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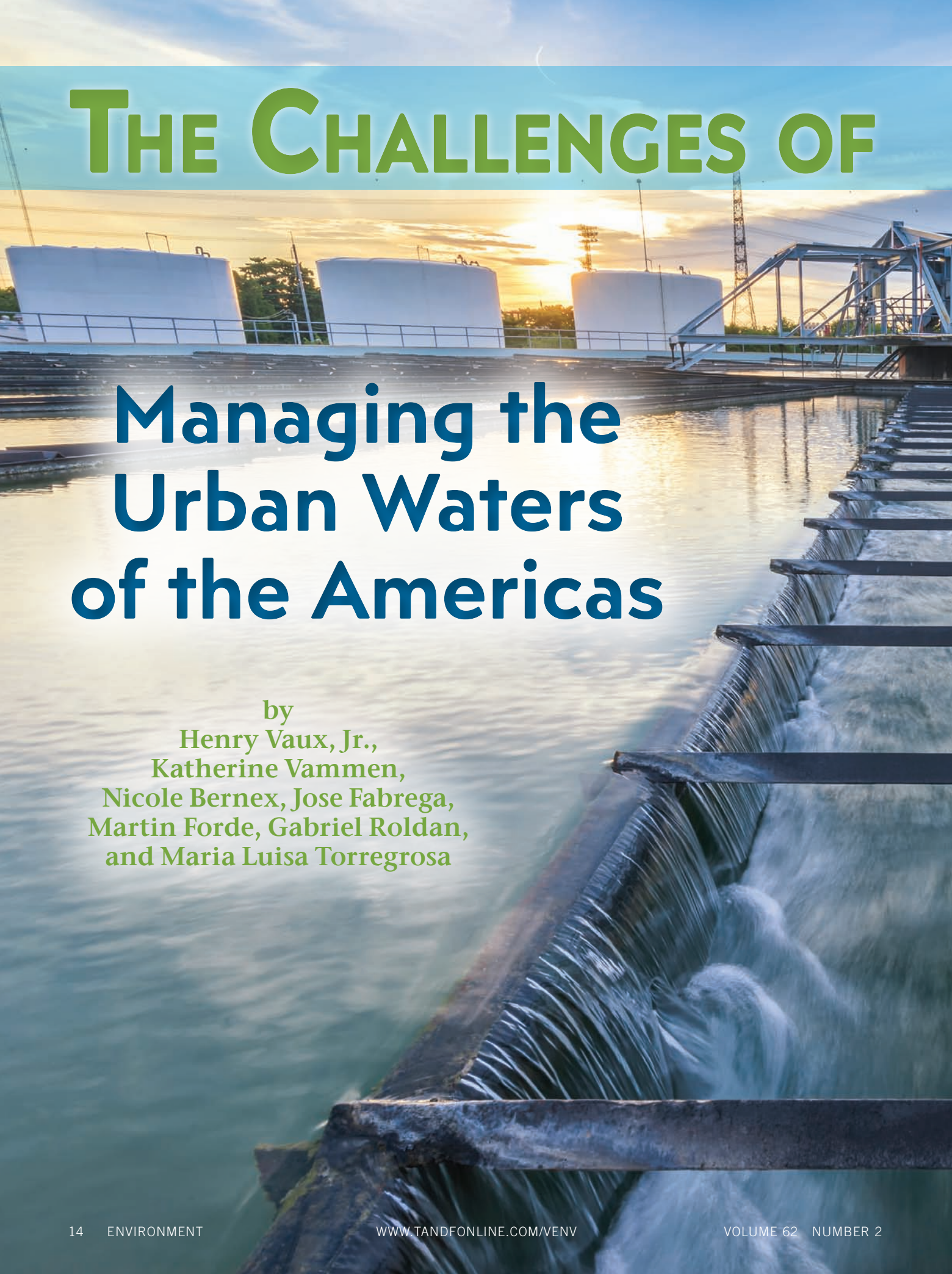

The Challenges of Managing the Urban Waters of the Americas

by
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As the Americas become increasingly urbanized, the challenges of providing water supplies for domestic and industrial uses continue to multiply in number and difficulty. Similarly, the problems of collecting, treating, and managing wastewater grow in magnitude and present their own special challenges to urban areas throughout the hemisphere. This article provides an overview and summary of these challenges in the entire American continent and part of the Caribbean and identifies directions for action to address many of them.

Urban Water in South America: Pacific Countries

The countries of Pacific South America considered here include Bolivia, Chile, and Peru. They range in population from Bolivia with 11.3 million inhabitants to Chile with 32.1 million inhabitants. All three have steep, angular landscapes. Chile and Peru rise from the Pacific Ocean to the crest of the Andes. Bolivia is landlocked but includes the crest of the Andes. Both Bolivia and Peru include lands to the east of the Andean crest in the Amazon Basin. The climates and landscapes in these lands tend to be moister and more tropi-

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cal. Like their counterparts in the Atlantic portions of South America, the three Pacific countries exhibit a broad range of urban water problems.

Bolivia

Bolivia has a population of 11.3 million and is the least urbanized of the three countries considered here. Sixty-four percent of the population lives in urban areas. Bolivia is a moist country, concentrating 27% of the runoff for South America. However, the patterns of precipitation and water availability are highly variable. Domestic consumption accounts for 10% of total use, while agricultural irrigation accounts for 85%. The two largest cities in Bolivia are La Paz and El Alto. The water supply for these two cities is partially composed of water from glaciers in the surrounding mountains. Since 1976 these glaciers have lost 43% of their area in response to warming temperatures. Continued warming could result in the total loss of the glaciers in the next 50 years, creating a critical water supply situation for these urban areas, both of which face continuing growth. In Bolivia, then, adaptation to climate change takes on a special urgency. The two metropolitan areas are already quite vulnerable inasmuch as approximately 40% of the delivered supply is lost to leakage and illegal connections.

There are a number of problems on the water agenda in Bolivia in addition to climate change. There is a need to improve access to drinking water, and this will become increasingly important as the urban areas continue to grow. Development of additional water supplies will likely be required, and rainwater harvesting offers an opportunity to accomplish that. Flooding and urban runoff have been problems historically and will require management in the future. The flooding and the water supply problem can be addressed jointly to some extent by the adoption of carefully tailored rainwater harvesting schemes. Finally, wastewater collection and treatment remain problems in most urban areas of Bolivia. If left unattended, these problems will grow, so efforts must be made to provide access and treatment for unserved urban populations and to accommodate the anticipated growth in the urban populations of the future.[1]

Chile

Chile, with a population of 32.1 million, has reasonably good water supply and sanitation systems and the coverage of those systems is quite good. Chile is among the most urbanized countries in the Americas, with 78.2% of the population residing in urban areas. One hundred percent of that population has access to potable water, and 96% have access to basic sanitation services. This situation is attributable to the fact that the country has enjoyed economic stability and enlightened public policies, particularly policies enacted for the purpose of supporting and facilitating effective water management. Water supply and sanitation services are generally supplied by regulated private companies. The companies have the advantage of being able to acquire additional water rights from the agricultural sector and are thereby well positioned to meet future population growth and urbanization. The regulation of companies has been successful in preventing concentration and monopolization while ensuring fair rates of return and fair consumer prices. In spite of this quite positive picture, some challenges remain.

The emergence of mining and industrial sectors with their potential to bid water away from other sectors has created concern. The threat to urban water suppliers from this source does not seem serious, however. There is concern about peri-urban communities attached to large urban areas and that are vulnerable to droughts and other supply disruptions. Bringing reliable supplies to those communities, which are likely to grow, is a future challenge. Concerns about the quality of urban waters are now focused on pharmaceuticals and personal care products. The worry is fueled by the lack of data and information on concentrations of these in wastewater and the lack of effective treatment regimes. Rainwater management remains a problem, but largely because control efforts are focused on the construction of large public works that facilitate the evacuation of water to the neglect of alternative nonstructural measures. Integrated rainwater management plans that incorporate a range of management alternatives need to be developed. Finally, climate change

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Effective regulation of private urban water purveyors in Chile has prevented monopolization and resulted in fair pricing.

poses a threat to existing patterns of water supply and sanitation management. A national adaptation agenda needs to be assembled and adopted if current patterns of management are to be preserved.[2]

Peru

Peru has a population of 31.5 million, of which 87.8% are concentrated in urban areas. The country is unique topographically and climatologically, as it is divided by the crest of the Andes. The western side, where water flows to the Pacific, has 21.6% of the land area, 62.5% of the population, and 1.76 percent of the water resources. Hence, the region of the country with the most people has, by far, the fewest water resources. More than 50% of the population is concentrated in the arid region adjacent to the Pacific. The increasing vulnerability to disaster of the west coastal cities is attributable to poor water governance and the lack of adequate water quality management. The importance of governance is illustrated by the fact that even the population of the water-rich eastern region of the country does not have adequate access to water services.

The multiple water problems that beset Peru and particularly arid western Peru are attributable, in part, to a general absence of water education, as well as to the lack of coordination between the central government and water providers at the local level. The solutions to the problems of water supply, waste water collection and treatment, and stormwater and other water quality issues lie with the creation of an integrated urban water management plan that subsumes and integrates the functions of the water supply system, the wastewater management system, the dry sanitation system, the stormwater system, and the solid waste management system. All sources of water should be included in this plan, including surface water, groundwater, stormwater, transferred water, desalinated water, and virtual water. Creation of such a plan will entail a strengthening of the central government and other reforms that will allow it to effectively create, execute, and manage such an integrated plan.[3]

Urban Water in South America: Atlantic Countries

The countries of Atlantic South America considered here include Argentina, Brazil, Colombia, Uruguay, and Venezuela. They range in size in terms of population from Uruguay with a population of 3.5 million to Brazil with a population of 212 million. They include landscapes ranging from very moist in the tropical areas of Brazil to arid and semi-arid areas in Argentina. These countries exhibit a broad range of urban water problems.

Most cities in Argentina have generous supplies of potable water.

Argentina

Argentina has a population of 44 million, of whom 90% live in urban and peri-urban areas. The latter include mainly areas that surround the major metropolitan centers such as Buenos Aires. Two-thirds of the country is arid or semi-arid. The remaining one-third accounts for 84% of the total water availability. There is a surprising, for the Americas, consistency between population and water availability, with 70% of the population living in the moist areas. This means that most urban areas have generous levels of water availability. Most supplies are from surface waters, but groundwater is used where surface supplies are absent. Currently, potable water supplies are available to 90% of the urban population, but sanitation services are uneven, with the proportion served ranging between 35% and 80%, depending upon the urban area. One obvious priority is focused on the provision of additional sanitation serves in urban areas. Another is to improve potable water access to 100% of the urban population. A serious but unusual problem, the consequence of rising water tables, has plagued the Buenos Aires area. This is attributable to anthropogenic causes such as the importation of water from external sources, declining use of household wells, and reductions in supplies of public water from groundwater extraction. Heavy rainfall has also played a role, and this calls attention to the fact that flooding is a major problem in many urban areas. For this country, urban water management priorities are flood control, both structural and nonstructural, augmenting urban water supplies for 100% availability, and developing more complete coverage of wastewater treatment plants and collection facilities.[4]

Brazil

Brazil has a population of 212 million and its largest city, São Paulo, with a population of 13 million, is one of the largest cities in the world. The accelerated population growth and urbanization over the last decades explain many of the challenges of providing adequate water supplies and sanitation while protecting water quality and minimizing the adverse impacts of floods. Among these problems are the higher volumes of wastewater and solid waste, and providing adequate drainage to prevent floods. Groundwater is often overdrafted and the water extracted can be salty or contaminated. Flood events are not infrequent and are exacerbated in some instances by the lack of adequate drainage facilities. The increase in paved areas and other causes of soil impermeability reduces groundwater recharge and also facilitates runoff and the risks

of flooding. Channelization of rivers has also contributed to flooding.

To guide water sustainability in cities, urban master plans should be developed using an urban integrated water management approach through which water supply, solid waste disposal, sanitation, and drainage are managed, employing all of the tools available in an integrated fashion. These tools include legislation, urban planning, and natural resources management. Through these processes the management of water-based resources and services can be rationalized by (1) identifying and assessing the problems; (2) fashioning plans to solve them; (3) implementing those plans; and (4) following up to ensure that the plans are effectively executed and adjusted in response to changing circumstances. Planning and management should be based on a broadly participatory approach. Implementation schemes should account for the values of ecological services, as well as the costs of providing the service in question.[5]

Colombia

Colombia has a population of 49 million, of which 9 million reside in the capitol of Bogotá. Water availability is generally good but is highly variable in terms of time and space. However, 70% of the urban areas are located in regions with relatively less water availability. Surface waters account for most urban supplies. However, 80% of those supplies come from watersheds that are not protected or where there are no programs of regulation of storage, transport, or treatment facilities. Urban water use accounts for 82% of all use nationwide, but only 18% of all municipalities comply with safe drinking water regulations. Sanitary services and wastewater management are inadequate. Significant quantities of water are discharged to receiving bodies with no prior treatment. The shortfall in wastewater treatment is due to both the lack of infrastructure and the low coverage of existing plants. Past development of urban water systems has occurred with only limited environmental planning.

Urban flooding is a major problem, and it has significant impact on urban

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Potable water supplies for major cities in Bolivia partly depend upon glaciers that are shrinking and may disappear within 50 years.

populations. Flooding in 2010–2011 was of larger magnitude than previously experienced, took many lives, and caused significant property damage. The flooding problem must be addressed, and this is particularly so because of the prospects of climate change. Extreme events such as the previous flood period are expected to increase in both frequency and magnitude.

The priority action is to plan the use of watersheds—with emphasis on urban watersheds—to guarantee water of sufficient quality and in sufficient quantities to serve current and prospective demands. Environmental planning will need to be improved and environmental guidelines to support watershed management will need to be developed and implemented to guide the work. Construction of additional wastewater treatment works and development of urban drainage solutions are also priorities, as is a commitment to develop comprehensive river basin plans as a guide for future development. Development of wastewater reuse schemes will also be high on the agenda. Discharges from unregulated gold mining have severe health impacts and will need regulation.[6]

Uruguay

Uruguay is the smallest and most urbanized country of those considered here. The population is 3.5 million, of which 95% live in urban areas. The country has close to universal access to potable water, and provision of good-quality drinking water remains a top priority, although, with urbanization, there are other important priorities. Intensification of agriculture affects water quality adversely, and regulations and management practices are needed to maintain and sustain water quality. Basic sanitation coverage is high at 94%, but 40% of that is static and has significant management problems. The challenges for sanitation will require additional laws and the institutional capacity to develop and enforce standards to protect water quality. Urban flooding is also a problem, with flood probabilities distributed relatively evenly throughout the country.

Existing hydrologic data and monitoring systems are inadequate to sup-

Only 20% of Colombia's urban watersheds are regulated, and regulatory oversight of treatment and transport facilities is lacking.

port the integrated water planning and management programs required for the future. High and early priority must be given to the development and maintenance of data gathering and real-time monitoring systems. The water supply, quality, and flood control problems will need to be managed under the terms of integrated basin plans that focus on both aquatic and terrestrial resources. The effort to develop such integrated plans will require much more information than is currently available, and such information will be needed over the long run. Adaptive management, participatory management, and technical innovation, all of which will be needed as a part of the integrated land and water plans, will require not only expanded systems of data gathering and monitoring but also the institutions needed to ensure that the data, analyses, and information are readily accessible.[7]

Venezuela

Venezuela has a population of approximately 3 million, which is concentrated on 20% of the land area. The supply of drinking water to the larger cities comes mainly from surface sources. Groundwater is also extracted to supply potable uses, but in the largest city, Caracas, groundwater accounts for only 10% of the supply. There is significant variability and significant vulnerability of water resources due to climatic variability, seasonal variability, and declines in water quality from a variety of sources. Wastewater collection systems provide substantial coverage, but only 50% of the wastewater is treated. Significant quantities of wastewater are discharged directly into the sea and into surface waters. Wastewater treatment and disposal are inadequate. A significant symptom of this is the frequency of waterborne diseases, including diarrhea, amebiasis, malaria, and dengue. These diseases have a disproportionate impact upon the poor.

There are numerous water problems that require early efforts to resolve them. Approximately 20% of households experience supply interruptions, with durations ranging from days to 2 weeks. Developing stable supplies for the households in question should have prompt attention. There are instances in which interconnections between sewage and potable water distribution systems have been found. It appears that rehabilitation or replacement of sewage and water distribution systems will be required to solve this very serious problem. Additional wastewater treatment and treatment plants will be required to guarantee the quality of water for domestic, industrial, and environmental purposes. Solving Venezuela's water problems will require extensive monitoring of hydrologic variables and gathering data upon which planned solutions can be based. There is a history of extreme droughts and floods in the major cities of this country. With climate change, these are likely to become more frequent and more intense. Improved monitoring and data gathering will be crucial in fashioning responses to the impacts of climate change.[8]

Urban Water in Central America

The Central American region considered here consists of six countries: Guatemala, Honduras, El Salvador, Nicaragua, Costa Rica, and Panama. A seventh country in the region, Belize, was not analyzed in detail. Each of these countries is heavily urbanized and faces a variety of challenges in maintaining and managing its urban water supplies and wastewater. The region is the fastest growing region in the Americas in terms of population. There is, therefore, some urgency attached to problems of supply adequacy, water quality, and effective wastewater management. Failure to address these problems means that they will likely grow in magnitude over the next decade or two as population growth and economic growth threaten to overwhelm existing water supply and wastewater management arrangements. In what follows, the countries are considered individually, followed by some concluding comments.

Guatemala

Guatemala is the largest country in Central America in terms of population and the third largest in terms of area. Fifty-three percent of the population lives in urban areas, and that figure is expected to rise to 70% by 2030. Thus, the country is significantly urbanized and will become more urban over the next decade. Several urban areas, including the largest, Guatemala City, population >3 million, are located on a high plateau. They rely significantly on groundwater for their supplies. Cities at lower elevations have access to surface water that is badly polluted and also rely on groundwater. The major aquifers are overdrafted due to excessive extractions and the reduction of recharge because of the paving of significant recharge areas, and are impaired because of contamination of untreated domestic and industrial waste. In the absence of action these problems will persist and also will be visited upon newly urbanizing communities and areas. Solutions to the problems include the adoption and execution of groundwater management plans that focus on augmenting recharge and regulating demand. Similarly, the lack of adequate wastewater management facilities will require the rehabilitation of existing facilities, construction of new infrastructure, and the training of wastewater facility operators.[9]

Honduras

Honduras is a country of nearly 9 million inhabitants and is extensively urbanized. The principal urban community is Tegucigalpa (population >1.6 million). The urban water problems of Tegucigalpa are illustrative. Only about half the population is served by a central system. Those who are unserved may buy water from vendors or access local sources. In the area served by the central distribution system, service may be intermittent and sometimes requires supplemental sources. Maintenance of adequate water quality is a major problem, especially for those without access to the central water system. Waterborne disease is a persistent problem, and child-

hood diarrhea poses special problems for children aged 5 years or younger. Improved sanitation measures including expanded access to wastewater management systems will be required if water quality is to be improved. Additionally, piped delivery of potable water to significantly larger portions of the unserved population will be required if the proportion of those with direct access to potable water is to increase. Significant financing will be needed since a disproportionate share of the unserved are poor and poverty-stricken. There is concern that in the absence of action, climate change may make all of these problems worse.[10]

El Salvador

El Salvador is the smallest of the central American countries in terms of area except for Belize. Its population is >6 million. The capital city of San Salvador illustrates the major urban water problems. Groundwater is the major source of supply. Water levels are receding as much as 2.5 m/year due to excessive extractions and declines in recharge rates. Changes in land use and urban growth impacts have led to deterioration of forested land where much of the recharge occurs. Both surface waters and aquifers are polluted from agricultural chemicals and low levels of wastewater treatment. For the future, significant population growth leading to increased demands for water is anticipated. Solutions lie with development of programs of strengthened research, a strengthening of the general water law (and concomitant enforcement), and more effective institutions of water governance. Financing for the facilities needed to rehabilitate and manage the water systems is estimated to amount to US$800 million.[11]

The picture that emerges is one in which water supply and sanitation systems need upgrades and expansions ...

Nicaragua

Nicaragua, with a population of nearly 6 million, is significantly urbanized with approximately 60% of that population living in urban areas. Ninety-eight percent of urban areas have water supply coverage and Nicaragua has ample availability of water. However, both surface water and groundwater are polluted from the lack of solid waste management, contamination from industrial and domestic wastewater, and conversion of land to agricultural uses and the associated deforestation of aquifer recharge zones. There is also a problem of continuity of water service, which limits access to water for households in urban areas. Although sanitation coverage needs improvement, most cities are planning or undertaking expansions and improvements of treatment plants and collection facilities. The picture that emerges is one in which water supply and sanitation systems need upgrades and expansions, but the task is complicated by the qualitative degradation of water sources. This latter problem must be addressed as part of any improvement scheme. In addition, there is a need to establish drainage systems that are well adapted to extreme events; investments are needed to expand water supply systems and control leaks; investments are also needed to expand sewage treatment and collection facilities; scientific research is needed to fashion responses to the adverse impacts of climate change; and reforestation and protection of recharge areas will be required to conserve aquifers that supply urban areas.[12]

Costa Rica

The potable water supplies available to urban areas in Costa Rica, population approximately 5 million, are generally good. Some smaller communities have problems of consistency of service and water quality. The widespread availability of good-quality domestic water supplies explains, in part, the relatively low incidence of waterborne disease. By contrast, sanitation has been neglected historically, with only 4% of the wastewater countrywide being subject to treatment. This has begun to change with completion of a wastewater treatment plant to serve the population of the greater San José metropolitan area. Nevertheless, much remains to be done to bring the country's sanitation services up to modern standards. The pollution of urban rivers is perhaps the most serious water problem of the urban areas. Additional resources will be needed for investment in the establishment and expansion of sewage treatment and collection facilities. Climate warming trends have been noted, as have reductions in runoff. Both point toward possible declines in precipitation and water availability in the future, though these will likely be less severe than elsewhere in central America. The country will need to undertake planning processes driven by long-term climate projections that can guide short-term planning. The processes need to consider both natural and anthropogenic sources of climate change.[13]

Panama

Panama has a population of approximately 4 million, of which two-thirds reside in urban areas. Over 90% of the urban population has access to potable water and 80% have access to improved sanitation facilities. The three largest cities in Panama rely for drinking water on the same source that supplies the Panama Canal. Outside Panama it is not frequently recognized that the canal, which is extremely important to the national economy of the country, utilizes fresh water. The competition between uses for the canal and domestic water supply means that as the population and the economy grow, efforts to conserve on urban water use will become increasingly important. Although the picture with respect to wastewater is reasonably good, problems remain. There is a national plan to eliminate contamination from untreated wastewater from the urban rivers of the country and from coastal Panama Bay. Implementation of the plan has proceeded haltingly, and additional financial resources and government support will be needed to assure timely

Volta Redonda (Rio de Janeiro), Brazil—January 19, 2016: A view of the water treatment plant on the Paraíba River. Several cities in the region use the Paraíba River for their water supply.

completion. Certain water-related health concerns must also be addressed, including vector-borne diseases such dengue and microbial contamination from *Cryptosporidium* spp. and *Giardia* spp. Increased surveillance will be necessary to contain and/or eliminate these risks. The urban areas of Panama are subject to increases in the frequency and intensity of extreme weather events. For the future there will be a need to build climatic resilience into both water supply and sanitation systems.[14]

For Central America, better and more comprehensive management systems are needed for the future. The rapid growth of urban populations together with variation in precipitation due to climate change, make water management a major task and one of increasing complexity. Solutions should aim to ensure water quality of sources by reducing pollution of urban rivers and lakes and by protecting ground water recharge areas. This requires significant additional emphasis on wastewater treatment and sanitation issues in urban areas while maintaining an awareness of the relationship between poor water quality and health issues.

Urban Water in Mexico

Mexico is a large, diversified country of 112 million with highly diversified ecosystems. The country as a whole is reasonably well off economically, ranking 15th in the world in terms of gross domestic product. It is a member of the Organization for Economic Cooperation and Development and has a high human development index. Yet these data mask the fact that there are striking contrasts in economic and social well-being. Thus, access to water is unequal even among the urbanized places. Urbanization is extensive and growing. The System of Cities is composed of 56 regions and 327 communities with populations greater than 15,000. Urban growth and expansion have characterized the last three decades. During that period the land area occupied by cities has grown four times more quickly than the population at large and the urban population has grown three times more quickly than the population. These trends are likely to continue. The growth in urban areas has been discontinuous, uneven, and scattered. Densities are often low, making water services physically difficult to provide and more expensive than where densities are higher. The most difficult problems will be found in the Mexico City megalopolis, which in the future will be formed by seven regions, all of which face current water service problems and have unsustainable supplies. By 2030, 50% of the population will live in 31 cities of greater than 300,000 people each. There

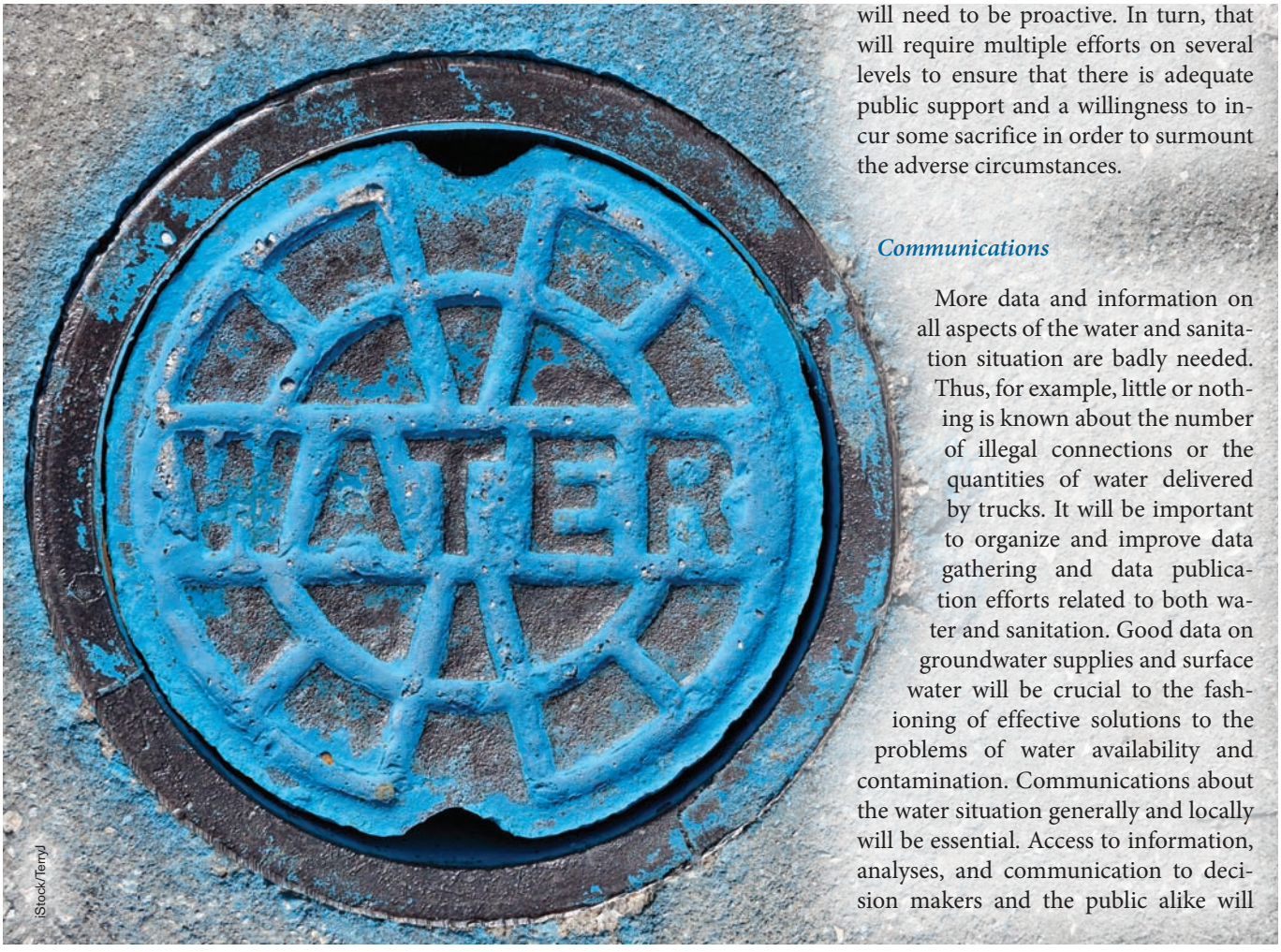
will be disproportionate concentrations in four mega-cities: Mexico City, Guadalajara, Monterrey, and Puebla. In each of these there is already a scarcity of water and water resources have been overexploited.

Nationally, potable water is available to 92% of the population. The companion figure for sewage services is 90.5%. Although surface waters are available in many regions, the semi-arid nature of the climate means that there is extensive reliance on groundwater. Groundwater is overexploited in two senses. First, the quantities of water extracted from most aquifers now exceed rates of recharge and have for some decades. Second, the paving over of recharge areas and other changes in land use have caused recharge rates to decline. The resulting overdraft, experienced over many years and with no end in sight, means that the aquifers in question will be prematurely exhausted, either physically or economically, and substitute sources will have to be identified. The problem is that in many areas substitute sources are unavailable. Where additional supplies may be available remotely, the financial costs and environmental damages make them unattractive. Thus, the urban population continues to grow and the water supplies are either fixed or shrinking.

While wastewater coverage is extensive, it is incomplete. It is estimated that less than 50% of the collected wastewater is subject to treatment. Untreated wastewaters pose a significant contamination threat. Also, degradation of water quality can restrict available water supplies as surely as drought. It appears that there are twin problems that require high-priority attention and research for resolution. First is the expansion and efficient operation of wastewater collection and treatment facilities. This will require significant funding, which will almost certainly have to be provided by the government. Where feasible, the level of wastewater treatment should be high so that the reclaimed waters can be reused for groundwater recharge or other purposes. Second is the replacement or substitution of recharge areas that have been lost, so as to augment groundwater recharge and increase the safe, sustainable yield.

The urban water supply situation in Mexico is serious, if not critical. As the population and the economy continue to grow, water and sanitation demands will grow. On the other hand, supplies will remain static or decline due to groundwater overdraft and contamination of both surface water and groundwater. If the situation is to be addressed successfully, government at all levels will need to be proactive. In turn, that will require multiple efforts on several levels to ensure that there is adequate public support and a willingness to incur some sacrifice in order to surmount the adverse circumstances.

Cities on the English-speaking islands of the Caribbean are experiencing significant growth in rural to urban migration. Urban water supplies are fixed or shrinking.



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Communications

More data and information on all aspects of the water and sanitation situation are badly needed. Thus, for example, little or nothing is known about the number of illegal connections or the quantities of water delivered by trucks. It will be important to organize and improve data gathering and data publication efforts related to both water and sanitation. Good data on groundwater supplies and surface water will be crucial to the fashioning of effective solutions to the problems of water availability and contamination. Communications about the water situation generally and locally will be essential. Access to information, analyses, and communication to decision makers and the public alike will

be a central element in any solutions to Mexico's water problems.

Education

Education and communication will go hand in hand. The public in Mexico is not well educated about the water situation and the challenges of managing it. It will be difficult to mount the programs needed to address the situation without broad public understanding of the nature of the situation. Both formal and informal methods of education will be needed to develop the levels of public understanding that will be required.

Finances

The financing of water and sanitation services will need to be reformed and augmented. Such reform will provide operational stability and will help to ensure that water services are provided efficiently. Water pricing schemes based on the costs of providing water and sanitation services and accounting for the scarcity value of water are an obvious means for ensuring efficient use of water. Federal funding needs to be provided to municipalities, but simultaneously municipalities must develop and execute programs that will respond effectively to the municipalities' various water problems. There is an urgent need to implement effective systems for the protection, restoration, and preservation of the nation's waters. In particular, declines in groundwater levels must be reversed and problems of water quality must be addressed. Efforts to respond to these problems must be well financed and prosecuted by a well-educated professional workforce.

Institutional Reform

Institutional reform is needed at all levels of government. States and municipalities should be required to provide operators with clear objectives, sufficient resources, and performance-linked budgetary support. There should be user participation in decision making, and responsible councils and boards should be held accountable. There should be open dialogue among authorities, operators, and citizens. In short, governance and institutional arrangements need to be strengthened and made more accountable. Reform should include ensuring that responsible agencies at all levels are focused on the tasks of reducing water stress and are made accountable for accomplishing this.[15]

Urban Waters in the Caribbean Region: Cuba, Grenada, the Dominican Republic

The three Caribbean nations of Cuba, Grenada, and the Dominican Republic include the two largest of the 31 Caribbean countries in terms of land area and population, Cuba and the Dominican Republic. These two countries are among the most urbanized of the region, with Cuba 77% urbanized and the Dominican Republic 81% urbanized. The third country, Grenada, is smaller in terms of both land area and population and less urbanized, at 39%. Grenada's geographic and population characteristics are typical of most small Caribbean countries. While the extent of urbanization in the region varies throughout, all of the English-speaking Caribbean islands show a consistent trend of migration from rural to urban areas and constant rising urbanization over the last few decades.

The main challenges due to urbanization arise from sharp increases in urban population, which has grown by 260% since 1950. Simultaneously, population density has doubled during the same period. These increases have placed significant stress on infrastructure, much of which was constructed in the late 19th and early 20th century. The rise of urbanization has also led to numerous instances of water stress and water scarcity. It has also created difficulties in delivering potable water to densely populated communities and significant challenges in how best to address problems of stormwater wastewater management in urban environments. In the future these latter two problems are likely to intensify with climate change and the expected rise in sea level. Urbanization also creates acute pressures on coastal zones, some of which are already altered and irreversibly damaged. This pressure will continue to get worse without more active management of such zones.

Each of the three countries that are the focus of this review have different challenges and hence different priorities in addressing urban water problems. In Cuba, the problem is poor infrastructure. Both the water distribution systems and the wastewater treatment and collection systems are aging and inadequate and need to be updated. The island of Grenada is characterized by steep topography, with 70% of the mountain slopes featuring a gradient of greater than 20 degrees. This puts terrestrial resources at great risk from rapid runoff and land degradation. In addition, the growth of tourism and related development has put significant added pressure on water and wastewater delivery systems. The Dominican Republic has very intense urban development. Two cities alone account for 50% of the total urban area. The water distribution systems are also inadequate, with up to 60% of the potable water being lost due to leakage. Water governance in the Dominican Republic has also been inadequate, with needed legislation perpetually stalled.

The problems just outlined for these three Caribbean countries mirror in a general way the challenges that other Caribbean nations are experiencing in managing and delivering urban water. Added to these is the problem of water scarcity. Economic and population growth in a number of Caribbean countries have generated water demands that regularly exceed available supplies, especially during dry seasons. The problems are further compounded by water and sanitation systems that are old and inadequate. In addition, water services and water availability are not climate resilient, with the consequence that available water supplies will be less secure in the future as climate changes and rainfall quantities become erratic and unpredictable. The fact that there

is a relative dearth of hydrologic data makes it more difficult to assess and manage available water and potentially available supplies in the face of climate change. Similarly, wastewater collection and treatment systems are either quite limited or nonexistent. As a result, 85% of the wastewater in the region is discharged untreated to the Caribbean sea.

Tourism in the region has grown explosively, and this places increasingly heavy pressures on water supply and wastewater service systems that are already overburdened. Studies show that tourists consume three times the quantities of water that the local populace consumes. The pricing of water does not reflect the true cost and scarcity value of providing it. This means that consumers have an incentive to consume more than the optimal quantities of water, which needlessly exacerbates water scarcity. Many water utilities have very limited financial resources. Funds are generally unavailable to support adequate maintenance services and to expand systems in the face of growth in demand. Moreover, there are severe limits on funds available to support investment in water storage and conveyance facilities, which means that facilities are rarely scaled at levels needed to serve contemporary demands on a reliable basis. Finally, governments do not support the water service enterprise adequately. Investment in needed facilities and infrastructure does not occur in a timely fashion, if at all. There is a lack of hydrologic data and other relevant information to support water planning and management. The basic legislation that governs the development and management of water resources is weak. This is especially true of legislation needed to protect and maintain water quality.

The urban water supplies of the Caribbean region are among the most vulnerable in the entire hemisphere. Water scarcity and inadequate treatment and distribution facilities are among the most pressing problems for virtually all urban areas. These problems are likely to become worse in the future with climate change, diminished precipitation, inadequate investment in facilities, and likely increases in demand for water services. Wastewater collection and treatment service are similarly inadequate, if not more so. Investment in such services is an imperative for the future to protect both human health and the quality of the environment, which is important to the economies of the Caribbean islands. In addition, nations with angular landscapes must learn to cope with destructive forces that are at work on terrestrial resources. Protection of watersheds will be critical to sustaining supplies of good quality water and protecting the quality of the marine environment. The need for land and water management to be done in a coordinated way points to the importance of adopting schemes of integrated water resource management (IWRM). Such schemes have not been well developed in this region of the Americas.

There are at least three critical elements that will be essential components of any successful strategy to address the urban water problems of the region. The first is to develop widespread recognition of the problems. The political directorate throughout the Caribbean region must recognize and address the fact that the provision of water to their respective populations is a key sustainability issue that has important long-term social justice and development implications. Second, a list of "best practices' for managing limited water resources in an environmentally and economically sustainable way should be developed and presented for review and implementation. The third element will be to provide sufficient financial resources to permit each island nation to invest in appropriately scaled water supply and wastewater management infrastructure, as well as funding to maintain and expand that infrastructure as required by economic growth in the face of changing climate.[16]

Urban Water in Canada and the United States

Canada and the United States are the two most developed countries in the western hemisphere in terms of per-capita gross domestic product, yet both are beset with problems of availability of plentiful quantities of high-quality water for drinking and sanitation services. Water scarcity and qualitative threats to drinking water supplies are common to both. The United States is unique because of inadequacies of water and sanitation infrastructure.

Drinking water and sanitation infrastructure in the United States exhibit the water paradox of developed nations. Virtually the entire U.S. population has access to generous supplies of clean, healthful water and good sanitation services. Waterborne disease is rare. Nevertheless, the water service infrastructure is aging, and despite this, little investment or provision is being made to renew or update it. The American Society of Civil Engineers estimates that the annual shortfall to replace aging drinking-water facilities and modifications needed to comply with current and future regulations amounts to US$11 billion. The current unwillingness of public officials at all levels—Federal, state, and local—to appropriate the necessary funds to replace and sustain both drinking-water and sanitation infra-structure will lead to increased jeopardy in the reliability of such systems to protect public health and deliver critical public services.

In contrast, Canada's water supply and sanitation infrastructure appears mainly adequate in urban areas, although it is inadequate in many rural areas and in communities occupied by indigenous people. A case study of the city of Toronto shows that it has developed comprehensive plans for renewal of sanitation and drinking-water facilities and has made an excellent beginning at financing the implementation of those plans.

Both Canada and the United States face similar threats to the quality of drinking-water supplies through potential failures to monitor and regulate toxic chemicals and biological contaminants. In the United States, existing Federal legislation is inadequate. The list of new contaminants grows every day and

much more rapidly than the capacity of the regulatory authorities to evaluate them. The threat to drinking-water quality grows as well. Canada suffers from inadequate monitoring and oversight of drinking-water quality. There has been no national surveillance system to track and monitor outbreaks of waterborne diseases. Instances of waterborne diseases are thought to be rare, but the lack of monitoring and surveillance makes it difficult to confirm this, as there may be significant underreporting. Groundwater is a significant but modest source of drinking water in both countries. Groundwater is known to be susceptible to contamination, and the absence of effective regulation increases the risk of waterborne disease from this source. Over time both countries will need to do a better job of identifying and regulating contaminants of all types if the quality of drinking-water supplies is to remain high and significant instances of contamination are to be avoided.

Both the United States and Canada are generously endowed with water resources. Canada has the second highest per-capita water endowment of any country in the world. Twenty percent of the world's surface-water storage is found there. Although the United States is not as generously endowed, most regions of the country have had plentiful water supplies that provide copious quantities of water for urban and industrial uses, including agriculture. Aggregate figures mask the fact that that there is significant variation in the availability of water over time, space, and season. Thus, in Canada 90% of the population lives within 100 miles of the U.S. border while 90% of the water flows to the north. In the United States, lands east of the 100th meridian tend to be humid and semi-humid, while lands to the west of that longitude tend to be arid and semi-arid. Nevertheless, problems of water scarcity exist in both regions and will intensify and become more common with the continued economic and population growth that is forecast. So too with the forecast population growth in urban areas, which will fuel additional demand for urban water supplies. This problem is made more difficult because in many basins existing supplies are already fully allocated. Here development of additional supplies to serve growth is either a limited option or not an option at all.

There are a number of measures available to all urban areas in North America to help in combatting the pressures of intensifying water scarcity.

Rationing

Rationing is commonly used in areas with extreme scarcity where restricted availability of water tends to be short-

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Water supply and sanitation infrastructure in the United States is outdated, and there has been little effort to date to modernize and renew it.

term. It is not always well suited to the regulation of indoor uses but can be tailored for such circumstances.

Education

There is abundant evidence to show that water use tends to decline when consumers know where their water comes from and how much they are using. Declines in use are also observed when consumers are aware of the costs of treating and delivering the water.

Pricing

The price of urban water is almost always based upon cost and does not reflect the scarcity value of the water itself. In such instances, water has a scarcity value of zero, which suggests to consumers that it is freely available. It has been clearly established that as the price of water increases, the quantities used decline. The pricing system does not always work perfectly, so that frequently prices should be included as part of a mixed strategy.

Water Markets

Prices that emerge from well-functioning markets almost always reflect the appropriate scarcity value. Markets work by facilitating the transfer of water from low-valued uses to high-valued uses. Since urban uses tend to be high-valued, the existence of water markets will almost always ensure that sufficient water can be acquired to serve urban uses fully. Markets typically work voluntarily because both parties benefit from voluntary exchange. The buyer gets water more cheaply than she could otherwise and the seller receives more for his water than he could in any other use. Both Canada and the United States have at hand the means for managing water scarcity that may affect the availability of urban water supplies adversely. As scarcity continues to intensify, they will need to make fuller use of all of the strategies outlined here.

There are other serious problems. In countries as geographically varied as Canada and the United States, many of the problems are local and regional in nature. The three identified here—lack of modern infrastructure, adequate regulation monitoring of contaminants, and water scarcity—are the top three national problems in both countries. They deserve serious and effective attention from government at all levels if serious problems of health and water shortage are to be avoided.[17]

Conclusions

There are five priority topics that appear repeatedly throughout the Latin American country summaries. They delineate topics that must be addressed in development plans to improve water management in the cities of Latin America.

1. The management of watersheds in urban areas should focus on both the water resources inside cities and those in surrounding watersheds in order to achieve integrated management of urban waters.
2. The management and protection of groundwater should receive attention coequal to that accorded to surface water. Persistent groundwater overdraft and the creation of impervious surfaces that lead to reductions in groundwater recharge should be given special emphasis.
3. Special strategies are needed to improve access to water and wastewater services in peri-urban zones that have been neglected in water governance in the cities they surround.
4. Adaptation plans should be developed that include measures that reduce the vulnerability of cities to extreme climate events.
5. In all countries of Latin America there is a need for additional infrastructure to improve wastewater collection and treatment facilities. The inadequate management of wastewaters has vast ecological and economic impacts and contributes to adverse health impacts in major urban areas and their surroundings. It will also be important to develop new initiatives for water reuse facilities in order to avoid the loss of this potential source of supply and reduce the volume of water that must ultimately be discharged into receiving bodies.

Canada and the United States are the two most economically developed nations in the hemisphere. However, this does not ensure that they have trouble-free sanitation and water supply systems.

1. Water-supply and sanitation infrastructure is outdated and in need of modernization in the United States. Some consumers, particularly indigenous people, are inadequately covered in Canada.
2. Drinking-water quality is inadequately regulated in both countries. Failure to address the inadequacy of regulations will ultimately result in the contamination of supplies.
3. Water scarcity afflicts both countries and raises questions about whether supplies can be made adequate to serve anticipated population growth in urban areas.

All countries of the hemisphere need better political recognition and acknowledgment of the entire range of water problems. Similarly, the water sectors of all of the countries need access to financial resources if they are to find and pursue solutions to these problems.

Recommendations

1. The strategy for management of water in urban areas should be based on science and should employ technology where appropriate to improve efficiencies in various uses of water. New tech-

nologies for control, monitoring, and reuse of water should be introduced. The reuse of water in cities is a fundamental process for improving efficiency and closing the hydrological cycle.

2. Apply and reinforce strong regulations and controls on water services to achieve continuity and stability in access to water for the population. This should help to reduce or eliminate diseases transmitted by water vectors.
3. Include all economic measures in evaluating investment programs in water and wastewater treatment. It is important that programs to create improved drainage systems and promote integrated watershed management be adapted to the new challenges of climate change and related impacts on the hydrologic cycle.
4. Improve education and capacity building for professionals, technicians, and operators of water and wastewater systems at all levels of government but especially for municipalities.
5. National governments should give priority to creation and support of programs for evaluation and regulation of contaminants in drinking water.
6. High priority should be accorded to construct more and better wastewater treatment systems. Only 20% of wastewaters in Latin American cities undergo treatment. Improvements are essential to reduce contamination and improve health conditions. Sanitation systems need to be extended to peri-urban areas. Treatment methods and technologies should be adapted to local conditions. One size does not fit all.
7. Conjunctive management of groundwater and surface water should be practiced on a continuing basis. This will help to reduce dependence on single water sources and take advantage of the unique characteristic of groundwater and surface water.
8. In urban areas dependent on groundwater, efforts are needed to reduce the extent of impermeable areas in order to optimize safe groundwater yield. Such efforts should be part of future strategic planning for the management of water resources.
9. Improvements are needed in the collection and dissemination of hydrologic data upon which planning can be based. Such data will be critically needed in fashioning adaptations at the time of climate change. Data should be made accessible to members of the public.

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