diagnosis and analysis of the water situation, identifies the pressures exerted on its availability, and formulates the prioritization and focusing of short and medium term actions, including the project to decontaminate the Acelhuate River, the main source of contaminated water in the AMSS. It estimates an overall investment for implementing structural and non-structural measures at the national level, in the order of $800 million USD.

However, in order to make this kind of initiatives viable, it is important to discuss and approve the General Water Law, which must reflect the country’s hydric-environmental reality, and the principles and objectives of planning with a focus on equity, public governance of water, citizen and sectoral participation and sustainable development. It is also necessary to intensify the actions and coordination of joint work among institutions, dialogue with the various actors, produce information and review the by-laws and regulations that prioritize the construction of environmentally integrated projects. A short-term objective should focus on strengthening research and methodological capacities in universities and academia, as an area that will enhance sustainable architectural implementations, the ecological design of cities, the socialization of knowledge, the modernization of processes, and the management and development of technologies that will enable better management, and the preservation and planning of urban waters and water resources at the national level.

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St. George's is the Capital City of Grenada. In 2004, Hurricane Ivan caused widespread damage in the Caribbean, and Grenada suffered serious economic repercussions. Photo credit: ©iStock.com/Flavio Vallenari.

Grenada

Impact of development on water supply and treatment in Grenada

Martin S. Forde[1]

1. Background

Urbanization is not limited to developed countries but is also occurring in many developing nations including those located within the Caribbean region. Indeed, the Caribbean is one of the most urbanized regions in the world with approximately 69% residing in urban settings.

Fundamentally, Grenada has an abundance of freshwater resources, however, several challenges currently exist in the management of these resources. These challenges range from managing growing urban centers, particular in the south of the main island, to legislative (e.g., no holistic over-arching water management legislation currently exists) and administrative issues (the sole water provider is also responsible for evaluation of water provisioning services). Further, Grenada's difficult mountainous terrain poses several logistical and practical challenges in trying to pipe water from sources to distal areas where the demand exists.

Grenada is mostly of volcanic origin with a mountainous center which quickly descends towards the flatter coastline. Approximately 70% of the mountain slopes in Grenada have a gradient greater than 20˚ which predisposes terrestrial resources to rapid water runoff and land degradation. Steep mountain peaks, sharp ridges and deep narrow valleys sloping towards the coastline thus characterize the topography of the island. Further, due to the very short 10 km average distance from the mountain peaks to the coast, there is low soil water holding capacity. The coastline itself is ringed by extensive coral reefs.

Seasonal shifts in the trade winds give rise to two main seasons––a dry season, which runs from January to May, and a wet season which runs from June to December. Approximately 77% of the annual rainfall occurs in the wet season. Grenada thus experiences a marked spatial variation in rainfall pattern due to differences in orthographic elevations. The high mountainous areas are cooler compared to the low coastline areas which are warmer. Annual evapotranspiration has been estimated to vary from 1000 to 1500 mm. High rainfall intensities are common and this leads to severe soil erosion on the sloping lands. Mountainous areas can experience an average of about 3,880 mm whereas lower areas along the northern and southern coastline can experience a much lower average of 1,125 mm annually.

This gives rise to different climatic zones. Some parts of the island experience moderately warm temperatures between 20˚C and 22.5˚C, no dry season,

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and rainfall in excess of 4000 mm whereas other parts of the island are characterized by very warm temperatures over 27.5°C, a long dry season, and rainfall ranging between 700 mm and 1000 mm.

2. Problems caused by Urbanization on the Water Sector

Urbanization, and more generally ongoing economic development, particularly in the tourism industry, when coupled with continued demographic growth has led to rising demand for potable water and challenges in managing Grenada's water resources. Over the past 30 years, maintenance and needed upgrades to water resource infrastructure has not kept pace with the demands that have been placed upon them. As a result, the present water supply system is not adequately resilient to ensure that supply for good quality water in the quantities required are met, especially in the dry season. This situation is further compounded by poor enforcement of water resource management regulations and the very weak financial position of the water managing agency, the National Water and Sewage Authority (NAWASA), who is mandated to provide and maintenance adequate water resources to the public.

In a recent review of Grenada's water sector done in 2007, four key challenges for the sustainability of integrated water resources management and water services were identified:

a. Financial Sustainability: The government of Grenada's historically poor and limited access to financial resources has meant that it has been very difficult to source sufficient funds to finance the necessary capital investments needed to ensure the adequate provision of infrastructure for water resources, as well as find the funds to carry out needed maintenance and eventual replacement of water resources as these suffer wear and tear.
b. Institutional Sustainability: In Grenada, the same agency that supplies water to the country also regulates itself. There is thus a need to establish an independent water resources management unit that can do water mapping, demand projection, and water quality assurance testing.
c. Operational Sustainability: This is contingent of the pricing of water services to recover full costs and investing the capital raised in operations and maintenance to provide better service standards. As it currently stands, the government sets the rates that the water utility NAWASA can charge which does not match the costs incurred to produce and deliver quality water to the local population.
d. Technical Sustainability: While a range of solutions may be available, these need to be carefully reviewed to ensure that they are financial feasible and meet the needs of the local population taking into account that any solution usually involves behavioral adaptation and therefore must be cultural acceptable

3. Water Service Challenges and Solutions

Fundamentally, Grenada has an abundance of freshwater resources. Urbanization, per se, does not pose a significant challenge for the Grenadian water service. Nonetheless, the management and financial maintenance of these resources poses significant challenges and, as a result, water supply problems continue to prevail.

Reducing water demand and improving resident resilience to water supply problems are two options for improving the present situation. Another technical approach to reduce water demand is to reduce leakage of the present distribution system. Additionally, policies can be devised and implemented to promote the efficient use of water or to persuade residents to collect and use rainwater.

4. Recommendations

Based on the above outlined challenges in trying to provide both the quantity and quality of water for a growing urban population in Grenada, the following recommendations are made:

a. For the proper and effective management of water resources, holistic, over-arching water-management legislation has to be passed and enacted.
b. The provisioning of water and the regulation of such a service should not be vested in the same entity. The latter needs to set up to act independently of the former to ensure proper oversight and effective monitoring of the quality of water that is being produced for the population.
c. Policies and programs should be implemented to help locals better utilize the potential of using Rainwater harvesting systems so that these can firstly help reduce the demand load on the water utility for pipe-borne water, and secondly help provide increased water security to locals especially during periods of water shortage.

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Guatemala City. People rest and shop on the "Parque Central", fountain and the National Palace's monumental facade. Photo credit: ©iStock.com/mtcurado.

Guatemala

Urban Waters in Guatemala

Manuel Basterrechea,[1] Carlos Cobos[2] y Norma Gil[3]

In 2016, it was estimated that there were 16 million inhabitants in Guatemala, 53% of whom lived in cities, and approximately three million of whom lived in the capital and neighboring municipalities. It is estimated that approximately 70% of the population will live in urban spaces in 2030 and that there will be nine intermediate cities -from half to over one million inhabitants- that will require water supply and sanitation.

Since the country is located in the middle of two oceans and crossed by the Andes mountain range, it has an abrupt topography, with several cities located on the high plateau (upper part of the river basins), where the main source of water is groundwater. The remaining municipal capitals are located in the middle and lower parts, where there is greater availability of surface water, although this is contaminated by point and non-point sources, whose middle and upper parts have not been treated; groundwater is also a major source of supply for the population and economic activities.

The integral approach to urban water is as yet incipient in the country while the related information making it possible to diagnose the impact caused by urbanization has focused on the capital city and neighboring municipalities - metropolitan area (MA). The urban growth of Guatemala City since its founding in 1776, particularly of other municipalities in the MA in the past four decades, has led to the reduction of water infiltration due to the waterproofing and overexploitation of aquifers as a result of growing demand, the contamination of surface and underground sources, the discharge of untreated wastewater and access to new water sources outside its jurisdiction, which creates conflicts.

In the first case, the solution to the problem depends mainly on organizing the use of aquifers through various management instruments, whose application is a result of the consensus between parties, and on encouraging the infiltration and reuse of rainwater from waterproofed areas. In the

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second case, treatment plants should be rehabilitated and built while the technicians who operate the treatment systems should be trained. In the third case - access to new sources - it will be necessary to consider allocation and compensation mechanisms.

Intermediate cities will be further conditioned by the effects of climate variability with higher and more frequent rainfall intensities, which poses complex challenges for the municipal structure for urban water management. As a result of urban sprawl and climate variability, municipalities are usually exceeded as regards service provision, especially as regards storm drains, sanitation and drinking water provision.

Unless they are planned, the nine intermediate cities will grow in the same way as the MA has done, and water sources will probably be depleted, contaminated by misuse, while abuse will create shortages and conflicts (*Revista Contrapoder*, September 8, 2016).

Supplying water and sanitation to the MA and intermediate cities therefore requires a coordinated effort among municipalities because continuing to exploit groundwater in the way this has been done to date is unsustainable unless infiltration is promoted by natural and artificial means and improvements are made to both demand (lower consumption per capita) and supply (fewer leakages and illegal connections). Another line of action is to achieve the treatment of all wastewater. The million-dollar investment that will be required should be shared by the wastewater producers. Research on the causes and effects of urbanization and the measures to be taken should be promoted among education centers and universities, which will yield significant results in the planning of the intermediate cities.

The Water Conservation Fund initiative was recently launched in the metropolitan region of Guatemala (FONCAGUA). The fund is a financial mechanism for investing in green infrastructure (soil, forest and water protection, best practices in production systems, water harvesting and water recharge infrastructure, strengthening of governance and institutionalization, water conservation education). The model envisions that large water users will be willing to contribute financial resources to strengthen the fund. In order to design and start up FONCAGUA, a promotion group has been set up, comprising private companies, public authorities, local governments, academic institutions and NGOs.

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Honduras

Urban water management in Honduras: The case of Tegucigalpa

Marco Antonio Blair Chávez[1] y Manuel Figueroa[2]

1. Introduction

This case study focuses on Urban Water Management in the Metropolitan Zone of the Central District comprising the cities of Tegucigalpa and Comayagüela, the capital of Honduras, with 1.21 million inhabitants (INE, 2013).

Honduras is a privileged country, with coasts on the Atlantic and Pacific oceans; a varied climate, ranging from humid warm tropical to dry temperate tropical and tropical savanna on the Pacific coast; with abundant, irregularly distributed water resources. It has three main characteristics: a very young population, an older population in rural areas and a majority of females.

2. Water sources in urban areas and the impacts of urbanization

In the capital of Honduras, problems arise due to population distribution , which does not correspond to water source availability and to critical problems in specific zones, such as informal settlements and periurban areas. In the Central District, the National Autonomous Service of Aqueducts and Sewers (SANAA) provides potable water service by gravity to 120,204 users, (50% PU). The service is rationed, with continuous interruptions due to network failures and pressure limitations, and has low water availability. The rest of the urban population is self-supplied with water by tanker trucks.

The impacts of urban development are reflected in the quantity and quality of water, due to open discharges or improper urban and industrial wastewater disposal, and lack of treatment; the waterproofing of urbanized areas (paving, roof areas); illegal wastewater and rainwater connections; street cleaning: gullies used as garbage deposits and flooding in the low parts of the city with highly contaminated water.

In addition to the National Autonomous Aqueduct and Sewerage Service (SANAA), water supply service in the Central District Municipality is also provided through Water Management Boards and tanker trucks.

3. Drinking Water service in the Central District urban zone

SANAA is the official decentralized institution of the Central Government responsible for administering the systems to supply water to the population

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of the urban area of the Metropolitan District, where many problems arise due to the inequality of population density and the high socioeconomic contrast in the latter, and developing districts with high population density that increases the already high demand for water.

The Framework Law of the Potable Water Sector and its Regulations (Legislative Decree N° 118-2003, National Congress of Honduras, January 2004) establishes the creation of the National Water and Sanitation Council (CONASA), the Regulating Body for Drinking Water Services and Sanitation (ERSAPS). It also adapts the legal and institutional framework of the drinking water and sanitation sector, creating the Municipal Commission for Water and Sanitation (COMAS) and the Local Supervision and Control Unit (USCL), both with jurisdiction throughout the municipality.

The municipal systems administered by SANAA are conventional, with individual house connections. Within the Central District Metropolitan Area, unconventional systems include tanker trucks, public tap banks, and the free sale of water from trucks artisanally adapted with cisterns. In the capital of Honduras, SANAA coverage of households with individual house connections amounts to 55%.

The per capita cost of service provision according to the degree of coverage establishes a differential relationship based on the client's economic status, creating four categories based on measured consumption, using the simple rule of "the more you use, the more you pay". Service categories include domestic, commercial, industrial, government, trusts and Water Boards.

In the Metropolitan Area of the Central District, the typology of the water supply system is based on gravity, influenced by its geomorphology. However, in addition to SANAA, there are also Water Boards operating small decentralized systems with groundwater sources. The characteristics of the services in terms of continuity, water quality, pressure, leakage from the drinking water network, among others, have been evaluated by the Regulating Body (ERSAPS).

Water use in the Metropolitan Area of the Central District comprises the following categories: domestic, commercial, industrial, public. SANAA establishes prohibitions on wasting water, imposing sanctions ranging from fines to service suspension. The ongoing water supply problem, for the population connected to SANAA's municipal network, is related to the rationing of the water supply, which is exacerbated in the summer.

4. Water treatment in cities

Treatment coverage for purifying water from the municipal network administered by SANAA is 100%. The network consists of five subsystems, each equipped with its own water purification plant. Treatment coverage for water purification is universal and there is no difference by economic level of the population to be served.

SANAA's treatment plants are conventional systems that include individual processes of coagulation, flocculation and disinfection requiring the use of chemical inputs. Treatment plants for purifying wastewater in a sector of the sewerage system in the capital city are aerobic, oxygen being the only input required for their operation.

Honduras has "Technical Standards for Wastewater Discharges into Receiving Bodies and Sewerage," which have regulated the values of liquid effluents of WPPs since 1997. According to the Tegucigalpa, D.C. Sewage Master Plan (SANAA, 1980), a WPP of 50 thousand m^3 of per day was built. In the private sector, there are small Wastewater Discharge Plants (PDARs) that have collapsed, becoming sources of environmental contamination.

5. Water and Health in Honduras

Hondurans' health is affected by both the scarcity and abundance of water. Inhabitants of neighborhoods located in the hills and high parts of the periurban neighborhoods have no potable water service or sewage system. Since many homes lack even latrines, sewage is washed away by rain to the neighborhoods below, polluting the streets before reaching the nearest gully. The health consequences are obvious: childhood diarrhea is the leading cause of death in the under-5s; while intestinal parasitism, amoebiasis, is common in childhood and even in adults. The mortality rate in Honduras is 19.85 per thousand births, (Secretariat of Health, 2013).

6. Climate Variability and Change

Climate change has increased the vulnerability of cities, as borne out by the capital of Honduras. The rainfall pattern is one of climate factors that has been most severely altered by climate change, causing serious problems in major cities. The flooding and destruction caused by Hurricane Mitch in Tegucigalpa and Comayagüela in 1998 serve as a reminder of the catastrophic impact of extreme weather events on urban areas.

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View of Mexico City, which, centuries ago, was a beautiful lake. Photo credit: ©iStock.com/ isitsharp.

Mexico

Urban Waters in Mexico

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Mexico is a country with unequal access to water and sanitation, as shown by some of the facts that have been presented. The outlook may worsen, especially because the urban population is expected to continue to grow, placing increasing pressure on urban development and water service provision, particularly in parts of the country where water is already scarce.

A key finding to proceed to better decision-making on urban water management is the need to have appropriate information for this use. This requires a change in the way databases are constructed, rather than new or different ways of obtaining data.

In Mexico, efforts should be made to ensure that the human right to water is fulfilled as regards access, coverage, quality and affordability. However, in certain areas where access is precarious, it has been observed that this is only possible through the creation of new forms of water supply, such as commercialization through water trucks or community arrangements for the construction, maintenance and operation of the local system, usually based on high investment by the settlers themselves and self-management regulations that include monitoring, surveillance of the system and the implementation of sanctions.

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Given the above scenario, water governance becomes important in achieving an equitable distribution of water based on access to water as a human right. And despite the fact that in recent years, water policy has undergone profound changes through the decentralization of the provision of public drinking water, the growth of water demand in metropolitan areas and securing the population's participation in problem-solving poses an enormous challenge for local and federal authorities. Efforts to improve the governance framework of urban water services and implement demand management mechanisms should therefore be at least as great as those still devoted to major projects for transporting the water flow between basins.

As mentioned earlier, Mexico produces approximately 1.5% of greenhouse gases yet is one of the countries most vulnerable to climate change. In urban areas, the effects of climate change will be increased and intensified by other processes that will make them more dangerous, meaning that a comprehensive prospective view of the vulnerability of cities in Mexico must be implemented. One might assume that the most vulnerable areas are rural areas, due to their historical conditions of poverty and marginalization. However, some of the most vulnerable regions are in fact some of the country's major cities, mainly due to constant population growth, urban concentration and the location of cities in areas with scant or overexploited water resources, which increase settlements in high-risk areas due to climate change impacts, and therefore expand their degree of exposure. The three levels of government should therefore improve their coordinated action to optimize and manage land use practices, and implement new urban planning models that take into account the impacts of climate variability and enable storm water runoff to be more effectively managed.

In regard to water and health, although progress has been observed in the declining rates of intestinal infectious diseases, much remains to be done since other diseases such as typhoid or salmonella cases have increased. Certain programs such as the Clean Water Program should be reinforced while new programs that promote increased drinking water coverage should be implemented.

On the other hand, as we have seen, not all cities can afford large pressure aqueducts. These also create social and environmental damage in the basins of origin and along the route of the aqueducts, in many cases increasing the use of energy for pumping and water treatment. The design of such projects on the grounds of "substituting sources" must not be interpreted as abandoning the mandate to control groundwater extraction and discharges into surface bodies.

The financial area must be reformed to help give operators stability and incentives for increasing their efficiency. Nowadays, a system that has been damaged due to poor decisions in the past can always be restored through federal funds, provided that the city has the political and financial negotiating capacity to arrange for this. Subsidy programs should gradually be implemented in conjunction with performance enhancements to promote the professionalization of municipalities and agencies in the administration of the systems. Likewise, although the Mexican government has made enormous efforts to increase coverage and improve the performance of municipal systems, huge challenges remain to ensuring sustainable, quality services. There is an urgent need to implement an effective system for the protection, restoration and preservation of national waters that will reverse the imbalance of numerous hydrological basins and aquifers. It will do little good to seek greater energy efficiency in extraction if groundwater levels continue to decline and quality, reliable sources are increasingly distant and vulnerable. There will be never be enough water if we lose clean water sources.

Likewise, a radical institutional reform should be promoted in municipalities and states to clarify the responsibilities of each organ or order of government for citizens. Operators should have operational clarity and independence, sufficient resources and performance-linked budgetary support, while municipal and state authorities should focus on regulating rates and the performance itself, but without continually interfering with operational decisions and the administration of systems. Users should be entitled to learn about and understand the status of their water and sanitation systems, participate in decisions and demand that they provide quality services at a fair price, insofar as they also undertake to comply with the payment and proper use of services.

A key point is agency boards of directors, which should be integrated into medium-sized cities with citizens who can really professionally support the proper running of systems, using good corporate governance practices and establishing mechanisms to ensure that councils are held accountable, particularly if they are citizens. Local political authorities should be fully responsible for the state of the assets and flows of operating organizations, and accountable for their delivery to the following municipal administration. Better communication mechanisms, such as citizens' water observatories, can help construct a mature, informed dialogue between authorities, operators and citizens.

Among the challenges derived from the physical aspects of water is the lack of criteria for determining appropriate volumes for efficient use, on the basis of which programs can be established in cities to ensure efficient water use. This would not only save water but also the energy used for transporting, purifying and treating it. On the other hand, and as yet barely acknowledged nationwide, there is the importance of water reuse in Mexican cities. In comparison with many other countries (Jiménez and Asano, 1998), Mexican cities, particularly major ones, are characterized by much higher reuse levels than cities in several countries including those in the developed world. This advantage is one that Mexico should not only preserve but further increase, to make it a country that exports knowledge and technology in this field.

As one can see, the current situation and prospects for water supply in Mexican cities is critical. It requires an enormous effort of organization and coordination to halt the dramatic decline in the quality and availability of water, land use and the lack of accountability mechanisms that would encourage professional management of the systems involved. The lack of reliable information in certain areas, together with the number of illegal connections and the amount of water supplied through water trucks means that the coverage figures mentioned in the official data should be viewed with caution. Access to information, its analysis and communication to decision makers and citizens can be an important lever in this change and is a task in which the academic community must play a central role.

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Managua, Nicaragua. Plaza de la Revolución. Lake Managua and mountains in the background, seen from Loma de Tiscapa. Photo credit: ©iStock.com/M.Torres.

Nicaragua

Urban Waters in Nicaragua

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The total population of Nicaragua was reported as 6.71 million in 2012, according to the National Institute of Information on Development (INIDE), with an average annual population growth rate of 1.2%. Various sources estimate the percentage of the urban population at between 58 and 60% (INIDE, 2012, WHO and UNICEF, 2014, Ortuste, 2014). Twenty-four per cent of the Nicaraguan population lives in the capital, Managua, the largest urban area with a population of 1,042,012 (INIDE, projection based on the 2005 census). There are 25 cities with a population of over 20,000 inhabitants throughout the country and 215 cities and localities are considered urban areas. Although the urbanization process has not been as intense as in other Latin American countries, there are many challenges for urban centers due to the concentration of the population in cities, since they have a high demand for drinking water and produce larger volumes of wastewater as a result of domestic, industrial and agricultural activities that must be treated.

The way urban water problems can be solved has been summarized from the full chapter on *Urban Waters of Nicaragua*, taking into account the

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analysis of the impact of urbanization, specifically in Nicaraguan cities, and some conclusions and recommendations, in order to facilitate the process of addressing urban water management in Nicaragua.

Although Nicaragua has high availability of water per inhabitant in urban areas, its sources of surface and groundwater have been exposed to impacts on the quality of its waters, caused by various factors of urbanization such as lack of solid waste management, contamination by industrial and domestic wastewater, intensification of agriculture accompanied by deforestation in recharge zones for groundwater that are sources of water for cities, lack of adequate drainage solutions that cause an influx of large amounts of sediment with rainwater into surface water bodies, informal and formal urbanizations that lack adequate domestic sewage treatment and leaks from the gas station system which contaminate the groundwater. Due to some of these impacts on water quality, two major surface water bodies in the city of Managua have been lost as possible sources for drinking water for the city of Managua: Lake Xolotlán and Lake Tiscapa.

Due to investment programs aimed at improving access to drinking water, Nicaragua has achieved 98% coverage in urban areas; There are still severe problems in the continuity of the service and, due to the lack of maintenance of supply networks, water continues to be lost due to leaks that can interrupt the service or reduce its efficiency. Lack of continuity and access can be observed more critically in the peripheral areas of the cities.

Despite investment efforts to improve sanitation coverage, Nicaragua failed to achieve the MDG target. However, at present, most cities are engaged in a planning process and/or undertaking programs to expand their sewage system and improve or install treatment plants. The state company ENACAL has made efforts to achieve better sanitation coverage in the city of Managua through the installation of a sewage treatment plant in Managua, where sewage coverage was increased in some human settlements in the capital.

An analysis of the health status of the population of Managua regarding waterborne diseases has shown an improvement in relation to the number of cases of waterborne diseases, dengue and malaria in the past ten years, which could be associated with efforts to clean up Managua in terms of reducing the epidemiological risk implied by Lake Xolotlán prior to the installation of the Treatment Plant, and the greater access by the population to public health services. Recent years have seen the emergence of new vector diseases transmitted by water supplies in or around the home, such as new serotypes of dengue, Chikungunya and Zika.

However, improving the continuity of water access could reduce the risk even more, since it would eliminate the need for storing water in ways that serve as a transmission focus for these vector diseases.

Nicaraguan cities are vulnerable to extreme weather events, due to the disorganized growth, lack of modernization of the supply and sanitation networks, as well as drainage and other infrastructure. The lack of intervention measures to improve the management of watersheds located in urban areas increases deforested areas, magnifying the effects of droughts and floods. Cities in the country's dry corridor in particular must improve the organization of water sources and management of the surrounding watersheds to ensure supply, since these problems are expected to be exacerbated by the progress of climate change, which would mean temperature increases and a reduction in annual rainfall. There is a severe risk of flooding in certain cities in Nicaragua due to the high rate of deforestation in recent decades. The currents produced by torrential rains and hurricanes drain quickly towards the lower parts of the country due to the deterioration of the basins.

On the basis of the analysis of water problem in Nicaraguan cities, the main recommendations for finding solutions for urban water management can be summarized as follows:

- Establish drainage systems in urban areas adapted to the extreme events involving intense rainfall, taking into account sedimentation, and the geomorphological aspects and topography of urban areas. It is important to focus on land-use management, taking into account the special properties by micro-basin in order to prevent the erosion that causes problems in cities and their water sources.

- Advance investment programs to achieve continuity in access to water and prevent the increase of leaks in the system. It is therefore necessary to strengthen the financial sustainability and capacity of ENACAL to guarantee the success of its investment programs.
- Prioritize investment in sewerage in urban areas in parallel with the improvement or installation of treatment systems.
- The solution to the effects of climate change in cities, both drought and flood, requires studies scientifically detailing their hydrological, hydrogeological and soil basis. Territorial plans would therefore focus on direct solutions.
- Orient urbanization programs towards encouraging reforestation and the protection of recharge areas to conserve the aquifers that supply water to cities.

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Balboa Avenue, one of the main arteries of the Panama City. Photo credit: ©iStock.com/ NTCo.

Panama

Urban Waters Panama

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Importance

Panama is a country with abundant water resources, with a hydrographic system comprising 500 rivers. Likewise, according to the 2010 census, 66% of the population lives in urban areas (towns> 1500). This percentage is expected to continue increasing, hence the importance for the country of good urban water management.

Water sources

In urban areas, the National Institute of Aqueducts and Sewerage Systems (IDAAN) manages 53 water treatment plants and 124 aqueduct systems. Of these water treatment plants, 52 obtain water from surface sources (reservoirs and rivers). This situation is compounded by the fact that the three municipalities with the greatest economic activity, which concentrate over 62% of the country's urban population, have their water source within the Panama Canal watershed. For example, the Chilibre water treatment plant, with a capacity of 250 MGD, which supplies much of Panama City, obtains its water from Alhajuela Lake. The foregoing, coupled with the

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short-term plans to build more water treatment plants with intakes within the Basin, makes it necessary to emphasize two aspects: first, how little alternative sources to surface water (such as groundwater) are used to supply urban communities and, second, the pressure on the water required for the Canal to operate that is beginning to be exerted by urban growth.

Drinking water access

Although the last population census (2010) indicated that on average, over 90% of the population has access to drinking water, there are marginalized areas in the country (especially regions with indigenous peoples) where this figure can be as low as 28%. There are also areas where the water supply is irregular. It follows that improving existing access inequalities, reducing the irregularity of water supply in certain areas and providing IDAAN with the necessary resources to maintain existing infrastructure are priority actions.

Wastewater treatment

In the case of wastewater management, recent years have seen enormous progress in terms of legislation as well as operational aspects. According to World Bank indicators, in 2012, 80% of the population had access to improved sanitation facilities. Regarding wastewater treatment, it is important to highlight the state commitment, honored by successive governments, regarding the implementation of the "Panama City and Bay Sanitation Project", begun in 2006 as the best way to restore the sanitation and environmental conditions of the metropolitan area and the elimination of contamination due to untreated wastewater in the urban rivers and coastal areas of Panama Bay. This project includes a Wastewater Treatment Plant (WWTP), which, once its three phases have been concluded, will collect approximately 70% of the wastewater from Panama City. It is a matter of some concern, however, that this investment has not been accompanied by the improvement of the administrative and operational capacity of IDAAN –as regards both human resources and financial resources- required to ensure the sustainability of this project.

Water and health

The persistence of dengue in the urban area is the main public health problem associated with vector-borne diseases that develop in water. Attention should also be paid to microorganisms such as *Cryptosporidium* spp. and *Giardia* spp. Isolated studies on raw water used by water treatment plants in certain urban centers, have found *Giardia* spp. cysts and *Cryptosporidium* spp. oocysts in the dry season. Likewise, studies in the city of La Chorrera (40 km west of Panama City) appear to indicate a relatively high prevalence of *Cryptosporidium* spp. and *Giardia* spp. in children. Accordingly, there is a need for an increase in the surveillance of the presence of these protozoan parasites, to prevent a possible outbreak of diseases related to the latter.

Effect of Climate change

The link between urban waters and climate change is becoming increasingly important. Various studies and analyses point to an increase in the frequency of extreme events and the vulnerability of urban areas, reflected not only in the increase in the number of floods, but also in the number of people affected by these events. Hence the importance of exploring alternatives designed to increase urban resilience to climate change. In addition to structural solutions, these actions must include an increase in the population's degree of awareness of the role each individual plays in the response to the problem.

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The Plaza de Armas or Plaza Mayor in the historical centre of Lima. Photo credit: ©iStock.com/Holger Mette.

Peru

Urban Waters in Peru

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Peru is the 20th largest and the 42nd most populated country in the world, with an area of 1,285,216km² and 31,488,625 inhabitants (2015). In ancient times, even though the country was much larger, Peruvians mastered a series of water management and care techniques such as "sunken farms", drying and drainage, irrigation through channels administered by basin, the construction of platforms, amunas and "water sowing", which enabled them to guarantee supply for their cities and crops.

Nowadays, 77% of the population is regarded as urban by the National Institute of Statistics and Informatics-INEI. The metropolitan city of Lima-Callao is home 40.18% of the urban population and 30.88% of the total population. Of the 46 cities with 50,000 inhabitants and over in 2015, two (Arequipa and Trujillo) have approximately one million inhabitants and 12 have between 200,000 and 650,000. Thus, although Peru is one of the richest countries in water resources, with 4.6% of the world's surface water and a water availability of 64,376.54 m3/inhabitant/year, the country has yet to address the complex challenge of efficient, equitable and sustainable urban water management.

Seven of the 14 cities with over 200,000 inhabitants (including Metropolitan Lima) are located on the coast, concentrating a population of 12,263,834 inhabitants, in other words, over 50% of the national urban population in the most arid region with the lowest water availability.

Population asymmetries are accompanied by inverse asymmetries of water availability. Together with inadequate water quality management, the increasing vulnerability of cities to disaster risks and poor water governance contribute to reinforcing urban unsustainability. At present, approximately 11% of the population of Metropolitan Lima lack access to water

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while 16% have no sanitation services. Average daily consumption varies between 229 and 250 liters per person, amounting to 450 liters /day/person in the most privileged neighborhoods and barely reaching 30 liters/day/person in the poorest peripheries. Water purification is extremely expensive due to the high load of pollutants from the Rimac River. Since 2014, the Taboada Wastewater Treatment Plant (WWTP) and the La Chira WWTP have treated 100% of wastewater (83% primary and 17% secondary treatment).

Water coverage is higher in coastal cities, where a large sector of the population is concentrated. The Lima-Callao Metropolitan Region (RMLC) has the highest coverage while certain parts of La Sierra and La Selva have the lowest coverage, reflecting the large gaps between rural and urban populations. Likewise, the impressive water availability of the Amazon basin fails to ensure access to water for its population, or its purification and treatment.

Drinking water availability and wastewater management obviously play a key role in people's well-being. In 2009, the INEI found that the infant mortality rate is 38% higher in households without potable water services from the public network and 53% higher in those without adequate wastewater disposal facilities.

In other cities such as Cusco, water quality has severely deteriorated. Its main source of water, the Huatanay River (fed by water from an underground spring), has been significantly affected in recent years due to the increase in the pollutant load, which makes its waters unfit for any use (Bernex *et al.,* 2005). A total of 98.19% of the population of Valle Sur has a water supply system, only 17.01% of which have drinking water and 82.99% piped water while 1.81% have no service.

The firm responsible for supplying water to the city of Cusco is SEDACUSCO and in February 2014, with a total investment of S/102 million, it inaugurated a modern Wastewater Treatment Plant (WWTP) to treat 80% of the waste produced by Ciudad Imperial and the province of Cusco, benefiting 330,000 users. This public work will ensure the clean irrigation of vegetables and other crops.

This city is highly vulnerable to climate change, as borne out by the fact that in February 2010, it experienced losses of 680 million soles and 35,000 Cusco residents were affected by the torrential rains. External geodynamics processes, coupled with urban explosion, have created a city at risk, with floods, landslides and mudslides.

Iquitos, capital of the Peruvian Amazon, located on the left bank of the Itaya River (a tributary of the Amazon River) has average annual rainfall of over 2000 mm/year while water for human consumption is captured in the Nanay River, a tributary of the Amazon River.

The local EPS is SEDALORETO, SA, and the Belén district is located on the left bank of the Itaya River, where it receives untreated discharge from the domestic drainage of every dwelling. In 2007, the sanitation deficit for a population of 41,000 inhabitants occupying 7,827 households was 73.8% in urban areas (INEI, 2010).

Nor does Iquitos escape the impact of climate variability and change, since it is extremely vulnerable to heavy rains and the consequent river floods, as happened on April 5, 2012, when the Amazon River broke its record by 4 cm, reaching 118.62. masl. Considerable damage was caused by the exception rainfall and the resulting floods, which increased the number of cases of acute respiratory infections, acute diarrheal diseases, febrile syndrome, parasitosis and leptospirosis, even during the period when flood levels began to drop. By the 36th epidemiological week, five deaths and 18,206 cases had been reported.

Likewise, global warming accelerates the processes of melting glaciers, as in the case of the city of Urubamba with 10,741 inhabitants (2014), at the foot of El Nevado de Chicón, where significant glacial retreat –at least since 1963-, has led to the detachment of blocks of ice that fall into nearby lagoons, creating floods. This is a situation where a large-scale earthquake could cause a large mass of ice that could produce a major flood, causing a serious human disaster.

Given this situation, it is clear that although the institutional framework of the sector is fairly well established, since it clearly differentiates between policy design for service regulation and delivery, it has yet to solve the problem of weak coordination between the authorities at the central level, and between the latter and other levels of government as well as certain gaps (Marmanillo, 2006).

Conventional water management in urban areas has failed to meet the key challenges of the

RMLC and large, medium and small cities. Generally speaking, water supply, sanitation and storm water management have not been undertaken in a joint, planned manner. Neither town planning nor urban development have managed to successfully integrate the various infrastructure components of urban water management (water supply, wastewater, dry sanitation, a storm drain system and solid waste) (Tucci, 2010).

Thus, on the basis of the understanding of the urban water cycle, it is necessary to develop an Integrated Urban Water Management System (GIAU) that considers all the water sources within an urban catchment area (surface water, groundwater, storm water, desalinated water, storm water, transferred water, virtual water) as well as the quality of the various water sources (including water reuse) and attempts to assign it according to the quality required for the various needs. Likewise, as noted by the Global Water Partnership (GWP), it is essential to see the process of storage, distribution, treatment, recycling and water disposal as part of a cycle rather than separate activities, and to plan the infrastructure accordingly; to make plans to protect, conserve and use water resources at source, and to ensure responsible participation and governance to strengthen sustainability and water security. Integrated Urban Water Management has become a issue on the political agenda that can no longer be postponed. It requires institutional strengthening, continuity in processes, sectoral and transdisciplinary vision as well as trained human resources and responsible participation.

In this respect, a process of water culture must be implemented at schools, colleges and universities. These educational centers are places where one not only learns how to use, reuse and recycle water but also the benefits they entail for the community. Lastly, all cities, where peripheries of poverty grow and gaps are accentuated between those with and without access to services, those that thrive as a result of their ecosystems, fields and natural areas urgently need to make their inhabitants aware of a new water culture, which requires building a new foundation based on a change in the scale of values, incorporating the value of the other and all others, the value of otherness, of ecosystems and the value of life itself, since the culture of water is the culture of life.

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Cityscape of Chicago, the loop area office buildings and the Chicago River. Photo credit: ©iStock.com/Arpad Benedek.

United States of America

An overview of the management and problems of water for urban use in the United States of America

Henry Vaux, Jr.[1]

Urban water systems in the United States are characterized by the "water paradox" of developed countries." Nearly the entire population has ready access to healthy water supplies and adequate sanitation services. Yet, the future is characterized by problems that are every bit as challenging as those faced by countries that are not fully served. Water scarcity is intensifying. Water quality is declining. Urban water supply and sanitation infrastructure is aging. Planning and financing for maintenance and renewal is inadequate and, without action, will become more so over time. Water scarcity intensifies because of population and economic growth in urban areas even while water supplies are static or shrinking. Accustomed sources of supply are fully allocated and unreliable in some areas. Declining water quality causes usable supplies to shrink even more. There are other causes as well.

Political leadership has failed to educate the public about the problems and has failed to provide the leadership necessary to resolve them. The annual costs of maintaining and modernizing the water supply and sanitation infrastructure are estimated to be $11 billion and will grow over time. The costs of renewing and maintaining new water supply infrastructure are high and consumers appear unwilling to pay them. The growth in the magnitude of the problems and in the costs needed to solve them only complicates the situation.

Water scarcity itself also threatens the ability of some urban areas to deliver supplies to growing populations. Demands for additional water are fueled by population growth and economic growth. The problem is complicated by the fact that waters in many regions of the country are already fully allocated among a variety of prevailing uses. The implications of climate change for available water supplies are uncertain virtually everywhere. Some existing policies tend to make the situation worse. Water pricing policies fail to reflect the scarcity value of water and, perversely, signal consumers that water is freely available, thereby contributing to public ignorance about water scarcity. In addition, those policies mask the fact that new technologies and new sources of supply are significantly more costly than the costs of existing supplies. The result is a lack of transparency about the nature of water scarcity and the costs of addressing it. The problem is made worse by trends

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of declining water quality which threaten future and current urban water supplies.

While existing laws have served the nation well in protecting the quality of drinking water and protecting the quality of the nation's surface waters there are signs that water quality is likely to deteriorate in the future. Potential new contaminants appear in the environment routinely. Existing legislation requires the government to decide whether to regulate a contaminant or not once it has been place on the candidate list. Further, legislation requires that at least five contaminants on the list be subject to regulatory decision each year. The number of new contaminants is growing much faster than five per year with the result that, without change, the public will be exposed to increasing numbers of contaminants each year that have not been subject to regulatory analyses.

The situation can be addressed directly in a number of ways. Water scarcity can be managed through water rationing in which limited quantities are delivered intermittently. There is ample precedent for this in other water-short areas of the world. Education of the public will also be important. Evidence show that water consumption declines when consumers are aware of where their water comes from and the limitations that apply. Pricing and markets also ensure that consumers are confronted with the true costs – including the scarcity value – of providing water as well as ensuring that water is efficiently allocated among different uses.

Problems of scarcity can also be addressed by employing emerging technology to augment supplies. Waters of impaired quality can be treated and upgraded for domestic use; household wastewater can be recycled and reused; desalination technologies to upgrade the quality of degraded ground water or for seawater conversion in some instances. It should be understood that supply augmentation will frequently be the option of last resort as policies on pricing, rationing and education can be improved in straightforward ways and at a fraction the cost needed to deploy new water enhancing technology. It is well known that the least expensive sources of additional water come from economizing on water (water conservation) and improved water management.

The chapter concludes with five recommendations for action:

1. The three threats to urban water security in the U.S. – water scarcity, inadequate infrastructure, declining water quality - should be addressed in an integrated fashion. Addressing a single threat but not the other is unlikely to result in achievement of a sustainable level of urban water security.
2. Water pricing policies should be reformed to account for the scarcity value of the water and also to acknowledge that the incremental cost of new facilities will likely be higher than the cost of existing facilities.
3. Those charged with the production of urban water supply and sanitation services should develop comprehensive programs of education and communication. Such programs should be aimed at developing informed user groups and an informed public.
4. The national government needs to authorize and fund adequately programs of evaluation and regulation of contaminants and potential contaminants. Funding support should be equal to the task at hand.
5. New technology and supply augmentation should only be employed after careful analysis of the costs of other options including policy innovations. Supply augmentation should be considered desirable only after other, cheaper options have been implemented.

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Cityscape of Montevideo from the the riverside. Photo credit: ©iStock.com/lucop.

Uruguay

Urban waters in Uruguay: Progress and challenges regarding integrated management

Adriana Piperno[1]

In the context of South America, Uruguay is a small country with a dense, homogeneously distributed water network, and an average rainfall of between 1,100 and 1,400 mm per year, and no clearly defined seasons. The urban population accounts for 95% of the total population (3,390,077 inhabitants, INE, 2011), with over half living in the metropolitan area of Montevideo, its capital. It has low population growth (INE, 2011) and a consolidated urban transition.

In Uruguay, changes are being promoted from sectoral visions to more integrative visions, which translates into a non-linear process of multi-stakeholder and dynamic transformations, with enormous potential yet not without difficulties. In particular, the country's regulatory framework is advancing towards the integration of water, the environment and the territory, although their regulation and implementation is still partial.

Uruguay is close to universal access to drinking water through its only public operator: the OSE.

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Although supplying **drinking water** to the population is the main priority for the use of basins, the intensification of agricultural uses is affecting the quality of the sources. This problem has promoted actions in which social participation is a key aspect (the main ones being the Commissions of the Santa Lucia River Basin, Laguna del Sauce and Laguna del Cisne).

At the same time, although basic sanitation coverage is high (94%), 40% corresponds to static systems with significant management deficiencies. The challenges for sanitation lie in the development of legal instruments and institutional capacities that will guarantee safe sanitation systems, considering the economic capacity of the population, to ensure their sustainability. In particular, with respect to collective systems, the main challenge is to increase coverage, wastewater treatment and household connections, and to explore unconventional systems that will make it possible to serve inaccessible areas. With regard to static systems, new technologies and management modalities should be explored.

Regarding **rainwater** management, storm drainage problems affect both departmental capitals and small towns. The challenges identified here seek to develop capacities, planning and the incorporation of more sustainable technologies.

Areas lacking potable water, sanitation or storm drainage services generally correspond to lowincome sectors, with a vulnerable population, often located in high-risk areas (areas outside land use).

Cities with flood problems are distributed homogeneously throughout the country - this being the main activation factor of the National Emergency System (SINAE) - and are one of the focal points of interest of the National System of Response to Climate Change (SNRCC). Factors that explain this problem comprise hydroclimatic agents (including the increase in the frequency of extreme events) and aspects of the social construction of threats and vulnerability, which makes the search for far-reaching solutions complex. The challenge currently lies in the incorporation of risk management and adaptation to climate change measures into public policies, particularly the incorporation of risk maps into local plans, the reappraisal of riverbanks and improvements to monitoring and warning systems.

One of the problems observed is the need to go beyond single-sector approaches (based fundamentally on the command and control paradigm) towards integral ones, with a real capacity to promote adaptive schemes, and to incorporate effective monitoring and learning mechanisms to understand the causes of the successes and mistakes of decisions and plans that have already been implemented.

In the current governance scheme, the recent creation of cross-cutting areas such as the Regional Councils and Basin Commissions, the National System of Response to Climate Change, the SINAE and the Territorial Planning Committee, are spaces to consider and strengthen.

On the other hand, **information and monitoring** for management in environments of uncertainty is uneven in the various sub-sectors and insufficient for the proper management of urban problems. At the same time, there is often a lack of coordination in the initiatives (e.g. duplicated data collection), inaccessibility and difficulty of analysis (in some cases because they are filed in paper format).

Planning and managing urban waters in a scenario of change (climate variability, economic, social and cultural changes, etc.) requires having the best information for decision making. Strengthening monitoring systems adapted to urban reality will make it possible to identify trends and possible changes in order to reformulate strategies. It will also contribute to transparency and participation in management, based on quality information, essential for decision making.

Building a city with water is a challenge on various scales. Services must be extended in keeping with the urban plans of the city: storm drainage infrastructure, small internal watercourses and river fronts must be integrated into the design of the city, not only to reduce infrastructure costs and flood risks, but also to create new spaces for the use and recreation of the population, changing it from a threat to a resource.

Promoting the **assessment of water as a resource, and its responsible, innovative use**, both consumptive and non-consumptive (recreational, educational), should be the central axis of an integrated urban water management strategy, together with the improvement of the mechanisms of access to information, opinion and control for the population. This investment in the empowerment of the population, together with the improvement of the technical capacities of the human resources that form part of the management system and changes in the structures of service providers designed to achieve decentralization, will contribute to achieving a flexible, adaptive management system, thereby contributing to water sustainability in a context of integral management.

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Paseo de los Próceres fountain and Old architecture zone in Caracas, Venezuela. Photo credit: ©iStock.com/moracarlos.

Venezuela

Urban Waters in Venezuela

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Venezuela has over 28 million inhabitants, 80% of which are concentrated in just 20% of the country. This creates problems associated with water distribution and the provision of sanitation services, in addition to those caused by the transport of large volumes of water from their original basins.

Nine regional hydrological companies and eight decentralized companies nationwide are responsible for the supply of drinking water and sanitation services. The supply of drinking water in large cities depends mainly on surface sources (reservoirs), with over 90% coverage of the urban population, over 80% of wastewater collection, yet less than 50% of wastewater treatment. Several basin sanitation and sewage treatment projects are currently being developed.

As for groundwater, it is estimated that renewable reserves amount to 22,312 million m3, and that 50% of this water is used for the supply of potable, industrial and irrigation water, through a catchment work network with over 100,000 wells. In the case of the capital, Caracas, it is estimated that less than 10% of the total consumption of drinking water (18 m3/s) is obtained from groundwater (1.2 m3/s).

Venezuela has 119 water treatment plants, with an installed capacity of 132,390 l/s. The existing types of plants are basically: conventional with traditional units; conventional with complete treatment, including flocculation, sedimentation, filtration and disinfection; conventional with partial and non-conventional treatment with partial treatment by modular, accelerated, compact and combined

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methods. Compliance with current regulations for bacteriological quality and organoleptic quality is between 85% and 83% respectively, for chlorinated water alone and between 91% and 85% for conventionally treated water.

Wastewater treatment is insufficient in percentage terms. The most commonly used types of treatment are stabilization or oxidation and extended aeration lagoons in the case of urban populations, septic-filter wells and septic-absorption field in certain rural populations. In general, most of the untreated effluents contaminate the coasts, given the proximity of large population centers to the sea, or because they are discharged directly into rivers that flow into it.

There are also plants located in the center-north region of Venezuela, the industrial heart of the country. In this region, private companies usually have wastewater treatment plants in order to comply with the regulations established to meet the parameters specified in Decree 883, concerning Standards for the Classification and Quality Control of Water Bodies and Discharges or Liquid Effluents.

With regard to the relationship between urban water and health, numerous cases of diseases associated with water resources have been reported in Venezuela, including diarrhea, amoebiasis, malaria and dengue. Water diseases usually have a higher incidence among the poorest strata of the population. Several authors state that the participation of organized communities (for example, Technical Water Panels) and educating the population, are key to mitigating the incidence of these diseases, in addition to sufficient state investment in river and gully sanitation.

The environmental health of housing can be analyzed through the use of indicators and indices designed to measure the interaction between water and the environment. A high proportion of households are incorporated into aqueduct systems as a means of receiving drinking water supplies. However, the population that receives water with different frequencies, ranging from every other day to every fortnight, accounts for approximately 20% of households. Supply interruptions can lead to a lack of personal hygiene, inadequate excreta disposal and poor handling of food and kitchen utensils, each of which can affect health. High rates of connections between toilets and sewers or septic tanks have been recorded, suggesting that attention should focus on two key aspects to ensure urban sanitation: 1) drinking water quality control due to the use of water below discharge points, which in turn is related to the design of water purification treatment systems, and 2) the need to treat sewage, collected by sewage systems, to guarantee the quality of water in the basins and its use downstream from the discharge points.

Venezuela's high vulnerability in the water regime makes it vitally important to monitor the effect of climate change on the various sources used for water supply, since most of the adverse effects are related to water availability. Phenomena of extreme drought and floods have been reported in the main cities in the country, both of which have negative consequences for urban populations. This points to the importance of timely planning (master plans) in order to prevent future damage to people and objects. Structural measures (channeling of rivers and streams, sediment control and erosion control on slopes) and non-structural measures (monitoring of hydrometeorological conditions in river basins, preparation of risk maps, preparation of contingency plans and installation of early warning systems) are also required to mitigate the effects of floods in cities.

It is concluded that water resource management plans must be implemented that are the result of well-planned interaction between technology, society, the economy and institutions, with the aim of balancing the water supply and demand to address scenarios of hydrological extremes. Likewise, water resource management plans and the mitigation of problems related to the water cycle in urban areas must involve the participation of organized communities.

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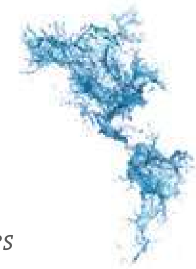
URBAN WATER CHALLENGES IN THE AMERICAS

A perspective from the Academies of Sciences

Summary



The Americas are among the most urbanized regions of the world (>80%). Urbanization goes hand in hand with intensification in the use of **water resources for human needs**; in turn, hydrological systems play a role in the development and growth of cities, not only as a source of drinking water but also for the deposition of wastes. ***Urban Water Challenges in the Americas*** describes and analyzes the problems of water in urban centers in 20 countries of the Americas: spanning from South America, Central America, Mexico and the Caribbean to the United States and Canada. This unique collection of experiences with urban waters in the Americas rests on a wide geographical representation that includes differences in water resource availability and levels of economic development.

The main challenges touched upon in this book of the IANAS Water Program are: Can the problems of urban water supply and sanitation be solved with better management? Can access to safe drinking water be improved? Can the challenge of improving sanitation and wastewater management be met? Can water related health problems and water-borne disease be better addressed in urban areas? What are the water related challenges in adapting to climate change for urban areas and how can they be met? What are good models and concepts for helping to improve water management in urban areas?

The goal of this volume is to look for different answers to these questions in the search for solutions to the challenges of properly managing water resources in urban areas.

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