Water Scarcity in Latin America and the Caribbean

Myths and Reality

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Why water scarcity matters?

With a population of 554 million and 20,136,000 Km^2, the Latin America and Caribbean (LAC) region is a mosaic of 34 countries within a very diverse climatic and geographical setting. While the LAC countries have a relative abundance of water on a per capita basis and high coverage of water supply services; there is ample evidence that water scarcity is affecting the daily life of millions. In the past few months alone, Mexico, Venezuela and Honduras have severely rationed their water supply services to cope with droughts.

While droughts are rapidly attributed to climate change and El Nino/La Nina cycles, a more comprehensive analysis is needed to explain the gap between supply and demand and the low quality of water services in cities and rural areas--even during the average hydrological years. Since the expectations are that water issues should be resolved at no cost to the population, water is mobilizing the civil society and the media demanding governments for actions that guarantee access to potable water and sanitation services, reduce pollution to rivers, and protect people and economic activities from devastating floods.

The main purpose of this paper is to discuss some of the underlying issues that drive water scarcity in the LAC region. It argues that rapid urbanization over the past 50 years, lack of infrastructure (including rehabilitation of existing facilities) and more importantly weak governance are crucial factors that affect scarcity in a water rich region (Figure 1). While the

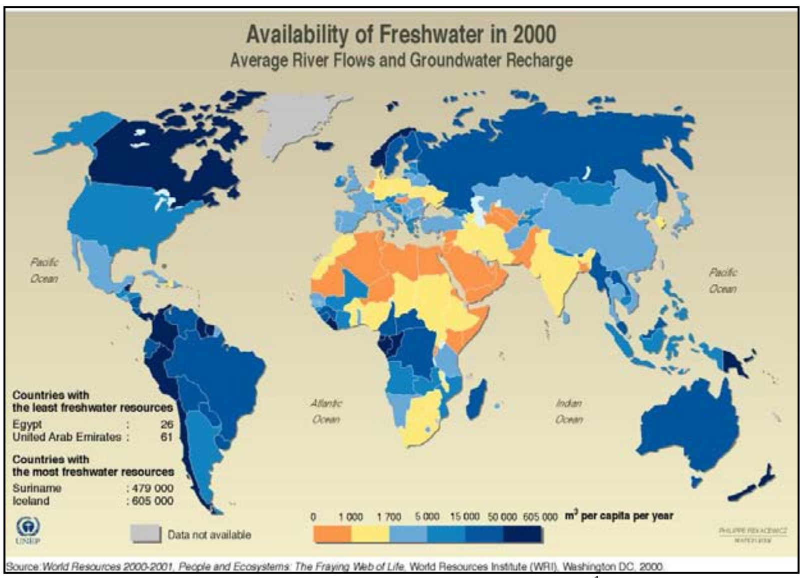


Figure 1: Availability of Freshwater in 2000[1]

paper focuses on urban water issues, it also recognizes that water scarcity is constraining irrigated agriculture in arid and semi-arid regions, and excess water is affecting agriculture production in humid areas. The paper discusses facts and perceptions about water scarcity with the intention of separating myth from reality and making a contribution to the policy debate about water scarcity in the LAC countries. For the sake of brevity, other important water issues related to scarcity like water productivity in agriculture, reduction of water availability due to

[1] World Resources Institute, 2000

pollution and the effects of extreme events, will be mentioned but not discussed in any detail in this paper.

Facts and indicators about water scarcity

With 30 percent of rainfall and 33 percent of the world's water resources, water is relatively abundant in LAC--about 28,000 M^3 per inhabitant/year[2] (Table 1). However, water availability[3] is highly seasonal and unevenly distributed in space. For instance, in the sub-region of Mexico, Central America, and the Caribbean, 49.3 percent of the streamflow takes place between August and October, but only 7.3 percent from February to April. In South America the ratio between the wettest and driest three months of the year are less skewed--34.6 percent of stream flow between May and July, and 17 percent between November and January[4]. Nevertheless, based on common indices of scarcity, the region as a whole is far from water scarce. In fact, the opposite would seem to be the case.

The Falkenmark indicator is a common and widely used metric of water scarcity[5]. It proposes a threshold of 1,700 M^3 of renewable water resources per capita per year to characterize water stress at the country level. This threshold is based on estimates of water requirements in the residential, agricultural and energy sectors, as well as environmental needs. Countries that fall below 1,000 M^3 are under water scarcity and below 500 M^3, are under absolute water scarcity. As shown in Table 2, only Haiti, Barbados and Antigua are below the 1,700 M^3 thresholds. The rest of the countries are well above this limit with the exception of El Salvador, the Dominican

[2] FAO. AQUASTAD.
[3] Water availability refers to surface water unless groundwater is mentioned.
[4] Shiklomanov, 1999. UNESCO/IHP. World Water Resources at the beginning of the 21st century.
[5] Falkenmark, et al. 1989. Macro-scale water scarcity requires micro scale approaches: Aspects of vulnerability in semi-arid development.

Republic, and Trinidad and Tobago. These latter countries are getting closer to the 1,700 M^3 threshold, all of them are below the 3,000 M^3 benchmark.

The water vulnerability index proposed by Professor Shiklomanov[6] is often quoted and frequently used in global and regional analysis of water scarcity. It deals with water scarcity by considering both the supply and the demand. This index estimates the total annual withdrawals as a percent of available water resource for each country and aggregates information for 26 economic regions in the world. It suggest that a country is water scarce if annual withdrawals are between 20 and 40 percent of annual supply and severely water scarce if this figure exceeds 40 percent. In the case of the LAC region, only Cuba with 21 percent barely falls in the range of water scarce. Mexico with 19.1 percent, the Dominican Republic with 16.1 percent and Argentina with 10.1 percent is in the range of 10 to 20 percent—the rest of the countries have a very low water vulnerability ratio (Table 2).

These indexes have been useful for aggregated analyses that identify trends and priorities for global policy discussions. However, its usefulness for water scarcity analysis at the country level, including policy analysis and investment planning, is limited since they do not capture seasonal and geographical distribution of water availability, and because of the implicit limitations of the estimates of cumulative water withdrawals.

More recently, the International Water Management Institute (IWMI) has proposed to take into account a more detailed estimation of demand by calculating the share of the renewable water resources available for human needs (accounting for existing water infrastructure), the primary water supply[7]. Its analysis of demand is based on consumptive use (evapotranspiration) and the

[6] Shiklomanov, IA (1991).The World Water Resources. UNESCO/IHP.
[7] Rijsberman, FR. IWMI 2004. Water Scarcity: Fact or Fiction?

remainder of water withdrawn is accounted for as return flows. IWMI estimated water demands in 2025 including an assessment of potential infrastructure development and increased efficiency in irrigation through improved water management policies[8]. In IWMI's approach, countries are called "physically water scarce" when they are not able to meet water demand in 2025, even after accounting for future adaptive capacity. On the other hand, countries that have sufficient renewable water resources, but not infrastructure to make these resources available to satisfy demand, are defined as "economically water scarce". According to this approach to scarcity, with the exception of Panama, Costa Rica, Ecuador, Surinam, and Uruguay; the rest of the countries in the LAC region will be economically water scarce by 2025 (Figure 2).

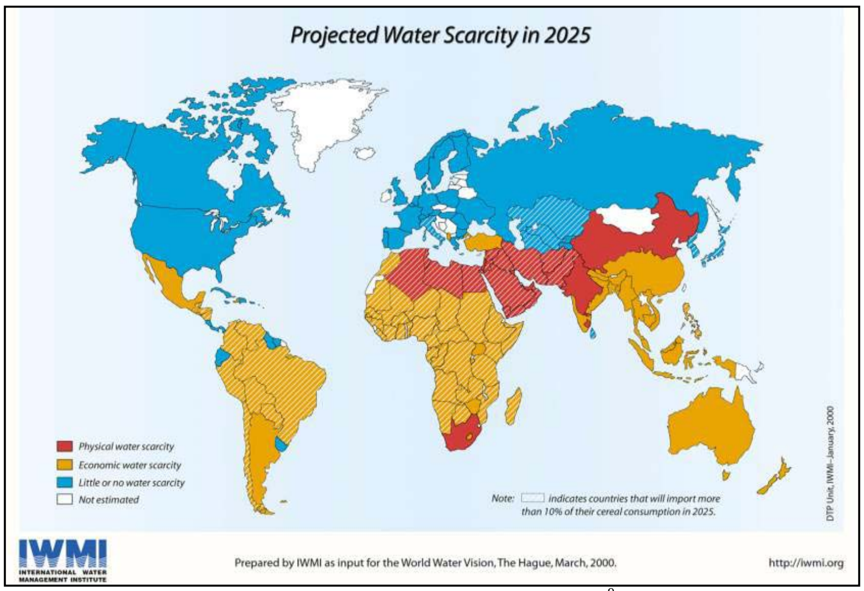


Figure 2: Project Water Scarcity in 2025[9]

[8] A Comprehensive Assessment of Water Management in Agriculture. IWMI. 2007.
[9] World Water Vision. IWMI 2000

The concept of economic water scarcity is particularly useful for the LAC region because it facilitates a deeper understanding of scarcity beyond simply per capita water availability. However, for meaningful policy analysis and decision making in the water sector a broader approach to demand for water services would be considered. This paper suggest that the unmet demand for water services would be assessed beyond the traditional water supply, sanitation, and irrigation sectors to include deficits of pollution, flood and ecosystems management infrastructure. It is not fortuitous that these are also high development priorities for the LAC region to help reduce poverty, and support sustainable economic development.

A suggestion for further analysis is to split the economic water scarcity index in two components: one that reflects the deficit of infrastructure to deliver water services (infrastructure water scarcity), and another that considers the institutional and policy capacity to deliver water services at the desired performance level (governance water scarcity). The basic insight behind this suggestion is that insufficiency of water in the LAC region, is primarily driven by inefficient supply of services rather that by water shortages. The World Water Assessment Programme has explicitly addressed this important recommendation by recognizing that the lack of basic services for water supply and sanitation is often due to mismanagement, corruption, lack of appropriate institutions, and bureaucratic inertia[10].

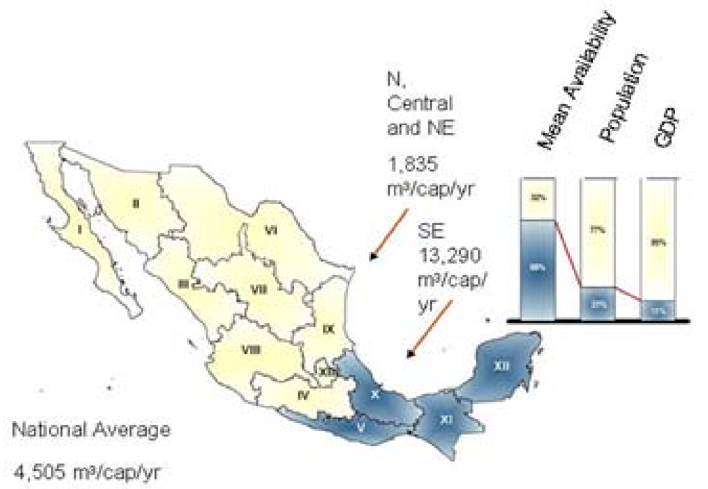
Plenty of water but…

Asymmetries between water resources availability and population at the country level are large. Water resources are mostly located in the inland of the continent, while urbanization and land development followed the path of decisions made in colonial times. Cities and economic activity

[10] The United Nations World Water Development Report 2. Water a Shared Responsibility. UNESCO 2006.

in the colonies was concentrated either near the coast to facilitate exports to Spain and Portugal, or on the hinterland of the main cities of the Aztec and Inca empires to take advantage of free and abundant labor.

In the case of Mexico, 77 percent of the population, 84 percent of the economic activity, and 82 percent of the irrigated area is located in the central and northern plateau and above the 1,000 meter elevation. In contrast, 72 percent of water availability is in the south and below that altitude (Figure 3). In Peru, with a per capita water availability of 58,000 M^3/year, 70 percent of the country's population of 29 million and 90 percent of the economic output is located along the Pacific Coast, with only one percent of the country's water availability. This asymmetry, makes the most economically dynamic region of Peru severely water stressed. In Venezuela, 90 percent of population and economic activity is located in the north of the country with less than 10 percent of water availability. Most of the water availability is found south of the Orinoco River away from the northern coast.



Source:

Figure 3: Regional contrast between development and water availability

Over the past 50 years, the LAC region has witnessed a large expansion of water and sanitation infrastructure, irrigated area, and hydropower generation (Table 2). Coverage of water supply services in urban areas has increased from about 40 percent in 1950 to 92 percent in 2005. This indicator is particularly impressive because, at the same time, with the exception of the smaller islands in the Caribbean and Guyana, the LAC region had experienced accelerated demographic growth and rapid urbanization—in the case of Guyana, urban population has decreased in 0.1 percent per year since 1990. With 85 percent of population in urban areas, as a consequence of an annual urban growth of about 2-3 percent over the period 1990-2005, the LAC region is today the most urbanized of the developing world.

However, in spite of high network coverage levels of water supply and sanitation services, their quality is still low. Continuity of water services, 24 hours and seven days a week, adequate pressure in the pipes, and meeting the Pan American Health Organization drinking water standards at the point of use, are challenging for many cities of LAC. While the LAC region enjoys a high per capita availability of water and has made substantial water investments, water services are lagging since they are not delivered to the population as expected. The high level of un-accounted for water (UFW)[11] that is within the range of 35 to 50 percent in many utilities of the LAC region, it's an excellent portrait of the paradox of water abundance, high coverage levels of network infrastructure, and low quality of water services (Table 3). Reducing un-accounted for water is not only about repairing leaking pipes, replacing water meters and reducing wastage, but more importantly they are related to the effective implementation of governance policies to enhance institutional accountability, charge water tariffs that are reflective of costs and implement transparent policies to address affordability issues.

The irrigated area in the LAC region has increased from 8 to about 18 million hectares from 1960 to 2000[12]. However, the actual irrigated area should be significantly lower when considering the existing problems in operation, maintenance, and rehabilitation of irrigation systems (public and private) and inconsistencies in reporting irrigated and rainfed areas—available information on irrigated crops of 8.5 million hectares is only about 50 percent of the total irrigated land. There are large statistical inconsistencies in the data sources. However, there is convergence in the estimation of the agriculture land—it is vast, about 719 million hectares, or about 35 percent of total available land. According to FAO, the irrigation potential is estimated at 77.8 million hectares, of which 65 percent is located in Brazil, Argentina, Mexico and Peru.

[11] Commonly used indistinctively as water losses and non-revenue water.
[12] FAO AQUASTAD.

While the global share of the LAC region in irrigated area is less than 7 percent, over the past decades it became an even larger world exporter of rainfed agriculture.

An increase of irrigated areas is foreseen for the more humid regions where irrigation constitutes production support as irrigation development has in many countries reached its limits due to scarcity and mismanagement. In tropical and other humid climate areas: the Pampa in Argentina, Lesser Antilles, Central America, Colombia, Amazon basin and Andean countries, programs are being carried out for supplementary irrigation on high yielding crops with the objective of stabilizing production during dry periods[13]. At the same time, there is a trend towards a better integration of surface water and groundwater in countries like Argentina, Ecuador, Peru, Mexico and the Dominican Republic.

Issues related to irrigation are also linked to the evacuation of excess water by rainfall in areas that are susceptible to water logging, and salinization. In Brazil, water logging valleys (v*arzeas*) cover approximately 1.2 million hectares. In Mexico, 2.8 million hectares of irrigation districts, and 2.4 million hectares of supplemental irrigation (*distritos de temporal tecnificado*) are the largest area with drainage infrastructure of the LAC region. Salinization induced by irrigation is also a serious concern in Argentina, Cuba, Mexico and Peru, and north east Brazil.

Water pollution is related to infrastructure and governance deficits in the water sector. Only 20 percent of wastewater is effectively treated in LAC, but there is infrastructure to treat about 35 percent. While large investments in wastewater treatment have been planned for Buenos Aires, Mexico City, Bogota, Lima, and Sao Paulo, they have been delayed for many years because of the lack of strong institutions and policy frameworks that are hindering effective actions.

[13] FAO. AQUASTAD.

In the period 2009-2010, Sao Paulo, Rio, and Buenos Aires have suffered from devastating floods with a balance of casualties and large economic losses. Urban floods are linked to a more intense hydrologic cycle, but more importantly they are the consequence of increases in imperviousness cover that reduces runoff concentration time and increases peak flows; fragmented decision making of metropolitan authorities; and lack of adequate planning and construction of regulating and trunk infrastructure to manage floods in urban watersheds.

In rural areas, floods are typically related to recurrent climatic events in large alluvial valleys and in foothill areas (flash floods). In the case of Argentina, a significant portion of the population and economic activity is located in the flood plain of the Parana River system, which has suffered a major flood event with a recurrence of about one every 10 years. Since the early nineties, the Argentinean federal government has undertaken a major effort to build infrastructure and implement non-structural measures to protect urban and rural areas. However, it needs strong coordination between the government authorities of the provinces and the federal levels, and substantial budgetary allocations to operate and maintain the extensive flood management infrastructure in place.

Since the early sixties, construction of dams and hydropower generation facilities has been impressive. A sustained financial effort to expand hydropower makes the LAC region the world leader in production of renewable energy as a proportion of total generation capacity. In most of the countries in South America, as well as in Panama and Honduras, hydropower represents more than 50 percent of the installed capacity for electricity generation (Table 2). The potential for hydropower development in the LAC region has been estimated in excess of 200GW and governments are eagerly interested in new projects. Expansion of hydropower capacity is taking place in sensitive ecosystems: the Amazon (Madeira, Tocantins and Xingu), the eastern slope of the Andes (Peru), the Caroni River in Venezuela and in southern Chile. All these new developments are facing formidable opposition because of their social impacts, issues linked to indigenous rights, and multiple environmental concerns (environmental flows and protection of biodiversity hotspots).

Water scarcity is also affecting urban and rural areas that are supplied from groundwater. In Mexico, about two million hectares (33 percent of irrigated area) depend on groundwater resources, and approximately 75 million people (about three fourths of Mexico population) as well as a large part of the industries depend on groundwater. As a consequence of wrong policy choices, including over allocation of water rights and large electricity subsidies in rural areas, overexploitation has increased: from 20 aquifers in 1970 to 103 in 2003. They supply 14 Km^3 per year—about half of the total groundwater abstraction consisting of 9 Km^3 from annual recharge and about 5 Km^3 from storage accumulated during thousands of years[14]

What drives scarcity

This paper makes the argument that the main driving force behind scarcity in the LAC region is the combination of rapid urbanization and weak governance. It also claims that a main consequence of urbanization and weak governance is the formation of slums[15]—27 percent of the urban population of the LAC region lives in slums[16]. While not all living in slums have the same level of deprivation, most are affected by poor water and sanitation services (economic water scarcity), and some, typically the poorest segment, are further affected by the lack of security of tenure, insufficient living area, and houses of non-durable materials.

[14] Asad and Garduno. Water Rights Program for Mexico. 2005.
[15] A Slum household is considered to be a group of individuals living under the same roof that lack one or more of the following conditions: access to improved water, access to improved sanitation, access to secure tenure, durability of housing, and sufficient living space.
[16] UN Habitat. State of the World Cities. 2008.

Empirical evidence shows that cities are integral to development and economic success, in spite of slums and other negative consequences like environmental degradation. While the rush to cities in developing countries seems chaotic, there is strong evidence that it is unavoidable and even necessary. The challenge is that countries must manage the rapid growth of cities when they still have low income and nascent institutions as it once happened in today's world class cities (Paris, New York, Dublin, and Tokyo). Historical data demonstrate that urbanization for developing countries over the period 1985-2005 is remarkably similar to the average for European and North American countries between 1880 and 1900[17]. It takes several decades to absorb informal settlements into more organized city structures—the development challenge is to speed up this process in the most efficient and equitable way.

This simplified conceptual framework of urban growth in developing countries allows a deeper understanding about the dynamics of city growth and poverty. Such a framework is also needed to design policies and set development priorities that address supply and demand gaps for urban water services over several decades; taking into account that the relative abundance of water and the existence of network infrastructure are frequently misleading. The proposition is that development priorities should be set to support governance and infrastructure investments that raise the performance of water services that are provided to the poorest segments of the population. Governance requires public policy reforms that enhance accountability and support efficiency incentives. Water investments should include a major component of rehabilitation of poor performing infrastructure that has suffered of inefficient operational practices and maintenance neglect.

[17] Reshaping Economic Geography. World Development Report. World Bank 2009.

This strategic development priority is strongly supported by recent evaluations of the cost of environmental degradation in the LAC countries that have shown that the hidden economic cost of poor quality of water and sanitation services could be in the range of one to two percent of GDP. In the case of Colombia, a country with one of the highest coverage levels in the region, the economic cost of poor quality of water supply and sanitation was estimated in 1.04 percent of GDP[18]. This cost is associated to high morbidity rates of water borne diseases, and to about 1,500 premature deaths per year. It represents a high cost to the economy due to life losses, costs of medical treatment and coping strategies, and losses in labor productivity due to illness.

Per a simplistic inference, the cost of environmental degradation associated to the lack of adequate water and sanitation services should be much higher in other countries of LAC that have worse health indicators than Colombia, that has an average under-five mortality rate per thousand births of 21. This is the case of Haiti with 120, Bolivia with 65, Guyana with 63, and Guatemala with 43. This cost is even higher when considering the high morbidity related to diarrhea prevalence[19]. Unfortunately, the data shows that prevalence of diarrhea in most LAC countries is comparable to less developed countries of Africa and South Asia which have lower coverage of water and sanitation services and a more limited stock of water infrastructure. Most countries in the LAC region are in the range of 13 to 25 (Table 2), which is similar to countries like India (19.2), Tanzania (12.6), Uganda (19.2), Kenya (17.1), and Egypt (18.4).

In addition, these average country indexes also hide large distributional disparities across income levels. This observation is particularly relevant for the LAC region which is considered the most

[18] Ernesto Sanchez Triana. World Bank. 2007. Environmental Priorities to Reduce Poverty in Colombia.
[19] Indicator of prevalence refers to the percentage of children under age five who had reported one episode of diarrhea in the two weeks prior to the survey. United Nations Children's Fund. Data is from 1998-2004.

unequal of the world as measured by the GINI[20] coefficient. Sao Paulo, Belo Horizonte, Fortaleza and Bogota have GINI coefficients above 0.6 which is considered extremely high. Quito, Buenos Aires, Santiago and Mexico City are in the range of 0.5 and 0.59 which reveal high levels of inequality. Montevideo, Asuncion, Caracas and Guatemala City are between 0.4-0.49 which is at dangerous high level[21] [22].

The analysis done in several countries of the LAC region prove that environmental degradation and low quality of water supply and sanitation services are not only highly correlated, but also the fact that they disproportionately affect the wellbeing of the poorest and most vulnerable population—children, elderly and women. In Colombia, the health impact of environmental degradation is three times higher in the poor population and 10 times higher when it is weighted per unit of income. In other areas and countries of the region: Central America, Peru, and Ecuador; where these studies have been made, health impacts of environmental degradation on the poorest segments of society are similar.

However, while urbanization and governance are the main drivers of scarcity, they are not the only ones. The comparative advantage of the LAC region to compete in the global market (water and land) is also a major driver to expand the agriculture frontier—mainly for exports of soy beans, sugar and meat. As global trade is rapidly transforming the regional landscape, it is also increasing water demand in rural areas at the river basin scale. This is particularly relevant for Argentina, Paraguay, Bolivia and specially Brazil that have developed world class agriculture technologies and cropping practices that support high yields even in hot and humid climates. As a consequence, a substantial volume of water is exported in trade of food commodities (virtual

[20] The GINI coefficient is a measure of inequality. A low GINI indicates a more equal distribution, with 0 corresponding to complete equality, while a higher GINI indicates a more unequal distribution. The average GINI for the EU countries in 2005 was 0.31 and 0.46 for the US.
[21] UN Habitat. Global Urban Observatory. 2009.
[22] For comparison purposes the GINI coefficient of New York and London are 0.48 and 0.32, respectively.

water). Worldwide, virtual water trade of crops has been estimated to be approximately between 500 and 900 Km^3 per year. An additional 130-150 Km^3 is traded in livestock products. The virtual water exported by the LAC region is projected at about 190 Km^3, or about 20 percent of the world estimate[23].

These are major drivers that are influencing quantity and quality of water availability at the river basin scale with changes in land use intensity and land cover change. Land use changes affect evapotranspiration, infiltration rates and runoff quantity and timing. It is particularly relevant to consider the reduction on the overall quantity of available runoff associated with different types of land cover change and how this can be transferred downstream through river networks.

Lastly, climate change is another important driver of water scarcity in the medium to long term. Most global circulation models show that climate variability, intensification of extreme events and more frequent water-related natural disasters are enormously important for the LAC region. Projections derived from global circulation models point to changing precipitation patterns across the region, with increased winter rainfall in Tierra del Fuego, higher summer precipitation in southeaster South America, and drier conditions in Central America and the southern Andes[24]. The most relevant climate-driven effects in the region are expected to be: wholesale coral bleaching in the Caribbean, rapid retreat of tropical glaciers in the Andes, loss of density in the Amazon rainforest, coastal flooding, and increased frequency and intensity of hurricanes. For instance, the IPCC assessment and research from climate scientists have concluded that Mexico may experience significant decreases in runoffs, of the order of minus 10 to 20 percent nationally[25]. Ongoing studies show that a temperature increase of 4 degrees centigrade might

[23] Millennium Ecosystem Assessment. Current State and Trends. 2005.
[24] De la Torre, et al. Low-carbon Development. Latin America Responses to Climate Change. World Bank 2010.
[25] P.C.D. Milly. et al. Global pattern of stream flow and water availability in a changing climate. Nature. 2005.

lead to a collapse of the Amazon's rainforest ecosystem[26]. Water supply to cities will be affected—in the case of Quito, new sources of water to substitute a glacier east of the city will increase productions costs in 30 percent.

Addressing priority water scarcity issues in LAC countries

An attempt has been made by the author to summarize myths and realities about water scarcity issues from the perspective of politicians and water policy makers (Table 4). As described elsewhere, there is the fallacy of water abundance and high infrastructure coverage when in reality water cannot be consumed directly from the tap, and the poor have to pay several times more than the rich to cope with the poor quality of water services. Perceptions about water policies have been summarized taking into account findings of an independent review of about 1,800 water projects financed by the World Bank in the period of 1997-2007[27], and the experience gained through policy and strategic dialog about water in many countries of the LAC region. It tries to capture different perspectives about water policies, and it is expected that it will be a practical contribution to focus the discussions about policies and the political economy of water scarcity.

Using the broader definition of scarcity suggested in this paper, priorities should account for deficits of water services that go beyond water availability, and include lack of infrastructure (infrastructure water scarcity[28]) and inadequate governance systems (governance water scarcity). Based on the analysis of data, regional reports and experience in development assistance, it is

[26] Levy et al. Modelling the impact of future changes in climate, CO_2 concentration, and land use on natural ecosystems and the terrestrial carbon sink. 2004.
[27] Evaluation of the Bank's Water Assistance in Water from 1997-2007. Independent Evaluation Group. The World Bank 2010.
[28] Including expansion and rehabilitation

proposed that the priority water scarcity issue in the LAC region is in urban areas, in particular to improve governance of water utilities.

Improving the accountability framework of utilities and implementing demand management policies and investments are the main priorities for water utilities in the LAC region. While the region has powerful utilities and technical capacity, and generally cover their operational cost with the exception of Bolivia and Venezuela (Table 3); they are still highly inefficient because public utilities generally lack strong performance incentives and accountability frameworks that are linked to efficiency objectives. Modernizing utilities requires reforms to clarify the role of governments, strengthen regulatory institutions, and build stronger performance incentives for managing utilities. A first generation of reforms has been implemented to address these issues but they have only been partially successful. However, there are also some clear successes over the past twenty years. Important progress has been made in advancing regulatory reform to reach coverage of about 75 percent of the region's urban population, and these are pushing utilities to be more transparent in reporting performance and in achieving a stronger focus on efficiency[29].

The priority water scarcity issue in the LAC region is in urban areas, in particular to improve governance of water utilities

Demand management to reduce un-accounted for water, control wastage, and adjust consumption to efficient levels have been identified as the most effective investment to address the supply/demand gap[30] . Water use in the industrial sector is expected to increase from current levels of 10-15 percent of total withdrawals, in the most advanced countries, to 20-25 percent that might even surpass domestic consumption. It will also require careful attention to establish

[29] Blue Book. International Benchmark Network. World Bank. 2010 (forthcoming).
[30] Charting our Water Future. McKinsey. 2009.

incentive and enforcement instruments to reduce water consumption in the energy sector (cooling of power plants) and increase reuse.

However, in spite of the potential increase of water supply to cities by simply reducing water losses, and rehabilitating and updating existing water facilities; water transfers have become one crucial investment for water starving cities of the region. Some of the largest cities of the region are already transferring important volumes of water from neighboring river basins: Mexico City from the Cutzamala system; Lima from the Mantaro river that belongs to the Amazon River basin; Sao Paulo from the Cantareiras system, and Rio de Janeiro from the Paraiba do Sul river, which are part of the Parana River basin; and, Caracas from the Camatagua River in the Orinoco River basin. These are examples of massive investments that have been made over the past 40 years; and there are more to come in Sao Paulo, Bogota, Lima, Quito, La Paz and Tegucigalpa as a consequence of increasing population and economic growth, and because of reduced rainfall and increased variability of runoff related to the long term impacts of climate change.

Another option for increasing supply is desalination which is already in use in small Caribbean islands and by high-end touristic developments. Furthermore, Trinidad, Curacao, cities in the gulf of California, and in Northern Chile are also considering large investments in desalination since energy intensity has been reduced to less than five kilowatts per cubic meter and production cost, including capital costs, are becoming more competitive[31]—between 0.70 and 1.5 US$/$M^3$.

Managing water in urban areas is complex and it goes beyond utility management. It should support economic growth and poverty reduction in the most efficient way by ensuring that demand for water services is met where and when needed, at the required quality and

[31] Water Technology Markets 2010. Global Water Intelligence. 2010.

performance levels, including cost effective management of extreme events (droughts and floods). To achieve this goal, there is a need of integrated approaches to the provision of urban water services that consider urban development (including services to slums) and sustainable use of environmental resources. Unfortunately, management of water resources (surface and groundwater) and water services in urban areas is very fragmented and political decisions for integrated water management in cities remains a big challenge.

Other important priorities to address scarcity are: improve efficiency in irrigated areas and in rainfed agriculture, manage groundwater resources sustainably, reduce impacts of urban and rural floods, increase efficiency of pollution control, and address emerging issues and conflicts of water allocation.

Rehabilitation of irrigation systems, addressing salinization and water logging issues, and sustainable management of aquifers are development priorities for the LAC region in order to optimize the use of existing irrigation infrastructure, and improve water productivity, as well as to increase income and reduce poverty in rural areas. At the same time, reforms in the governance framework of irrigation systems, like the transfer of infrastructure operation responsibilities to user's association, provides a proven approach that has been implemented in Mexico, Argentina and NE Brazil—they provide a pool of good regional practices and models that should be more widely disseminated.

However, such institutional improvements require transparent rules and policies for allocating water rights. Chile's Water Code has been successful in enhancing investment in irrigation and increasing water productivity through a system of water rights that facilitate the transfer of water to higher value crops. Following the experience of Chile, irrigation systems in the Pacific Coast of Peru have proven that stable macroeconomic conditions, more transparent allocation of water rights, and dissemination of technologies (like drip irrigation) have a large impacts in improving water productivity, and in fostering innovation and entrepreneurship.

> **Other important priorities are:**
>
> **Improve water efficiency in irrigated and rainfed agriculture**
>
> **Manage groundwater resources sustainably**
>
> **Reduce the impacts of urban and rural floods**
>
> **Increase efficiency of pollution control**
>
> **Address emerging conflicts of water allocation**

The 2008 World Development Report (Agriculture for Development) emphasized that in order for agriculture to meet future demand, water productivity improvements need to be achieved not only in irrigated but also in rainfed areas. However, improvements in rainfed areas might also imply large increases in evapotransporation which has impacts on runoff, in downstream flow of rivers and in groundwater recharge. The potential for expansion of rainfed agriculture and supplemental irrigation in LAC is large and it is requiring sustained financial and institutional support to R&D and to the generation and dissemination of agro-climatic information that can be used by farmers[32]. While institutions like EMBRAPA in Brazil and others in Mexico and Peru, including CGIAR Centers, are world leaders of R&D in the

[32] Improving Water Management in Rainfed Agriculture: Issues and Options in Water-Constrained Production Systems. The World Bank. 2010.

agriculture sector, the institutional framework for production and dissemination of agro-climatic information is not yet at the same level.

Wastewater use for urban and peri-urban agriculture is an emerging priority for LAC countries. It can reduce water scarcity and provide a reliable source of water, improve agriculture productivity, reduce pollution, and create livelihood opportunities for urban households[33]. However there are tradeoffs that need to be managed including risks to human health, and to the environment. Wastewater use in agriculture is growing steadily around most of the large cities of the LAC region and their contribution to local markets of vegetables, fruits, poultry and dairy is significant. In Mexico alone, about 25 percent of municipal wastewater is reused in agriculture to irrigate about 300,000 hectares[34].

To address these type of issues, there is broad consensus in the LAC region about the need of integrated approaches to optimize policy and investment decisions and well functioning basin-wide water institutions. However, in spite of multiple efforts made over the past 50 years to create river basin agencies, their impact in improving water management is disappointing.

Sustainable management of groundwater resources is another priority for LAC countries. Mexico, Central America, Brazil, Paraguay, Argentina and Peru have substantial groundwater issues of overexploitation and contamination. Mexico is the country with the most severe set of groundwater issues of the region and it has attempted multiple approaches to improve management of its overexploited aquifers. Results to date of these attempts are mixed, including efforts to collect and analyze information, planning and modeling tools, and policy oriented programs to reduce the over allocation of water rights and eliminate perverse electricity subsidies

[33] Improving Wastewater Use in Agriculture: An Emerging Priority. World Bank 2010.
[34] Jimenez, B. La Contaminacion Ambiental en Mexico. UNAM. 2001.

to rural electricity. The design and the balance of successes and failures in implementing these options offer a wealth of information that should be analyzed and disseminated.

In August 2010, devastating floods in Pakistan, India and China took the center stage of the media with staggering videos of human suffering, deaths and loss of livelihoods of the poorest people of those countries. The LAC region is not different; over the past months, Rio de Janeiro, Sao Paulo, and Buenos Aires have also suffered from major urban floods and mud slides with a large balance of fatalities and economic losses. These flood events are linked to large transformations of land use at river basin scales, urbanization characterized by uncontrolled expansion of impervious areas and lagging drainage infrastructure, and to the intensification of extreme weather conditions that are related to changes of the hydrologic cycle that cannot be explained by traditional projections of historical records. Moreover, since floods travel across spatial scales and administrative jurisdictions, their management requires a strong coordination of water agencies across and within countries.

At the same time, flood management infrastructure, such as dams, engineered channels, levees and other facilities that keep rivers from entering the floodplains are generally considered public goods that require large investments and substantial budget allocations to cover recurrent costs of operation and maintenance. Unfortunately, the disparate combination of large demands for investment and budgets with weak, fragmented and uncoordinated institutions to provide flood mitigation services has not delivered and it has led to a major public policy failure in LAC countries, which is not different from other developing countries of the world---most notably India.

This situation is often aggravated in developing countries due to deficiencies of solid waste collection and disposal and poor management practices for erosion and sedimentation control. Furthermore, poor management of solid waste and erosion issues is often combined to cause clogging of existing (and generally insufficient) drainage infrastructure. Fortunately, there are also a few successful initiatives to address flood and drainage issues more systematically which can provide good lessons and practices that would be useful across the region. Specifically, there are urban flood management projects in Curitiba, Belo Horizonte and Porto Alegre in Brazil, and in the Maldonado and Matanza-Riachuelo urban river basins in Buenos Aires, that offer useful policy and implementation lessons to address urban floods with a balance of structural and non-structural measures. Similarly, the emergency, rehabilitation and prevention programs for alluvial floods from the Parana River in Argentina also offer valuable lessons on how to design and implement a large program of investments, regulation of land use, reallocation of population, and coordination of federal, provincial and local governments' jurisdictions.

Cities, particularly in the high end middle income countries of the region, are demanding increasing priority to eliminate pollution from their urban rivers. In Sao Paulo, Buenos Aires, Bogota, and Caracas, urban rivers have BOD concentrations that are similar to open sewers, with negative impacts on the quality of life and degradation of potentially high value urban land and property. There are multiple initiatives, and large investments to reduce pollution but results to date are below expectations, even after a large portion of the contaminant load is removed. While there is not a single explanation to the limited impact of current initiatives, it can be speculated that they are related to uncontrolled discharges from informal areas (slums), illegal connections to the storm water network, and the contribution of non-point sources of pollution, among others.

At the same time, there is also an expectation to reach a high level of pollution control in a relatively short period of time from 20 to 30 years, while countries in Europe with more resources and higher income levels have managed to control pollution of their rivers, like the Tames and the Seine Rivers, in a much longer timeframe. In some cases, following the logic of a stylized Kuznets environmental curve, water pollution might deteriorate even further while average income continues rising. It might be argued that it will be enormously difficult and expensive, to achieve very high levels of removal of pollutants if large part of the city is informal, and if there is not an explicit strategy to build individual connections and trunk infrastructure that it is adapted to high density and irregular patterns of urbanization.

There are, however, several useful experiences to manage quality and control pollution in large cities of the LAC region. For instance, the experience of Sao Paulo investing billions of US dollars to build treatment plants along the Tiete River, and develop the US$500 million Guarapiranga Water Quality and Pollution Control project that included sewerage connections, slum upgrading of 200,000 poor urban dwellers, and wastewater treatment to protect one main source of drinking water for the city, have provided a wealth of lessons that can be useful to other cities in the LAC region.

Currently, there are other large wastewater treatment investment programs in Mexico City, Caracas, Bogota, Lima, Buenos Aires and Santiago that can gain much by learning from each other and from the analysis of their collective experience. Some of these initiatives to clean rivers from pollution and restore degraded urban areas have been taken under strong pressure from the public opinion and the judiciary. This is the case of numerous pollution reduction projects in municipalities in Brazil that are responding to judicial pressure of legal suits presented by the Public Prosecutor (*Ministerio Publico*). A similar approach is taking place in

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Buenos Aires by the High Court (*Corte Suprema*) that has mandated the Federal Government, the City and the Province of Buenos Aires to proceed with the clean-up project of the Matanza-Riachuelo River.

Water conflicts between countries in the LAC region are not major when compared with the situation in the Middle East and in South Asia. In these regions, water conflicts are considered a threat to national security, as it is in the Nile, Indus, and Euphrates Rivers, that have become an important concern for the international community. In the case of the LAC region, while the level of international water conflicts is relatively low from a broader international perspective, there are increasing areas of dispute and conflict at the country level. These country conflicts are generally associated to scarcity and to the distribution of decision making power about water allocation between the federal, the state, and the local levels of government, and between river agencies. Generally, potential water disputes arise due to uncertainty about future allocation of water and the discretionary power that can be exercised through administrative permits and concessions. In LAC countries, water is allocated at the federal level with the exemption of Argentina which follows provincial legislation, and Chile which is the only country with a system of private water rights.

However, the fact that the current level of international water conflicts is low; it does not mean that the LAC region is problem free when taking into consideration that most of the surface water in the LAC region is shared by several countries. In South America, more than 90 percent of the surface water is in the Amazon, Parana and Orinoco river basins. In Central America about 60 percent of the surface water is also shared, including the sensitive Lempa River basin which is essential for El Salvador, and it is shared with Honduras and Guatemala. Similarly, the Guarani aquifer, that is claimed as one of the largest reserves of fresh water in the world, is shared by four countries, and there are several other groundwater reserves in south and central America that are shared by two countries.

The long history of LAC region with international water treaties has been instrumental to address international water development issues. For instance, there are about 100 years of experience of multilateral and bilateral negotiations of international agreements in the Parana-La Plata river basin, which have provided a legal framework for development of multiple bi-national hydropower projects, support inland navigation and facilitate a fluid exchange of relevant river basin data. In the case of the Amazon basin, there is a successful agreement among eight countries, with a permanent secretariat in Brasilia, and sector programs covering science and technology, environment, health, tourism, transport, communication and infrastructure, education and indigenous affairs.

The key of these agreements has been the implicit recognition of the complementarities across countries, and the needs of joint development to expand the benefits of river basin development. This culture of water negotiations has been ratified again just recently with the decision taken by Brazil, Argentina, Paraguay and Uruguay to continue their joint efforts to evaluate and monitor the Guarani aquifer, following the recommendations of a highly successful GEF international waters project that was managed by the four countries with assistance of the OAS and the World Bank.

Opportunities for moving forward

Until now, water scarcity issues in LAC have been seen from a country perspective and less from a regional viewpoint; therefore, the untapped potential for enhanced collaboration is large. A higher level of collaboration is expected to facilitate a more effective and better informed approach to water problems, specifically, by learning from systematic evaluations of successes and failures in managing water resources and delivering water services within the LAC region and elsewhere. However, to be successful, such efforts need much stronger regional networks, more effective relationships with international agencies, and a closer interaction with water agencies and research institutions outside LAC.

The region offers several well known water agencies in the largest countries like IMTA and CONAGUA in Mexico, ANA in Brazil, and INA in Argentina; as well as leading water utilities with valuable operational experience. Similarly, there are water departments at the federal and state levels in several countries with a notorious tradition in formulating and implementing water policy. There are also a few water institutions with regional mandates which are doing a notable work, in spite of being chronically underfunded.

They include, CEPIS, which belongs to the Pan-American Health Organization and it is based in Lima with a strong background in sanitary engineering; the water group in ECLAC based in Chile with a strong focus on water policy; and others that are mostly dedicated to capacity building in water like CINARA in Colombia, and CIDIAT in Venezuela. There are also professional networks and associations at country and regional levels that have the convening power to disseminate knowledge, and provide technical training. They include the Brazilian Association of Water Engineers (ABRH), the Latin America Association of sanitary Engineers (AIDIS), and several others. Finally, there are a few universities in the region with strong water programs, at the graduate level, most notably in Mexico, Brazil and Argentina.

As a conclusion, an enhanced collaboration of water agencies and research institutions across the continent to address water scarcity issues should be seen within the larger framework of sustainable development. Such a framework would include sound strategies and bold actions to close the gap between supply and demand for water services, preserve the environmental services of water resources and their related ecosystems, whereas recognizing that water is a core infrastructure sector of the economy and an essential component to reduce poverty. The very positive development perspectives of LAC for the next years, with stable rates of economic growth and enviable democratic institutions, offer an unprecedented opportunity to engage on a major effort of collaboration to improve water management in the LAC region.

Table 1
Distribution of Water Resources in LAC Region

Sub-region	Area	Precipitation		Water Resources	Per-capita Water	Water Withdrawals [1]
Units	Km^2	mm	Km^3	Km^3	M3/hab	Km^3
Mexico	1,958,200	772	1,512	409	4,338	78
Central America	521,598	2,395	1,194	6,889	20,370	12
Greater Antilles	198,330	1,451	288	82	2,804	15
Lesser Antilles	8,460	1,141	17	4		
Guyana Sub-region	378,240	1,421	897	329	191,422	2
Andean Sub-region	4,718,320	1,991	9,394	5,186	49,902	50
Brazil	8,547,400	1,758	15,026	5,418	33,097	55
Southern Sub-region	4,121,190	846	3,488	1,313	22,389	50
LAC Region	20,451,190	1,556	31,816	13,429	27,673	263
World	133,870,200		110,000	41,022	6,984	3,253
LAC/World	15.27		29	33		8.1

Source: UNESCO-IHP. World water Resources at the Beginning of the 21st Century. 1999.

Table 2
Water Indicators by Country
Latin America and Caribbean Region

Water Indicators	GNI cap	Area	Population	Urban Pop	Urban Growth Annual %	Ag land	Ag Land	Hydropower	Freshwater	Water Withdrawal	Water Supply Urban Coverage	Water Supply Rural Coverage	Sanitation Urban Coverage	Sanitation Rural Coverage	Under-5 Mortality	Diahrrea Prevalence
Units	US$	000 Km^2	1,000.00	%	1990-2005	%	mill Ha	%	M3/cap	%	%	%	%	%	1000 births	% under 5
Mexico	7,310	1,908.70	103.10	70.00	1.70	56	106.89	11.20	3,967	19.10	100	87	91	41	27	9.70
Guatemala	2,400	108.40	12.60	47.20	3.20	43	4.66	34.70	8,667	1.80	99	92	90	82	43	13.30
Belize	3,570	22.80	0.29	48.30	3.00	7	0.16		54,832	0.90	100	82	71	25	17	11.00
Honduras	1,120	111.90	7.20	46.50	3.60	26	2.91	48.10	13,311	0.90	95	81	87	54	40	19.30
Nicaragua	950	121.40	5.10	59.00	2.50	58	7.04	11.40	36,840	0.70	90	63	56	34	37	14.00
El Salvador	2,450	20.70	6.90	59.80	3.30	82	1.70	31.20	2,587	7.20	94	70	77	39	27	19.80
Costa Rica	4,700	51.10	4.30	61.70	3.60	56	2.86	79.00	25,975	2.40	100	92	89	97	12	
Panama	4,630	74.40	3.20	70.80	2.00	30	2.23	65.60	45,613	0.60	99	79	89	51	24	12.60
Cuba		109.80	11.30	75.50	0.60	61	6.70	0.60	3,361	21.50	95	78	99	95	7	
Jamaica	3,390	10.80	2.70	53.10	1.20	47	0.51	1.90	3,540	4.40	98	88	91	69	20	
Puerto Rico	10,950	8.90	3.90	97.60	2.70	25	0.22		1,815							
Dominican Republic	2,460	48.40	8.90	66.80	2.80	76	3.68	11.50	2,361	16.10	97	91	81	73	31	20.10
Haiti	450	27.60	8.50	38.80	3.30	58	1.60	47.50	1,524	7.60	52	56	57	14	120	25.70
Trinidad and Tobago	10,300	5.10	1.30	12.20	2.90	26	0.13		2,911	8.20	92	88	100	100	19	
Barbados		0.40	0.27	52.70	1.40	44	0.02		371	90.00	100	100	99	100	12	
Antigua and Barbuda	10,500	0.40	0.08	39.10	2.50	32	0.01		1,208		95	89	98	94	12	
Dominica	3,800	0.80	0.07	72.90	0.50	31	0.02				84	100	86	75	15	
Grenada	3,860	0.30	0.11	30.60	0.50	38	0.01				97	93	96	97	21	
Saint Kitts and Nevis	7,840	0.40	0.05	32.20	0.40	28	0.01				99	99	99	99	20	

Water Indicators	GNI cap	Area	Population	Urban Pop	Urban Growth Annual %	Ag land	Ag Land	Hydropower	Freshwater	Water Withdrawal	Water Supply Urban Coverage	Water Supply Rural Coverage	Sanitation Urban Coverage	Sanitation Rural Coverage	Under-5 Mortality	Diahrrea Prevalence
Units	US$	000 Km^2	1,000.00	%	1990-2005	%	mill Ha	%	M3/cap	%	%	%	%	%	1000 births	% under 5
Santa Lucia	4,580	0.60	0.16	27.60	1.00	33	0.02				98	98	89	89	14	
San Vincent and the Granadines	3,530	0.40	0.12	45.90	1.40	41	0.02				93	93	96	96	20	
Curacao																
Aruba																
Bonaire																
Martinique and Guadalupe																
Suriname	2,540	156.00	0.45	73.90	1.30	1	0.16		195,887	0.80	98	73	99	76	39	14.80
Guyana	1,020	196.90	0.75	28.20	-0.10	9	1.77		320,812	0.70	83	83	86	60	63	
French Guyana																
Venezuela	4,820	882.10	26.60	93.40	2.70	25	22.05	71.00	27,185	1.20	85	70	71	48		21.00
Colombia	2,290	1,109.50	45.60	72.70	2.10	38	42.16	79.80	46,316	0.50	99	71	96	54	21	13.90
Ecuador	2,620	276.80	13.20	62.80	2.60	27	7.47	58.90	32,657	3.90	97	89	94	82	25	19.90
Peru	2,650	1,280.00	28.00	72.60	2.00	17	21.76	72.30	57,780	1.20	89	65	74	32	27	15.40
Bolivia	1,010	1,084.40	9.20	64.20	3.10	34	36.87	49.00	33,054	0.50	95	68	60	22	65	24.80
Brazil	3,550	8,459.40	186.40	84.20	2.30	31	262.24	82.80	29,066	1.10	96	57	83	37	33	13.10
Argentina	4,470	2,736.70	38.70	90.10	1.40	47	128.62	30.40	7,123	10.60	98	80	92	83	18	
Chile	5,870	748.80	16.30	87.60	1.80	20	14.98	45.40	54,249	1.40	100	58	95	62	10	
Paraguay	1,040	397.30	5.90	58.50	3.50	63	25.03	100.00	15,936	0.50	99	68	94	61	23	16.10
Uruguay	4,360	175.00	3.50	92.00	0.90	85	14.88	81.00	17,036	5.30	100	100	100	99	15	
Total		20,136.20	554.76				719.40									

Source: World Bank, FAO Aquastad, World Resources Institute

Table 3
Performance of Water Utilities in Selected Countries of the LAC Region

Country	Year	Water Coverage	Sewerage Coverage	Non-Revenue Water	Metering Coverage	Operational Cost	Collection Period	Operating Cost Ratio
Units	\	%	%	%	%	US$/M3 sold	days	%
Brazil	2004	80	26	46	82	0.79	135	1.00
	2008	81	43	39	76	1.04	112	1.49
Chile	2002	100	98	28		0.23		2.84
	2006	100	99	33	98	0.62	88	1.39
Colombia	2003	88	82	45	86	0.48	241	1.43
	2004	89	83	44	92	0.53	220	1.51
Costa Rica	2002	94	38					1.02
	2004	97	31	50	23	0.17	40	3.27
Ecuador	2003	63	28	73	59	0.29	148	2.44
	2005	68	34	71	80	0.70	151	1.04
El Salvador	2006	73	39	34	65	0.03	93	1.17
	\							
Bolivia	2002	99	78	33		0.52	192	0.57
	2006	88	66	35	92	0.26	72	1.56
Argentina	2002	88	63	31	11	0.13	124	1.71
	2006	85	63	31	33	0.16	61	1.49
Mexico	2005	100	84	32	82	0.66	108	1.14
	2006	100	64	28	62	0.63	65	1.16
Nicaragua	2002	73		50				
	2005	94	34		69	0.38	151	1.11
Panama	2002	99	55	69		0.13	298	2.24
	2006	100	48	39	43	0.18	112	1.44
Paraguay	2002	75	43	45		0.14		
	2005	72	32	44	91	0.17	170	
Peru	2004	84	76	61.9	63	0.44	149	1.01
	2008	86	78	42	63	0.58	67	1.18
Uruguay	2001	96	15	51	96	0.89	71	1.55
	2006	94	22	54	97	0.82	45	1.66
Venezuela	2006	90	74	62	38	0.26	416	0.95

Source: World Bank. International Benchmark Network. 2010

Table 4
Water Scarcity: Myths and Reality

Water Scarcity Indicator	Myths of Politicians about Water	Reality for Water Policy Makers
Availability of Water	Plenty	Asymmetry between population and economic activity and water.
Water Supply	High coverage, meet the MDGs	Low quality of services, high cost to the poor.
Sanitation	More pipes	High incidence of water borne diseases, lack of hygiene, service in slums.
Irrigation	More dams and channels	Focus on rainfed and sustainable use of groundwater. Improve drainage and reduce salinity. Eliminate electricity subsidies.
Floods	Remove water from flooded areas as quick as possible	Non-structural measures, manage water within their basins, reduce peak flows.
Pollution	Contract wastewater treatment plants	Existing capacity is not fully utilized.
Hydropower	Develop new projects	Large social and environmental tradeoffs.