Vladimir Arana

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## Trends, Challenges and Opportunities

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# Introduction

Latin America is currently undergoing dramatic population distribution changes that will negatively and irreversibly affect the region's water resource availability and sustainability. An important percentage of the population, especially in rural areas, still has no access to safe drinking water and sanitation. Identifying the causes and possibilities for disrupting these dysfunctional systemic situations involving sustainable water and land-use scenarios constitutes the main challenge for the future of the region.

This book provides an overview of the complex situation and possibilities for water resource management, mainly freshwater resources, drinking water and sanitation, considering the new population settlement trends and changes that will determine water and land security in Latin America. These trends are analyzed using an ecoregional approach as a permanent criterion, meaning that one country depends on the same water source as another. So a common vision is needed from the outset.

Water supply and sanitation are issues that have special importance owing to, on the other hand, the millions of people whose lives, health and productivity are degraded as a result of the lack of these basic services; this represents a major challenge because of the significant resources needed to close present gaps. Water supply and sanitation are not just a matter of building infrastructure; they are essentially a matter of management, which implies considerations of collecting water resources, ecosystem services dynamics, water distribution, sanitation and wastewater treatment and reuse. They also imply accountability, where intensive users can pay for the socially vulnerable or residents upstream of water sources conserve and protect water resources for those living downstream, and where the latter recognize the efforts of the former to protect the water.

This research highlights the necessity of having a discussion about building regional integrated institutions, policies and projects since many problems and opportunities may be better and more efficiently addressed through joint national efforts. At the country level, management models could also be more comprehensive, coordinating multisector interventions and facilitating integrated decision making at the local, subnational and federal government levels. These proposals define new opportunities and challenges for policy and decision makers.

It is known that high-quality water supply and sanitation services strengthen household security and lead to a reduction in the number of diseases. However, it is also important to know, as shown in this text, that a lack of water and, especially, sanitation keeps people in poverty, and access to these services represents the first threshold that vulnerable people need to cross to begin their path to building wealth. Inaction on this matter, in addition to financial and institutional constraints, is also a cultural issue, where government officials and representatives believe that the lack of water and sanitation faced by poor people may not be a very urgent issue and that one more day of such conditions will not change those people's lives. Nevertheless, the situation affects a nation's economic performance and people's productivity. Latin America needs a new culture surrounding the issue of water resources and access to drinking water and sanitation.

However, many regional and international conferences and forums are held every year, where water resources, drinking water, sanitation and land are treated as human rights, but with a price. Policy and decision makers in Latin America need to find alternatives that address the combined needs of social, environmental and financial sustainability. This book identifies several proposals based on the data, analysis, approaches and successful experiences connected to the region that have been widely validated and described. The challenges for the future are to establish conditions to satisfy the needs of people and the environment, for present and future generations, while at the same time preventing social unrest and economic repression. This book represents a modest contribution to addressing these important issues.

# Executive Summary

This book analyzes scenarios and trends linking different factors, such as water availability, drinking water, sanitation, economic growth, poverty, urban density, population concentration, health and disease. The text highlights the interdependency of these factors with larger contexts, such as ecoregions and ecosystem services. At the same time, it analyzes the governance and management structures that may determine conditions in all countries, and presents Latin American experiences that might be replicated elsewhere. Finally, following the analysis and discussion of trends, the book presents several policy recommendations and project proposals that could be useful for Latin American development.

The first chapter, "Methodological Aspects," discusses the book's preparation and how the research was conducted. It also identifies the primary and secondary sources consulted, as well as the logic behind the concepts and the analysis.

The second chapter, "Population Behavior and Land Occupation Trends," conducts a review and analysis of population growth and how it is distributed in the different territories. At present, the majority of the Latin American population is concentrated in coastal zones or at country borders, where there are fewer freshwater sources than in the highlands or in the Amazon, increasing the demands placed on the few water sources that do exist. In rural areas, high population dispersion has origins in several involuntary resettlements, from pre-Columbian to Colonial and Republican times, that have mostly affected indigenous communities in Latin America and disrupted their economic and social fabric for centuries. This population dispersion makes the provision and maintenance of water infrastructure more expensive. At the same time, rural headwater territories in Latin America are currently being depopulated as a consequence of increased poverty and economic disincentives. Headwater maintenance is a key issue in safeguarding water resources in Latin America, and in the near future, headwater loss may affect around 70 % of the Latin American population and economic activities in the region. Climate change also affects water resources and causes migration within a territory, land-use changes, resettlement and accelerated urbanization. On the other hand, to better observe the relationship between water, population and land, in the analysis of water resources, areas are grouped into ecoregions, which determine the biophysical dynamics and conditions on which water resources depend.

The third chapter, “The State of Water Resources,” analyzes the availability of water resources by country and renewable water resources per capita. It identifies the existence of important water resources in South America, while noting that Central America has less availability; at the same time, demands for water resources have intensified, which suggests that nontraditional sources must be found.

The fourth chapter, “Water Supply, Sanitation, Energy and Industrial Constraints,” focuses on how access to water supplies and sanitation is critical in Latin American countries, especially in rural areas, and how in urban areas, informal growth and property-rights conflicts make more difficult and costly the building of infrastructure. This chapter analyzes the relationship between gross domestic product (GDP), water resource availability and access to drinking water. One of the findings of the analysis is that countries with lower water availability have less access to water supply and sanitation. Consequently, these countries have a lower GDP per capita, which has become a permanent, endemic cycle that entrenches poverty.

The fifth chapter, “Quality, Sustainability, and Investment Levels,” describes how low-quality service to meet demands for water supplies and sanitation is a common feature in many Latin American countries, where investment in water supply is very low compared to other investments. In addition, water tariffs in these countries are very low and have come to create perverse incentives, where water conservation is discouraged, and approaches to ecosystem preservation are weakly considered in water supply and basin management. This reduces the countries’ capacity to face new climate change realities, which also diminishes opportunities for attracting complementary private investment, which in turn is seen as a potential trigger of social unrest.

The sixth chapter, “Governance, Planning, Capacities and Management Models,” describes how there is no holistic, integrated approach to resolving the one common resource: water. It is observed that capacities, investment and management models are not optimized and generate fragmented decisions. Additionally, land management policies should be integrated with water resource decisions, which does not currently happen in Latin America. This disjointed approach to policymaking causes serious economic losses for governments and societies. On the other hand, an important part of the analysis is to show the weak levels of coordination among the governments in the region and the unsophisticated institutional and legal frameworks governing water supply and water resource management. Further, this text is meant to show the low synergy among consumptive uses demands, which is a common state of affairs in Latin America.

The seventh chapter, “Lessons Learned,” reviews the experiences in water supply, sanitation and basin management, identifying the lessons learned in each particular case and the possibilities of replicating the successes in other Latin American countries. These experiences, successful or not, show what worked and what did not, which could be very helpful for decisionmakers.

The eighth chapter, "Policy Recommendations and Project Proposals," describes several policy recommendations that have been made, including those that could be implemented at the national and multinational levels. One of the key phenomenons explained in this research is the fact that headwater territories in Latin America, with few exceptions, are being depopulated. This will cause reduction of agricultural activities that allow the existence of, for example, irrigation, pastures and forests and that will have a negative impact on basins, reducing water infiltration and accelerating deglaciation processes. This phenomenon demands specific policies to conserve headwaters, especially because 80 % of Latin American populations live in coastal areas where water stresses are greater. Other recommendations are made at the national and multinational water policy levels since some management models do not work in the present context, but they might work in a more integrated context.

In general, the analyses contained in this book lead to the identification and generation of a set of elements and opinions that could be considered in the debate on water resources to strengthen national and regional policies and create sustainable changes. These changes will require a well-thought-out vision for the future, strong political will, budgetary firmness and innovative solutions, so the interventions may create a fundamental, positive transformation in people's quality of life.

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# Acronyms

| | |
|---|---|
| AECID | Spanish International Cooperation and Development Agency |
| ANA | National Water Authority |
| BOT | Build, operate, and transfer |
| CAF | Latin American Development Bank |
| CEPIS | PanAmerican Sanitary Engineering Center |
| CGIAR | Consultative Group on International Agricultural Research |
| CIP | International Potato Center |
| CONAPO | National Population Council of Mexico |
| CONDESAN | Andean Ecoregion Sustainable Development Consortium |
| DANE | Administrative Department for National Statistics of Colombia |
| DESA | Department of Economic and Social Affairs |
| DGEEC | General Office for Surveys, Statistics, and Census of Paraguay |
| DNS | Dirección Nacional de Saneamiento de Perú |
| ECLAC/CEPAL | Economic Commission for Latin America and the Caribbean |
| ECSM | Ecosystem Services Reward Mechanism |
| ENSO | El Niño southern oscillation |
| EPS | Water Supply and Sanitation Company |
| ERSSAN | Regulatory Agency for Sanitation – Paraguay |
| ESA | Ecological Society of America |
| FAO | United Nations Food and Agriculture Organization |
| FOB | Free on board |
| FONDAM | Fund for the Americas |
| GDP | Gross domestic product |
| GIZ | German International Development Agency |
| GWI | Global water intelligence |
| IADB/BID | Inter-American Development Bank |
| IBGE | Brazilian Institute of Geography and Statistics |
| IBNET | International Benchmarking Network for Water and Sanitation Utilities |
| IFAD | International Fund for Agricultural Development |
| IFEA | French Andean Research Institute |

| | |
|---|---|
| IGAC | Agustin Codazzi Geographical Institute |
| IICA | Inter-American Institute for Cooperation on Agriculture |
| IMF | International Monetary Fund |
| INDEC | National Institute of Statistics and Census of Argentina |
| INE | National Statistics Institute of Uruguay |
| INE | National Statistics Institute of Costa Rica |
| INEI | National Statistics and Data Institute of Peru |
| IPCC | Intergovernmental Panel on Climate Change |
| IWRM | Integrated water resources management |
| JASS | Rural Water Supply and Sanitation Committee |
| JBIC | Japan Bank for International Cooperation |
| JICA | Japan International Cooperation Agency |
| KARI | Kenyan Agricultural Research Institute |
| KfW | German Development Bank |
| LAC | Latin America and the Caribbean |
| MINAM | Ministry of the Environment of Peru |
| MMA | Ministry of the Environment of Chile |
| MVCS | Ministry of Housing, Construction, and Sanitation of Peru |
| OAS | Organization of American States |
| OCSAS | Rural Water Supply and Sanitation Community Organizations |
| OECD | Organization for Economic Cooperation and Development |
| ORELLANA | Observatory for Networks and Spaces in the Plains, the Andes, and the Amazon |
| PAHO/OPS | Pan American Health Organization/Organización Panamericana de la Salud |
| PCES | Conservation and social equity portal |
| PDRS | Rural Sustainable Development Program |
| PMO | Plan Maestro Optimizado |
| RWRGE | Renewable water resources generated externally |
| RWRGI | Renewable water resources generated internally |
| SANAA | Local public water supply company in Honduras |
| SDC | Swiss Development Cooperation |
| SEDAPAL | Water Supply and Sanitation Company of Lima and Callao |
| SEMAPA | Public Water Supply and Sanitation Company in Bolivia |
| SEMARNAT | Secretary of Natural Resources and the Environment |
| SNIP | Peruvian Public Investment Projects System |
| SUNASS | Peruvian Water Supply and Sanitary Services Superintendance |
| SURP | Society of Urban Planners of Peru |
| UNCTAD | United Nations Conference on Trade and Development |
| UNDP/PNUD | United Nations Development Program |
| UNEP/PNUMA | United Nations Environment Program |
| UNESCAP | United Nations Economic and Social Commission for Asia and the Pacific |
| UNESCO | United Nations Organization for Education, Science and Culture |
| UNICEF | United Nations Children's Emergency Fund |

| | |
|---|---|
| USAID | United States Agency for International Development |
| USD | United States dollar |
| WHO/OMS | World Health Organization |
| WPD | World Population Division |
| WSP | Water and Sanitation Program (World Bank) |
| WWF | World Wildlife Fund |

# Contents

# Chapter 1
# Methodological Aspects

Latin America is keeping an important rhythm of economic growth thanks to major governmental efforts to maintain a macroeconomic and fiscal balance while at the same time promoting private investment as one of the pillars of job creation and development. However, this growth and social equity are threatened by weak policies, like water and land policies, that if not correctly managed will drag down growth and development to lower levels, allowing and entrenching poverty regardless of government efforts to promote wealth.

In urban areas, where three-quarters of the Latin American population is located, the informal and unplanned expansion of cities constitutes a larger challenge to water supply and sanitation companies, not only considering the need to increment the sources and coverage, but also to improve wastewater treatment.

In rural areas, enough arguments could be made to show the importance and need to supply water and provide sanitation, where dispersed families and villages exist in conditions of extreme poverty and where local productive capacities are limited when diseases caused by the lack of appropriate water and sanitation disrupt household economies and degrade their living conditions.

Water management and sanitation in Latin America, including all uses, cross several performance constraints caused by different factors that create limitations or that increase the rationalization of access to water at every step of the water use value chain.

There are several causes that create rationalization, not only as a result of a lack of water resources or a low water-treatment and production capacity, but also by other additional factors such as a lack of resource maintenance, insufficient treatment, limited availability of financial resources and revenues, an incomplete distribution of infrastructure, expansion of informal human and economic activities disconnected from land planning, irresponsible use of water, low level of sewage treatment, and almost no reuse of treated wastewater. Water rationalization, under this hypothesis, is composed of several water rationalization issues. Each issue is generated by a weakness or failure in the water use value chain. The goal of identifying these failures – or bottlenecks – in the water use value chain relies on identifying



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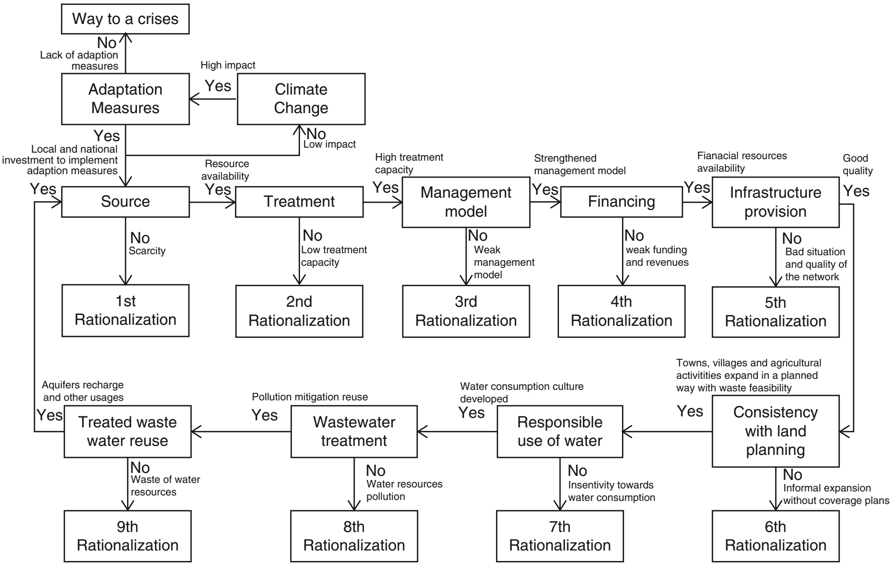


**Fig. 1.1** Factors that promote rationalization in the water use value chain in Latin America. Elaborated by Vladimir Arana

proposals that might make it possible to strengthen and improve the dynamic and performance of this value chain. Analysis has revealed nine issues in water rationalization that contribute to water crises (Fig. 1.1).

# 1 Why Conduct This Research?

The need to identify the lessons learned and validated experiences in the Latin American region that could be replicated or scaled up in other parts of the same region, in the form of new policies, programs, or projects, as well as the need to identify the challenges and opportunities associated with reducing the intensity of water and land use, are the main motivation behind this research. The search for expanded south–south cooperation and the identification of tools to improve sustainable access to water, sanitation, and land resources and to help policymakers come up with their own solutions constitute part of the interest in undertaking this research. What measures could Latin American countries implement to improve sustainable access to water, sanitation, and land management?

The identification of lessons learned and successful experiences will help Latin American countries define the measures they need to adopt to put some teeth in their policies. However, each country faces a unique situation, which will determine the specific measures needed and which reinforces the argument that every country's water use value chain must be considered individually. Each country has developed each individual link in the water use value chain in different ways, and this fact will dictate the type and magnitude of measures to be implemented. Thus no single approach will suit every situation.

## 2 Methods and Assumptions

This document examines the situation and relations among water sources, water supply, and sanitation and land management in Latin America. It considers these relations in three ways. First, it uses information to elaborate a conceptual model that seeks to interpret the vulnerabilities of water, sanitation, and land management. Second, it assesses the factors that influence the capacity of organizations to make and implement decisions. Third, it provides case studies and proposals that could be implemented in other parts of Latin America.

The research contained herein is based on published material, national statistics, reports, master plans from water supply and sanitation companies, and policies from municipalities or national governmental bodies. Interviews were also conducted that were very helpful in focusing this research on the most relevant aspects and policy proposals.

Water, sanitation, and land management can be analyzed using two different approaches, though other approaches are possible as well. The first approach is to explore the capacity of providers, such as companies, local community organizations, and municipalities that oversee water supplies and sanitation, to freely change their service productivity ranges, as well as their mobility in water and land markets as an adaptive response to water scarcity. The second approach is to focus on the provision of a specific service or services. This research follows the second approach, focusing on water and land because they are common goods that need somehow to be provided to all residents in a given community, and there is a clear interest in public policymakers to continue providing them. Also, water and land management service providers have already been operating for a long time and will continue providing these services. However, water supply companies, community managers, municipalities, and governmental bodies make decisions individually, and new approaches may affect their capacity to adapt, such as to improve their efficiency in water, sanitation, and land management.

Therefore, it was important to focus this research on the basis of the latest knowledge of water, sanitation, and land management, within the framework of variable analysis and the hypothesis used. Different grammatical styles could be used by researchers to write hypotheses, but a hypothesis interpreted literally cannot be subjected to empirical evaluation, at least when quantitative methods are being used. For this reason, it is very important to state hypotheses in mathematical terms, to adapt our literal hypothetical formulas to formally existing choices. In general, a formal hypothesis is expressed as a mathematical function:

$$y = f(x),$$

ehere $y$ is a function of $x$, which means that $x$ is the cause of $y$. Thus, in this document, three hypotheses with three explanatory variables are formulated. Variables are always present in a hypothesis, so some variables play the role of causes and are called independent, or explanatory, variables. Other variables play the role of effects and are called dependent, or known, variables (Mejía 2005).

One important explanatory variable in this research is the *change in water source conditions* ($x$), which has a direct impact on the dependent variable *quality and quantity of water provided by deliverers* ($m$), which are water supply and sanitation companies, water supply and sanitation community committees, and municipalities. Here we can compare the variables and see what might happen to families that depend on these deliverers.

Another explanatory variable in this research is the *vulnerability of urban and rural water and sanitation deliverers* ($y$), understood as water supply and sanitation companies, water supply and sanitation community committees, and municipalities, since this variable affects the dependent variable *quality and quantity of water provided by the same deliverers* ($m$). Here the vulnerability may be caused simultaneously by different phenomena such as informal land-use changes, financial constraints, or natural disasters.

Another explanatory variable is *water and sanitation management model evolution* ($z$), which largely depends on sectoral planning, governance, public policies, and market conditions, which affect the variable *quality and quantity of water provided by deliverers* ($m$).

Analysis of the three explanatory variables links them together since the first one may explain water source trends and how threat to a water supply would evolve. In the same way, the second explanatory variable makes it possible to compare a vulnerability scenario involving water and sanitation deliverers. The third explanatory variable could enable the identification of weaknesses and strengths of certain water and sanitation management models:

$$m = f(x, y, z).$$

# Chapter 2
# Population Behavior and Land Occupation Trends

World urban population will grow 75 % in the next four decades and will reach 6.3 billion by 2050 as a result of the unprecedented growth that Asian and African cities will experience, as stated by the United Nations Department of Economic and Social Affairs (DESA) in the World Urbanization Prospects Report, 2014 Revision (United Nations, DESA 2014), while by the same year 89 % of the population in Latin America will live in towns and cities (IADB 2012).

Population growth defines the demand for water, for human consumption purposes and sanitation requirements, and we can compare countries' current coverage with the per capita demand. In addition, we can compare the countries' population densities with water resources or water supply coverage, in other words, identify the demographic pressure trends on such a fragile resource.

In this chapter, the existence and management of water resources is treated as an important part of water supply management. In the case of Latin America, the availability of water sources depends on geographical conditions that determine the generation and storage of this resource through ecosystemic services. These services transcend national borders and emerge in shared territories. These territories where the macro biophysical processes that help maintain and generate water resources take place may be termed ecoregions, which is a systemic concept that describes a territory's performance and that can be used at different scales. This document identifies ecoregions, macro territories, in Latin America that need to be managed to ensure the existence of water sources in the region.

Latin American countries process statistical information in different ways, and just a handful of countries have detailed, up-to-date information available. At the same time, just a few countries have official projected data. This is especially important when trend comparisons need to be made to identify common social weaknesses, as in the case of water supply and sanitation. To an even lesser degree are the statistics organized in relation to those shared resources, like water, that each country depends on for its survival. The ecoregional approach represents a way to see the management of these water resources from their origin, from the headwaters, and



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even their management lies far beyond the scale of independent nations; these resources present an opportunity for neighboring countries to work together to establish new cooperative mechanisms for common interests.

## 1 The Ecoregional Approach

The ecoregional approach is applied in different ways by different organizations and constitutes the conceptual basis on which sustainable development projects can be built, especially when the ecological conditions of the territory, like water, must be considered for further analysis. While the ecoregional approach has been subjected to different interpretations, all of which point to sustainability as a supreme goal, the approach is now more interdisciplinary and transdisciplinary than merely an issue mainly related to biological or agricultural sciences. These sciences allow other disciplines to collaborate in the development of this approach. At the same time, social, ecological, and productive demands promote the development of complementary and more integrated approaches to linking social, economic, land, and ecological management sciences.

In Latin America, poverty and environmental degradation have become part of an increasingly entrenched vicious cycle. Food insecurity and other conditions that threaten the quality of human life become permanent when this vicious cycle asserts itself. The application of development and conservation approaches, like the ecoregional approach, helps to break the links that cause the vicious cycle of poverty–environmental degradation, positively impacting families and organizations that need sustainable change.

The ecoregional approach can be applied to environmental conservation programs and to the relationships between conservation, food security, and production, which are mainly linked by water. However, still, one of the challenges lies in its integration with other disciplines and scenarios present in the same territory. In this way, the ecoregional approach is applied to the territorial scale beyond the basin level, integrating the role of other basins and the interdependency between ecosystems to ensure the biophysical dynamics on which natural resources, including water, depend.

The concept of an ecoregion comes from four different clearly identified streams. The first one, mainly promoted by conservation organizations, may define it as "An area of similar climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables" (USGS 2015). The World Wildlife Fund defines an ecoregion as a " large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions."

The second one comes from eco-development streams, where an "ecoregion is an urban-rural unity that maintains productive and environmental relations." For eco-development, the satisfaction of socioeconomic needs is a priority, even if it means reaching the environment's carrying capacity. Ecological concerns are important, especially if they promote socioeconomic development. The third stream, which is more recent, emphasizes the productive-ecological relationships within an environmental unit, defining ecoregions as "agroecological zones with regional character," giving special emphasis to agroecological sustainability, which implies agricultural development.

In addition to these concepts, a fourth one defines ecoregion, based on systems theory, which interprets meaning in a different way, so that "an ecoregion is a set of elements that interact," defining their depth of analysis, using only biophysical variables, socioeconomic relationships, or both. So an ecoregion's boundaries change depending on the sectors involved and the depth of analysis.

Nevertheless, despite these four different ecoregion concepts, this document uses the eclectic version that considers the previous ones and defines an ecoregion as "a territorial unit, or a set of territorial units, characterized by similar and interdependent biophysical conditions with the capacity to maintain these conditions and to develop human activities" (Arana 2006).

In South America, and for the purposes of this research, four main ecoregions have been identified: the Andean ecoregion, the Amazon ecoregion, the Dry Chaco ecoregion, and the Paraná-La Plata ecoregion. These ecoregions are defined based on similar climate conditions, physical conditions, and altitude that determine the ecosystems that characterize them and on the existence of an independent regional scale headwater, set of headwaters, or water sources (Map 2.1).

## 1.1 Andean Ecoregion

The Andean ecoregion is well defined since it has natural homogenous conditions and water sources originating in the Andes headwaters, also called water towers, which provide water to neighboring regions that share similar historic processes. The Andean ecoregion has a cold sea and high cordillera and gives birth to the Amazon, another important ecoregion. The Andean ecoregion mainly includes the countries of Bolivia, Ecuador, Chile, Colombia, Peru, Venezuela, and parts of other neighboring countries.

## 1.2 Amazon Ecoregion

The Amazon ecoregion is an area that has a tropical humid climate that allows a high density of unique flora and fauna species and biodiversity, which makes this ecoregion an ecologically differentiated area. The main water sources come from the Dry Chaco and Andean ecoregions. However, the capacity of the Amazon to retain water is one of the features of this impressive ecoregion. The Amazon ecoregion includes mainly Brazil and some areas of neighboring countries.


**Map 2.1** Graphic scheme to identify Andean ecoregion, Amazon ecoregion, Dry Chaco ecoregion, and Paraná-La Plata ecoregion. *Sources:* Rowntree, Lester; Lewis, Martin and Price, Marie. 2002. Diversity Amid Globalization: World Regions, Environment, Development, 2nd edition. Prentice Hall, Englewood Cliffs, NJ. Mediateca – Biblioteca digital. 2015. Available at: http://mediateca.cl/. Reviewed on 13 September 2015. Map elaboration: Vladimir Arana

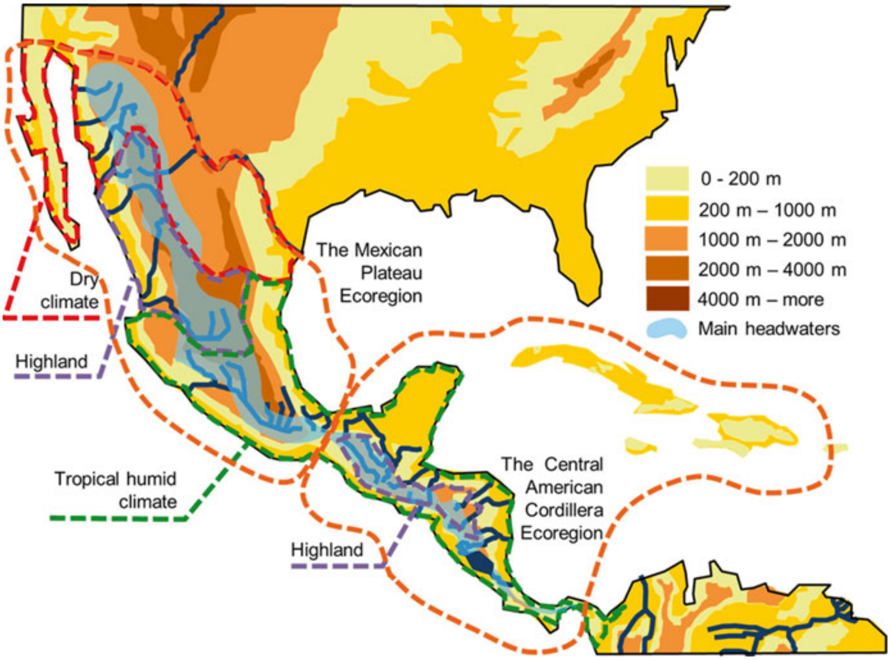
## *1.3 Dry Chaco Ecoregion*

The word *chaco* comes from the Quechua *chaku*, which means "hunting land," which is also an ancient South American practice of capturing animals by surrounding them. It includes the territory that contains Paraguay and part of the neighboring countries of Argentina and Bolivia. This ecoregion presents a dry vegetation ecological systems transition, from tropical savannas to thorny scrubs, and dunes with vegetation.

## 1.4 Parana-La Plata Ecoregion

The dry climate that starts in the southern part of the Andean ecoregion transforms into a mild climate, and both comprise the Parana-La Plata ecoregion. This area combines several ecosystems, including the delta, semiflooded lands, and the subtropical upper territories. This ecoregion includes mainly Argentina and Uruguay.

In Central America, and for the purposes of this research, two main ecoregions have been identified: the Central American Cordillera ecoregion and the Mexican Plateau ecoregion. These ecoregions are defined on the basis of similar climatic conditions, physical conditions, and altitude that determine the ecosystems that characterize them and based on the existence of an independent regional-scale headwater or set of headwaters (Map 2.2).




**Map 2.2** Graphic scheme to identify Mexican Plateau ecoregion and Central American Cordillera ecoregion. *Sources*: Rowntree, Lester; Lewis, Martin and Price, Marie. 2002. Diversity Amid Globalization: World Regions, Environment, Development, 2nd edition. Prentice Hall, Englewood Cliffs, NJ. Mediateca – Biblioteca digital. 2015. Available at: http://mediateca.cl/. Reviewed on 13 September 2015. Map elaboration: Vladimir Arana

### *1.5 Mexican Plateau Ecoregion*

The Mexican Plateau ecoregion is a large arid-to-semiarid plateau, and it is mostly covered by deserts and xeric shrub lands, with pine-oak forests covering the surrounding mountain ranges and forming sky islands on some of the interior ranges. This ecoregion combines the biodiversity and tropical humid highlands and dry climates. This ecoregion mainly related to the country of Mexico (Ricketts et al. 1999).

### *1.6 Central American Cordillera Ecoregion*

The Central American Cordillera ecoregion combines the highlands of the Cordillera climate with the highlands climate, all in a very narrow strip of land. Climates and biodiversity interact closely since this ecoregion the Pacific and Atlantic Oceans are located at very close distances. It includes mainly the countries of Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, and other neighboring countries.

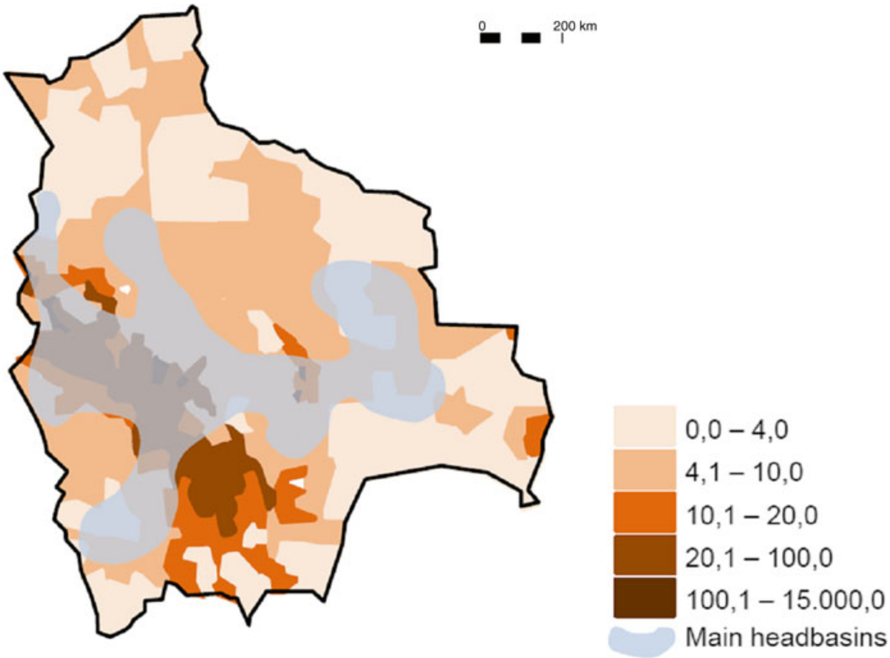
## 2 Population Behavior, Land Occupation Trends, and Water in the Andean Ecoregion (Ecuador, Colombia, Venezuela, Peru, Bolivia, Chile, Part of Argentina)

The Andean ecoregion is formed by the countries of Ecuador, Colombia, Venezuela, Peru, Bolivia, Chile, and part of Argentina. However the information about this last country will be treated with more detail in the Paraná-La Plata ecoregion chapter. The Andean ecoregion extends around the ecosystems of the Andes Cordillera, a South American chain of mountains from 11° latitude N–S and 56° latitude S. The average altitude is 4000 m, with many places reaching latitudes higher than 6000 m above sea level.

It is the largest cordillera on the American continent and one of the most important in the world. This enormous mountain mass runs in a north–south direction along the south Pacific coast for more than 7500 km. The southern tip of this cordillera descends into the Atlantic Ocean east of the Staten Island (Wegener 1983).

In Bolivia in 2004, the percentage of the total population living in cities reached 64 %, while the rural population decreased to 36 % of the total (PAHO 2004). By 2015, the urban population was around 68.5 % and will reach 70.4 % in 2020 (United Nations, DESA 2014). On the other hand, the capital of the country, La Paz, is located in the central part of the country on the Andes, and it is growing and concentrating ever greater numbers of people (Map 2.3).

Most of the population of Bolivia is located on the southwestern part of the country, where there are important water sources called headwaters. Other important headwaters are located in the eastern part of the country, where the areas with the lowest

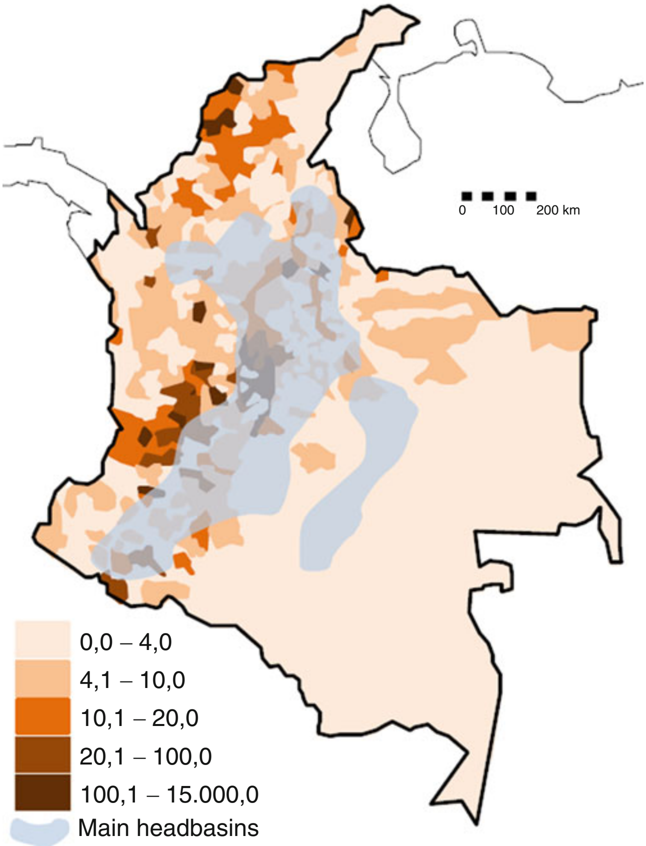



**Map 2.3** Bolivia: population density (population per square kilometer) and main headwaters approximate location 2014. *Source*: ORELLANA 2003a. Observatorio de las Redes y de los Espacios en los Llanos, las ANdes y la Amazonia. Population density of Andean Community of Nations. Available at: http://www.mpl.ird.fr/crea/orellana/eorellana/epays/eandes1.html. Map elaboration: Vladimir Arana

population densities are located, and since the country is undergoing rapid urbanization, the two major trends are, on the one hand, depopulation in the eastern rural areas where important headwaters are located and, and on the other hand, destruction of the headwaters in the western part of the country owing to the rapid urbanization, which is in general illegal and irregular.

In Colombia, an analysis by the Pan American Health Organization reveals that the country is consolidating its urban primacy, which went from 69 % of the total population in 1990 to 72 % in 1995 (PAHO 2004), 76 % in 2015, and around 80 % in 2020 (United Nations, DESA 2014). By 2020, Colombia will have a population of around 51 million inhabitants, of which around 40 million will live in towns and cities (DANE 2011). These data demonstrate the abandonment of rural areas, especially isolated areas such as headwaters, a situation that is confirmed by the urban consolidation in areas containing headwaters.

As in Ecuador, the capital of Colombia, Bogota, is also located in the Andes, not in the coastal zone. However, strong urban coastal development is taking place in the country that is being firmly consolidated, as can be seen in the map of population densities and headwater locations in Colombia (Map 2.4).

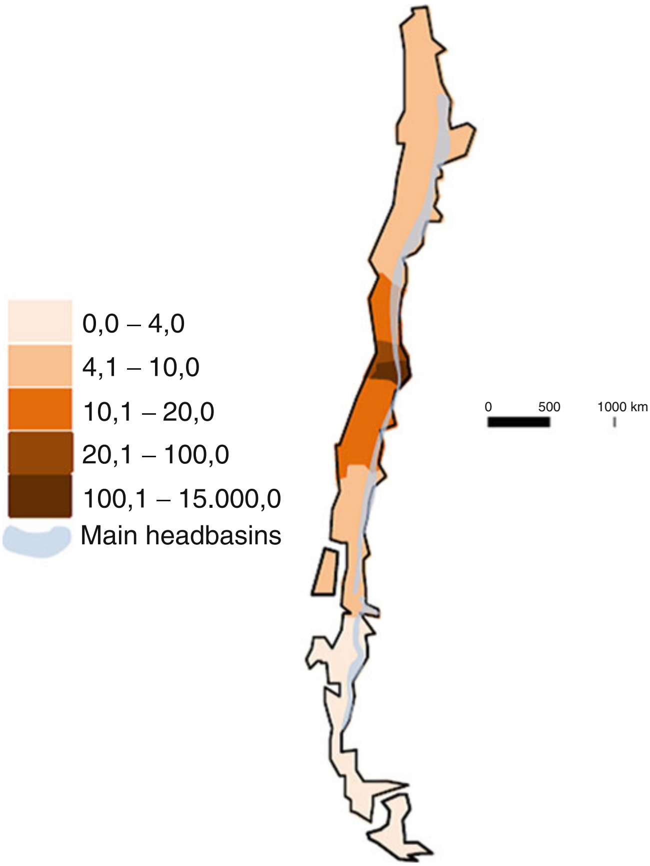



**Map 2.4** Colombia: population density (population per square kilometer) and main headwaters approximate location 2015. *Source*: Paez, Gustavo; Jaramillo, Luis and Franco, Camila. 2013. Estudio sobre la geografía sanitaria de Colombia. Ministerio de Salud, Bogota. Research on the sanitary geography of Colombia. Ministry of Health. Available at: https://www.minsalud.gov.co/Documentos%20y%20Publicaciones/Estudio%20sobre%20la%20geograf%C3%ADa%20sanitaria%20de%20Colombia.pdf. Reviewed on 26 September 2015. Instituto Geografico Agustín Codazzi. 2012. Densidad de la Población. IGAC, Bogotá. Available at: http://sigotn.igac.gov.co/sigotn/PDF/Densidad_Poblacion_Nal_Soc_V2.pdf?. Reviewed on 26 September 2015. Map elaboration: Vladimir Arana

This urban consolidation phenomenon is concentrating population in the western part of the country and depopulating the eastern, mainly rural, part, where most headwaters are located. The depopulation of the eastern part is caused by different factors, such as the absence of the state and the presence of the terrorist-military conflict in this part of the country that has resulted in the expulsion of large numbers of people and the attracting force of the economically flourishing urban coastal areas. These combined situations have created a trend in which the population is flocking to urban areas, and mainly on the coast.

Chile is a long strip of land located in the southwestern part of South America. In 2015 it had an urban population of 89.5 % of the total, which will grow to 90.3 % in

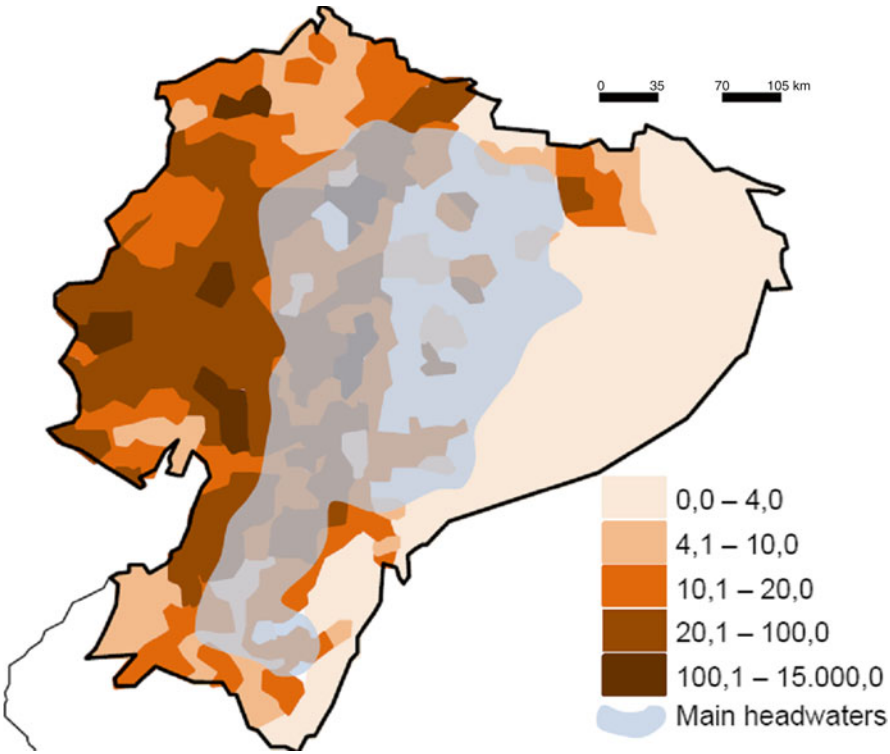
2020 (United Nations, DESA 2014). Most of the population is concentrated in the central part of the country, with the extremes being less populated; the southern part of the country has the lowest population density. Analysis shows a trend whereby people are concentrating in the central part of the country, around the metropolitan region. There are no rivers in the northern part of the country, except some land-locked streams and the Loa River. The central part of the country contains more rivers, which irrigate the agricultural valleys, and in the southern part of the country rivers have a special importance in terms of hydroelectric production (Niemeyer and Cereceda 1983). According to the general direction of waters, from the northern part to the metropolitan region water availability per capita is less than 1000 $m^3$ per year, which is lower than international standards. From the metropolitan region to the south per capita water availability increases up to 100,000 $m^3$ (Biblioteca del Congreso Nacional 2006), and it is this area that has the lowest population density in the country (Map 2.5).




**Map 2.5** Chile: population density (population per square kilometer) and main headwaters approximate location 2014. *Source*: Sala de Historia. 2014. Geografía de Chile. Available at: http://www.saladehistoria.com/geo/Cont/C029.htm. Reviewed on 28 September 2015. Instituto Geográfico Militar de Chile 2008. Hidrografía de Chile. Available at: http://www.educarchile.cl/Portal.Base/Web/VerContenido.aspx?ID=132525. Reviewed on 28 September 2015. Map elaboration: Vladimir Arana

Ecuador is a country with a strong tendency toward urbanization: the population went from 58 % urban in 1995 to 60 % urban in 2000 and around 64 % in 2015 (United Nations, DESA 2014). It is estimated that the country will have a population of 17 million inhabitants by 2020 (Wikipedia 2012a) of which 65 % will live in towns and cities.

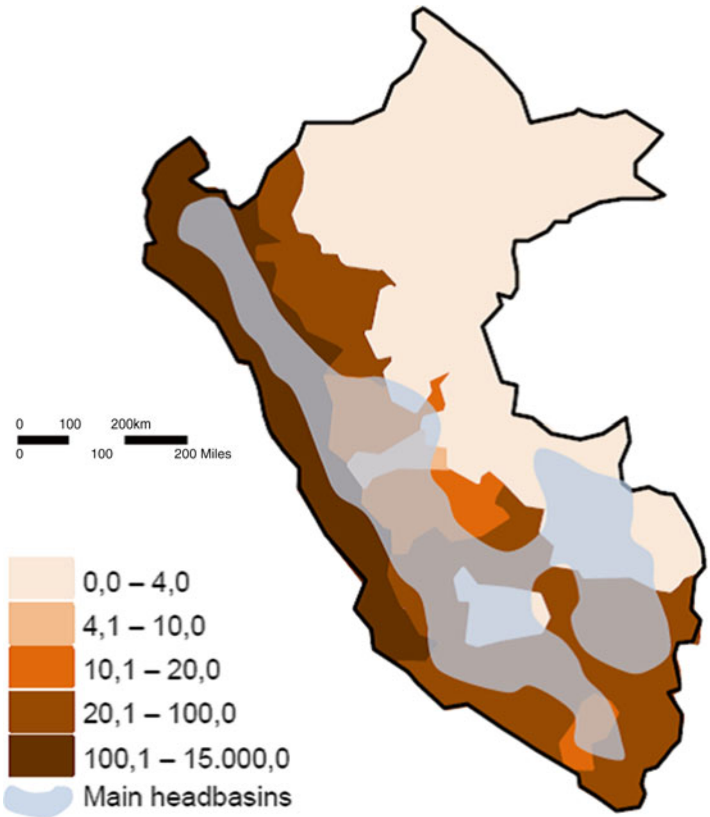
Analysis of the country's population density and the location of water sources shows that most of the population is moving to the western part of the country, occupying some of the headwaters, but depopulating many important areas where headwaters are located, especially those that discharge their water into the Amazon Basin. Unlike other Latin American countries in which the capital was located on the coast during colonial times to enable the export of minerals and spices to Spain, the capital of Ecuador was located in the Andes, which for many years served as the main attracting force in the country. However, in the last 20 years, density has been steadily increasing in the Pacific territories. This trend will continue in the near future, and urban consolidation in Ecuador will take place mainly on the coast. This is creating a gradual abandonment of the territories that contain the main water sources, or headwaters, of the country (Map 2.6).




**Map 2.6** Ecuador: population density (population per square kilometer) and main headwaters approximate location 2014. *Source*: ORELLANA 2003a. Observatorio de las Redes y de los Espacios en los Llanos, las ANdes y la Amazonia. Population density of the Andean Community of Nations. Available at: http://www.mpl.ird.fr/crea/orellana/eorellana/epays/eandes1.html. Reviewed on 27 September 2015. Map elaboration: Vladimir Arana

In 2004 (PAHO 2004), the urban population in Peru was around the 74 % of the total and the rural population around 26 %. In 2012 the urban population reached 76 %, which means that around 7 million inhabitants were living in cities by that year (INEI 2006). The Peruvian urban consolidation is unstoppable. By 2020 around 78 % of Peru's population will live in towns and cities, and with the 22 % of the population living in rural areas, the total population of the country will be around 31 million (Peru Experience 2006).

The highest population density in Peru is in the western part of the country next to the Pacific Ocean, which has lower water availability than in other parts of the country. The Andean region and the Amazon, which contain more important water resources, have the lowest population density. The urban concentration on the coast and the high population density in the capital are a consequence of the Spanish heritage, which located the capital of the viceroyalty in the center of the coastal part of the country (Map 2.7).

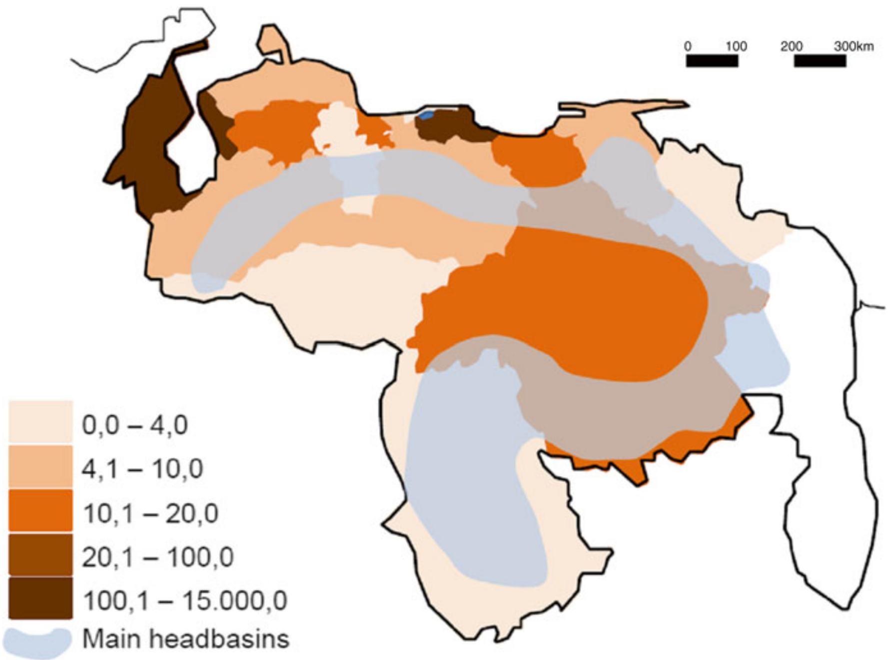



**Map 2.7** Peru: population density (population per square kilometer) and main headwaters approximate location 2012. *Source*: Abad, Tito 2012. Situación del Agua y Saneamiento en el Peru. Available at: http://es.slideshare.net/abadtito/giz-ppto. Reviewed on 28 September 2015. Map elaboration: Vladimir Arana

In Venezuela, 88 % of the population was urban in 2004 versus 12 % in rural areas (PAHO 2004). the urban population was 89.0 % in 2015 and will grow slowly to 89.3 % in 2020 (United Nations, DESA, 2014). However, other estimations predict that around 95 % of the population will live in towns and cities by 2020 (Fundación Escuela de Gerencia Social 2001) versus 5 % rural. This by itself shows the gradual migration from rural to urban areas that has been taking place; in this case, the highest-altitude territories are the first to be abandoned (Map 2.8).

In the case of Venezuela, most of the population, that is, the urban population, is now concentrated in the northern part of the country, leaving the southern part for rural activities and population, where most of the headwaters are located. This situation will continue and the headwaters will eventually be abandoned.

In the Andean ecoregion the urban primacy is led by Chile and Venezuela. Peru and Colombia are witnessing a steady increase in their urban populations, as are Bolivia and Ecuador, but at a slower rate. This urban growth is occurring in areas far from the main headwaters of these countries, and this could increment the costs of obtaining water in the future or the loss of headwaters due to the abandonment of forest and agricultural activities that contribute to the maintenance of ecosystemic services that help conserve these resources (Fig. 2.1).




**Map 2.8** Venezuela: population density (population per square kilometer) and main headwaters approximate location 2014. *Source*: Ministerio de Poder Popular para el Ecosocialismo, Habitat y Vivienda. Instituto Geográfico de Venezuela Simon Bolivar. 2014. Sistema de Información para la Gestión Integral de las Aguas. Available at: http://visor.ide.igvsb.gob.ve/sigia/portal.php. Reviewed on 15 September 2015. Map elaboration: Vladimir Arana

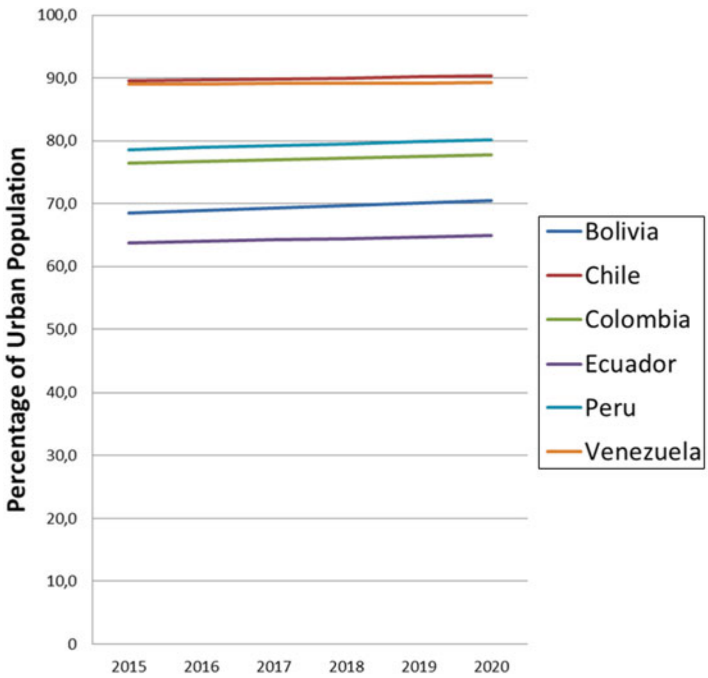



**Fig. 2.1** Andean ecoregion: percentage of urban population, 2015–2020. *Source*: United Nations, Department of Economic and Social Affairs (DESA), Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352). Available at: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf. Reviewed on 29 September 2015. Elaboration: Vladimir Arana

## 3 Population Behavior, Land Occupation Trends, and Water in the Amazon Ecoregion (Mainly Brazil and Parts of Bolivia, Colombia, and Peru)

The southwestern Amazon forest is an ecoregion that stretches from western and central Brazil to southeastern Peru and northern Bolivia, covering around 2,093,811 km$^2$. The population of Brazil is growing fast, and the urban population reached 84 % of the total in 2004 and the rural population 16 % (PAHO 2004). By 2020 the total population of this country-continent will be around 209 million, with a strong increment of elderly people and a decrease in the number of child (Folha 2004); the urban population will be around 89 % by 2020 (United Nations, DESA 2014) (Fig. 2.2).

The Brazilian population is located mainly in coastal zones, where important urban centers have developed over the years and where there is the highest population density, while the central part of the country has a low population density. In Brazil the main headwaters are located in the central, northwestern territories and part of the southeastern area of the country. It is in this last area, where some head-

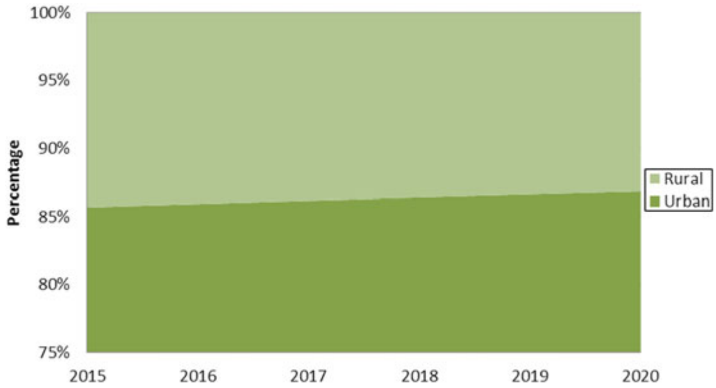



**Fig. 2.2** Brazil: urban trends, 2015–2020. *Source*: United Nations, DESA 2014. Elaboration: Vladimir Arana

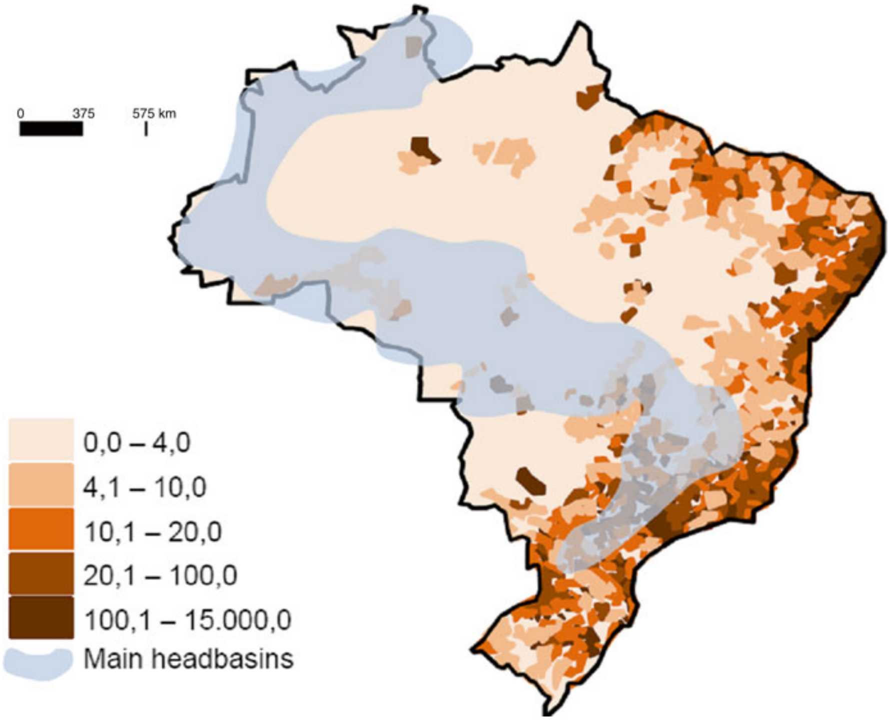
waters are located, that there is a large population density. However, another important population is located in the coastal north-eastern part of the country where headwaters are not located, even though important rivers and water sources cross this part of the territory. As shown by the map of the region, the lowest population density in the country is located where the main headwaters are, on the western side of the Amazon ecoregion. The urban primacy is concentrated, and will continue concentrating, on the coastal side of the country (Map 2.9).

## 4 Population Behavior, Land Occupation Trends, and Water in the Dry Chaco Ecoregion (Mainly Paraguay and Parts of Bolivia and Argentina)

The Dry Chaco ecoregion is located mostly in Paraguay; and it is composed of a wide sedimentary plain in the cordillera from where a large amount of sediments are transported and silt up the rivers beds, causing increased flows and floods (Torrella and Adámoli 2005).

Paraguay is undergoing an inexorable urban primacy, though not as strong as in other South American countries. In 1990, the urban population was 51 % of the total, while the rural population was 41 % of the total population, marking a slow decrease (PAHO 2004). After some years the slowing urban primacy started growing steadily, mainly as a result of internal migration processes, and in 2004, the urban population reached 58 % of the total (PAHO 2004).

The urban primacy in Paraguay is unstoppable, and in 2015 the urban population comprises 59.7 % of the total population, and in the medium term, by 2020, around 61 % of the country's total population will live in cities and towns (United Nations,




**Map 2.9** Brazil: population density (population per square kilometer) and main headwaters approximate location 2014. *Sources*: IBGE 2010. Sinopse do Censo Demografico 2010. Available at: http://www.censo2010.ibge.gov.br/sinopse/index.php?dados=10&uf=00. Reviewed on 28 September 2015. Portal São Francisco. 2010. Bacia Hidrografica. Availabe at: http://www.portalsaofrancisco.com.br/alfa/bacias-hidrograficas/bacia-hidrografica-2.php. Reviewed on 28 September 2015. Map elaboration: Vladimir Arana

DESA 2014). The population is mainly located in the eastern part of the country, east of the Paraguay River, which crosses the country from north to south and occupies 39 % of the national territory, where 97.3 % of the total population lives (Fig. 2.3 and Map 2.10).

The map of the population density and main headwater locations shows headwaters located in and around those areas of the country with the highest population density. This might be positive if the urbanization patterns corresponded to the hydrological functions and incorporated these criteria in the urban design and construction of new urban areas. If informal settlements occupy the land where the headwaters are located, then there is a big risk that these headwaters will be lost. The other important headwater is located in the western part of the country in areas with the lowest population density. Since an important percentage of the population

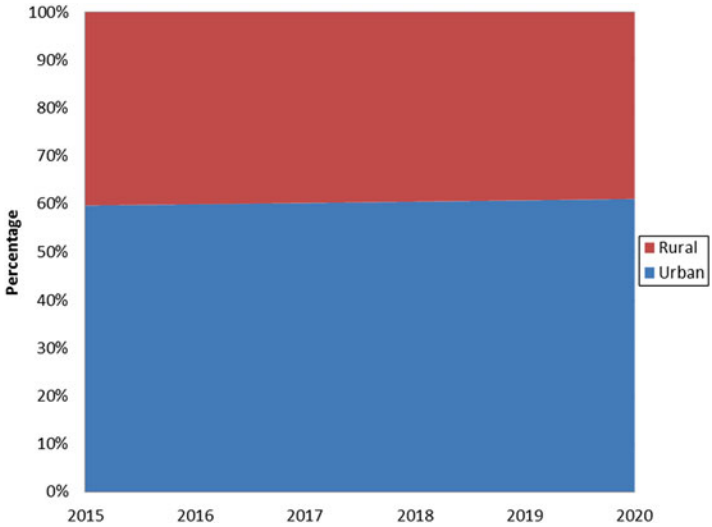



**Fig. 2.3** Paraguay: urban trends, 2015–2020. *Source*: United Nations, DESA 2014. Elaboration: Vladimir Arana

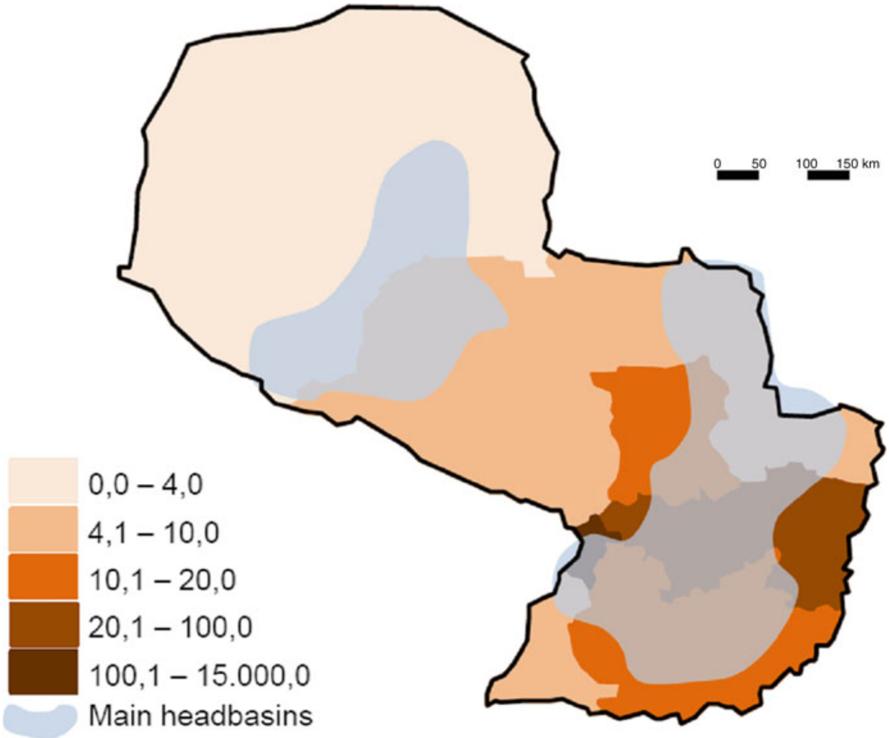
remains rural, there are opportunities to incorporate productive rural activities with ecosystemic services and conservation actions that might allow the conservation of these water sources.

## 5 Population Behavior, Land Occupation Trends, and Water in the Paraná-La Plata Ecoregion (Mainly Uruguay and Parts of Argentina and Paraguay)

In this ecoregion we find the La Plata Basin, with an approximate surface of 3,200,000 km$^2$; it is the second largest hydrographical basin in the world. It abuts territories that belong to Argentina, Bolivia, Paraguay, and Uruguay. The precipitations that fall accumulate in two of the most important rivers of the La Plata Basin, the Paraná and the Uruguay, which have a large number of tributaries, streams, and affluents and that subsequently flow down to the La Plata River, which finally discharges into the Argentine Sea in the Atlantic Ocean.

In 2004, Argentina, one of the most urbanized countries in Latin America, had 38,372,000 inhabitants, of which 90 % was urban and 10 % rural (PAHO 2004), showing a slow trend toward urbanization; by 2020, the country's population will be around 45,347,000, of which 94 % will live in urban and 6 % in rural areas (Torrado 2004).

In contrast, in 2004, Uruguay had a population of 3,439,000, with 93 % in urban and 7 % in rural areas (PAHO 2004), with estimates projecting that by 2020 the country will have around 3,441,000 inhabitants (INE 2005b), with an urban primacy




**Map 2.10** Paraguay: population density (population per square kilometer) and main headwaters approximate location 2014. *Source*: DGEEC 2002. Densidad de la población según el censo del 2002. Available at: http://www.comercioexterior.ub.edu/correccion/05-06/paraguay/geografia_econ3_poblacion.htm. Reviewed on 23 September 2015. Paraguay Educa. 2000. Mapa Hidrografico del Paraguay. Available at: http://biblioteca.paraguayeduca.org/biblioteca/contenidos_educativos/recursos-pedagogicos/mapas/Mapa%20hidrografico%20del%20Paraguay.jpg/view. Reviewed on 23 September 2015. Map elaboration: Vladimir Arana

of 96 % (United Nations, DESA 2014). The southern part of the country contains 96 % of the country's total population, mainly located in its capital, Montevideo, and in neighboring urban areas. The northern and western parts of the country have a dispersed population with less than ten people per square kilometer. The western side of Uruguay is very important for the country and is home to the Uruguay River Basin, which starts out in Brazil, runs through Argentina, flows into La Plata River, and ends in the Atlantic (El Uruguayo 2008) (Fig. 2.4).

Argentina is a country with a specialized economy whose population resides largely on the Atlantic Coast, as a heritage of Spanish colonial times, during which the main cities were founded next to the sea. Some Argentine headwaters are located in the western part of the country, fed from the Andes, and important water sources are located in the southern part of the country, which has the lowest population densities. Also, the northernmost part of the country contains

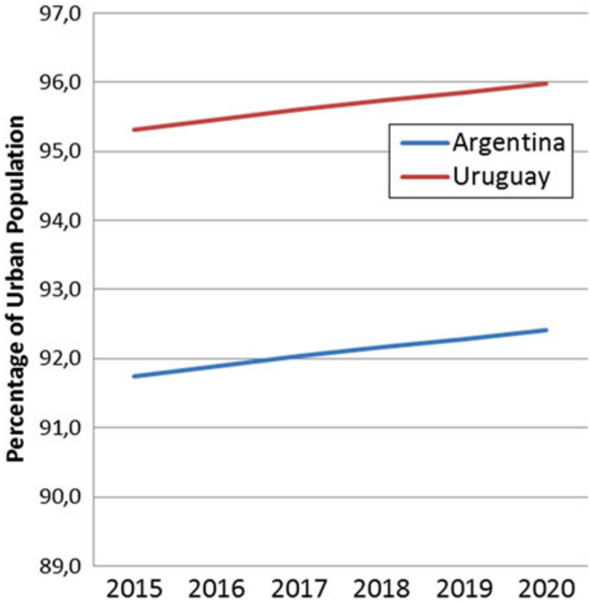



**Fig. 2.4** Paraná-La Plata ecoregion: urban trends, 2015–2020. *Source*: United Nations, DESA 2014. Elaboration: Vladimir Arana

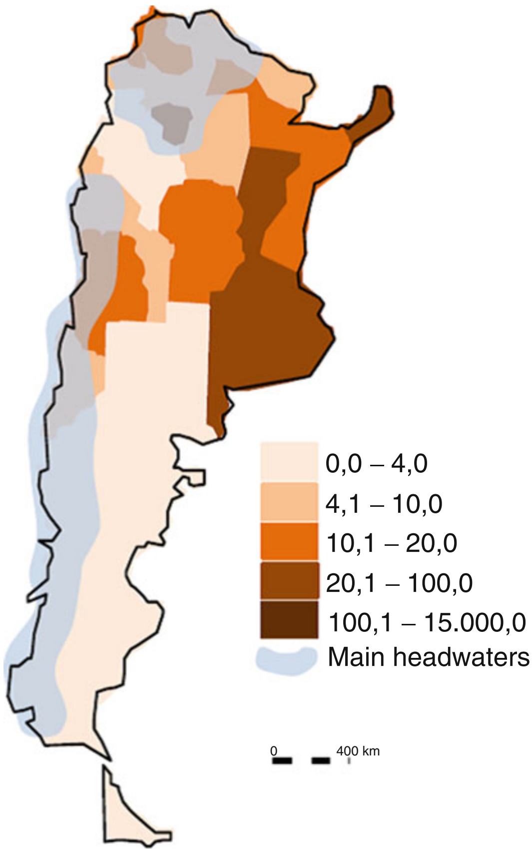
important headwaters with the lowest population density. Argentina has followed and consolidated the urbanization pattern imposed during colonial times in which urban growth was organized around the export of silver from Bolivian mines to Spain through the La Plata River (Silver River in English), a trend that has continued to this day.

The area around La Plata River has the highest population density in the country, consolidates the Argentine urban primacy, is home to most services, and accounts for most of the GDP of the country. La Plata Basin is not just a geographical basin; it is an economic basin on which Argentina depends (Map 2.11).

In Uruguay, the consolidation of urban primacy has taken place mainly in the southern part of the country; the central and northern parts of the country have the lowest population densities, which are where the main headwaters are located. This shows a clear abandonment of headwater areas that could create additional costs to obtain freshwater resources for human consumption and economic development (Map 2.12).

# 6 Central American Cordillera Ecoregion (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panamá and Part of Mexico)

The Central American Cordillera is the only mountain range in Central America and crosses all continental countries of the region, having different names in each country. It is formed by several plateaus, volcanoes, hills, and mountains, where dozens of rivers and streams start out, filling lakes and ponds that traverse all Central



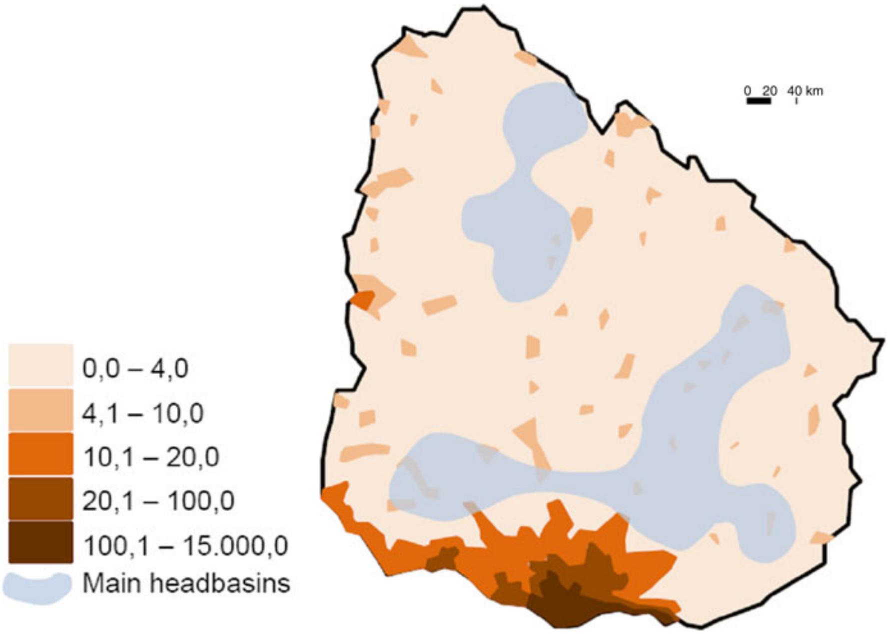

**Map 2.11** Argentina: population density (population per square kilometer) and main headwaters approximate location 2014. *Sources*: INDEC (Instituto Nacional de Estadística y Censos). 2010. Argentina: Density of the Country. Available at: http://www.sig.indec.gov.ar/censo2010/. Reviewed on 26 September 2015. Map elaboration: Vladimir Arana

American countries, discharging their water in the Pacific and Atlantic Oceans. Six countries are considered in the analysis of the Central American Cordillera ecoregion: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama.

In 2004, Costa Rica had 4,253,000 inhabitants, of which 61 % lived in urban and 39 % in rural areas (PAHO 2004). By 2010, Costa Rica had a population of 4,695,000, of which 66 % were in urban and 34 % in rural areas (RUTA 2007). By 2020 Costa Rica will have 5,084,000 inhabitants (INEC 2008). The country will consolidate its urban primacy, and the population will tend to concentrate in the central part where the capital is located. It, too, will concentrate most of the infrastructure and services of the country.

El Salvador had a population of 6,762,000 in 2004, of which 60 % were in urban and 40 % in rural areas (PAHO 2014). By 2020, it is estimated that the population will reach 8,533,700 inhabitants, where 69 % will be in urban and 31 % in rural areas (United Nations, DESA 2014).

Guatemala went from having 12,295,000 inhabitants in 2004, with 43 % in urban areas (PAHO 2014), to 18,055,025 inhabitants by 2020, with 53.9 % living in towns and cities (United Nations, DESA 2014). In contrast to other Latin American




**Map 2.12** Uruguay: population density (population per square kilometer) and main headwaters approximate location 2014. *Source*: La Academia. 2014. Geografía de Uruguay. Available at: https://academiapaso.wordpress.com/2014/01/31/geografia-de-uruguay/ Reviewed on 25 September 2015. Map elaboration: Vladimir Arana

countries before 2010, Guatemala's population was largely located in rural areas, developing essentially primary economic activities. Honduras' population will go from around seven million inhabitants, with 54 % in urban areas in 2004 (PAHO 2004), to around ten million in 2020, with 57.6 % of the people living in towns and cities (United Nations, DESA 2014). Like Guatemala, just a few years ago Honduras had a rural population predominance, which explains the large amount of primary economic activities.

Nicaragua will consolidate its urban primacy, passing from 58 % in 2004 (PAHO 2004) to 61 % urban in 2010 and 66 % urban in 2020 (Instituto Nacional de Información del Desarrollo 2010), while the UN projects that Nicaragua will be 60 % urban in 2020 (United Nations, DESA 2014). In any case, the urbanization trends will remain strong in Nicaragua, and the country will consolidate its urban primacy in subsequent years.

Panama, with a total population of around three million people in 2004, had a 57 % urban and a 43 % rural population (PAHO 2004). In 2020 Panama will have around four million inhabitants (Contraloría General de la República 2006), of which 68.1 % will be urban (United Nations, DESA 2014). The urbanization process in Panama has been steady and not accelerated as in other Latin American countries.

In 2015, the average percentage of urban dwellers was 62.5 % with Costa Rica having regional urban primacy with 76.8 %, followed by Panama with 66.6 %, El Salvador with

66.7 %, Nicaragua with 58.8 %, Honduras with 54.7 %, and Guatemala with 51.6 %. In 2020, the Central American Cordillera ecoregion will have an average percentage of urbanization of 65 %, led by Costa Rica with 80.6 % of its population in urban areas, El Salvador with 69 %, Panama with 68.1 %, Nicaragua with 60.5 %, Honduras with 57.6 %, and Guatemala with 53.9 % (United Nations, DESA 2014). In the next 5 years, urban population projections show that Costa Rica and El Salvador will have more dynamic urban and economic forces, and a faster consolidation of the urban primacy is predicted for those areas. Costa Rica will see a 3.8 % increase in its urban population and El Salvador's will increase by 2.2 %. Note that El Salvador and Panama have almost the same percentage of urban population in 2015, but in 2020, just 5 years later, El Salvador's urban population will surge and surpass that of Panama by a wide margin (Fig. 2.5).

The highest population density in Costa Rica is located in the central part of the country, and the Costa Rican headwaters traverse the country from north to south; the area with the highest population density, which includes the capital, is located near the central headwaters. The northern and southern parts of Costa Rica have the lowest population densities, also located on important headwaters.

The main basin of El Salvador is the Lempa River Basin, which starts out in the neighboring country of Honduras. The highest part of this basin contains the lowest population densities in the country, which is mainly a declining rural population. Most of the population is concentrated in the capital and neighboring areas, especially in the northern and eastern parts of the country. The urban primacy tends to consolidate along the Pacific coast, and, as in other countries, headwaters showing a declining rural population.

In Guatemala, rivers are short, fast, and irregular with a shallow depth on the Pacific side. On the Atlantic side, in contrast, rivers are larger and deeper, which

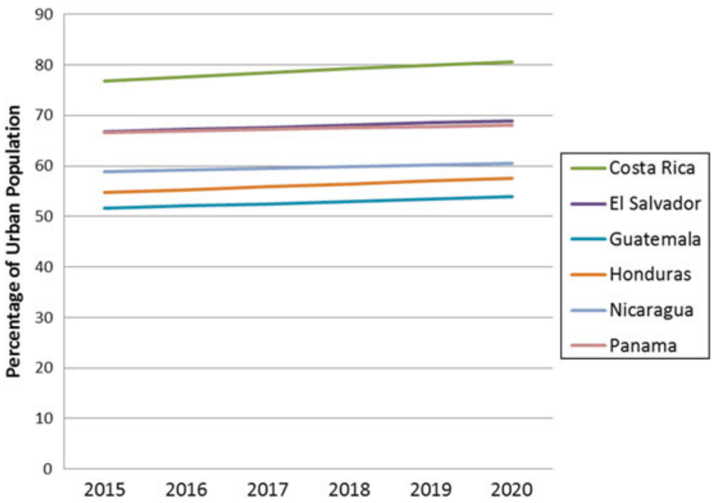
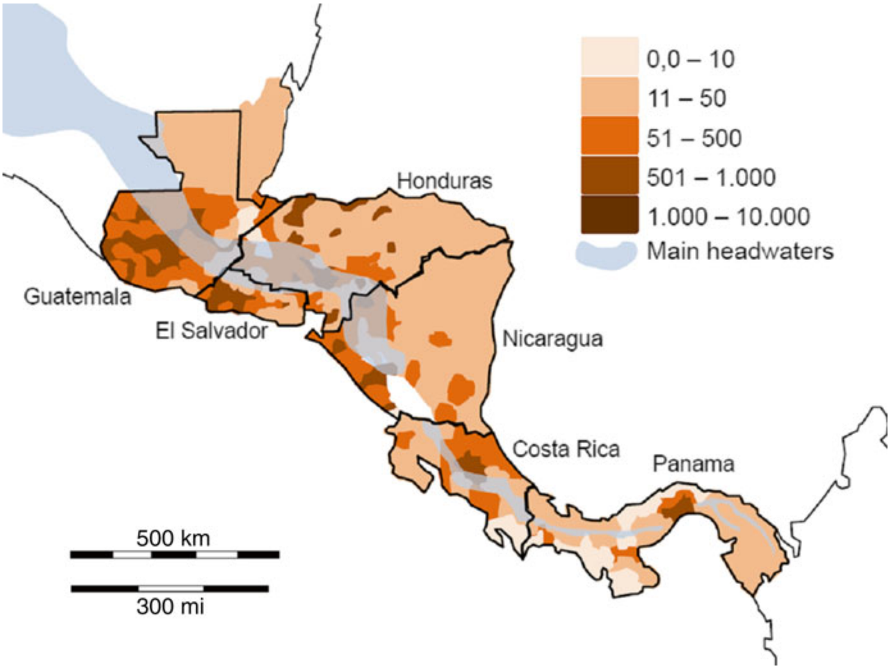



**Fig. 2.5** Central America: urban trends, 2015–2020. *Source*: United Nations, DESA 2014. Elaboration: Vladimir Arana

makes them navigable. Most of the population of the country, including in the capital, is concentrated in the central and eastern parts, where there are important headwaters; the northern and western parts have the smallest population density, which is where the largest rivers are. The Motagua River is the most important of Guatemala's rivers and discharges into the Caribbean Sea (Geografía La Guía 2000, 2007a). Illegal settlements around the capital threaten the conservation of the country's headwaters.

In Nicaragua most of the population is concentrated in the western part of the country, and since the country is undergoing a pronounced urban consolidation, it is estimated that the Pacific territories will experience increasing density and see the emergence of important informal settlements. The eastern part of the country has the smallest population density and the most important river basins. Headwaters are located closer to the Pacific side next to the main urban areas, which will threaten these water sources in the medium term.

In Panama, relatively small headwaters traverse the country longitudinally, and the main urban areas are settled in the center of the country on the Pacific side. The eastern and western sides of the country have the smallest population densities and some important water sources (Map 2.13).




**Map 2.13** Central American Cordillera ecoregion: population density (population per square kilometer) and main headwaters approximate location 2014. *Source*: UNISDR (United Nations Office for Disaster Risk Reduction). 2007. Change of population density in Central America. Available at: http://www.eird.org/cd/redlac/capitulo1/temas-ambientales.html. Reviewed on 26 September 2015. Map elaboration: Vladimir Arana

# 7 Mexican Plateau Ecoregion (Mexico)

Mexico is a country with a predominantly urban population. Already in 2004, Mexico had about 105 million inhabitants, and the urban population was around 76 % and the rural population 24 % of the total (PAHO 2004). By 2020, it is estimated that Mexico will have around 115 million inhabitants (CONAPO 2005), of which 80.6 % (United Nations, DESA 2014) will live in cities and towns, and the rest, 19.4 %, in rural areas. In the heartland of the country is located Mexico DF, the capital city, and the surrounding urban areas, one of the largest urban conglomerates in the world that contains around one quarter of the country's total population with the highest population density in the country. This urban mass has an overwhelming attracting capacity, which is now consolidating from the Pacific to the Atlantic Oceans and will soon form a complete urban continuum, becoming the largest conurbation in Latin America (Fig. 2.6).

The capital has the highest population by territorial unit. The northern and southern parts of the country have the lowest population densities. The country's headwaters go from north to south, and while the southern headwaters overlap with high and medium population densities, the northern headwaters overlap with low population densities. The largest water availability is located in the southern part of the country, which has a tropical humid climate, while

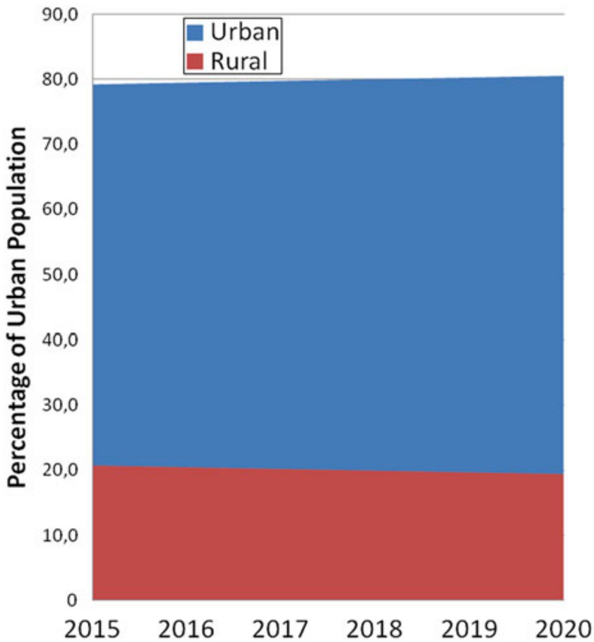
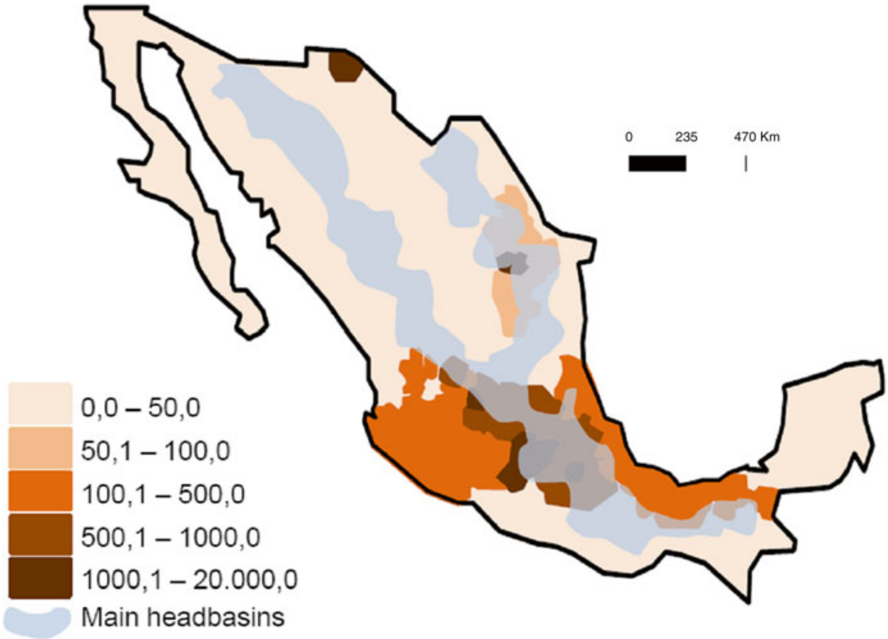



**Fig. 2.6** Mexico: urban trends, 2015–2020. *Source*: United Nations, DESA 2014. Elaboration: Vladimir Arana




**Map 2.14** Mexican Plateau ecoregion: population density (population per square kilometer) and main headwaters approximate location 2015. SEMARNAT 2005. Densidad de población. Availabe at: http://app1.semarnat.gob.mx/dgeia/estadisticas_2000/incendios/estadistica-am/informe/polacion/demografica/mapa%20densidad.htm. Reviewed on 28 September 2015. Ediciones Culturales Internacionales. 2015. Mapa Mexico Hidrografia. Available at: https://www.ediciones.com.mx/?attachment_id=5722. Reviewed on 28 September 2015. Map elaboration: Vladimir Arana

the northern part has a dry climate, desert in many places. Urban growth in Mexico is a legacy of colonial urbanization patterns that have consolidated over the years (Map 2.14).

Latin America had a high rate of urbanization between 1950 and 1990, where most of the urban centers and capital cities emerged very quickly, spurred in particular by migration from rural areas. Since 1990 the rate of urbanization has slowed down a bit but has maintained a steady rhythm that will consolidate the region as predominantly urban; there is a large tertiary economy where headwater territories will be abandoned in the medium and long term. By 2050, the urban population of Latin America will be close to 90 % (United Nations, Department of Economic and Social Affairs 2014), and the rural population of the region will be around 10 %, meaning a very small percentage of the region's population will be producing agricultural products or engaged in agricultural activities, which could help conserve water resources (Fig. 2.7).

However, the urbanization process in Latin America has created a positive impact on personal incomes. Analysis has shown that a higher degree of urbanization has a strong correlation with higher per capita GDP. Countries such as

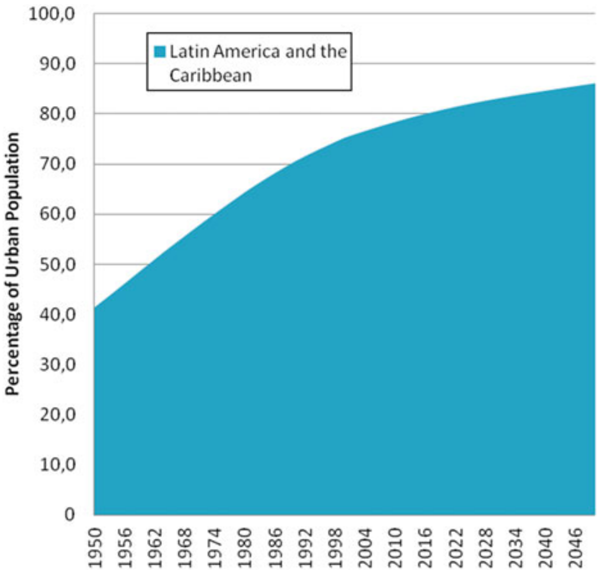



**Fig. 2.7** Latin America and the Caribbean: urban trends, 1950–2050. *Source*: United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352). Available at: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf. Reviewed on 29 September 2015. Elaboration: Vladimir Arana

Argentina, Uruguay, and Chile have the highest urbanization primacy in the Latin American region and the highest per capita GDP. Countries such as Haiti, Honduras, and Nicaragua have the lowest degree of urbanization and the lowest per capita GDP. However, Guatemala has a lower degree of urbanization than the last mentioned countries but a higher per capita GDP than any of those three countries. This means that, even if there is a strong relationship between GDP and degree of urbanization, this relationship does not necessarily correlate with economic growth, which could be based on rural economic activity or larger specific economic activities with a large scale market. In the case of Guatemala, among the most important factors in Guatemala's economic growth are the maquila factories. There are a significant number of Korean-owned maquila factories in the highlands of Guatemala. Korean entrepreneurs have adopted a buyer-driven commodity chain process that depends on the existence of a large labor force, low capital investment, and low skills. Korea's presence in Guatemalan industry and ultimately among Guatemalan workers is through subcontractors that are responsible for delivering finished orders to multiple buyers, mostly located in the USA. Buyers include Macy's and JC Penny and brands such as Liz Claiborne, OshKosh, and Tracy Evans (Wikipedia 2009) (Fig. 2.8).

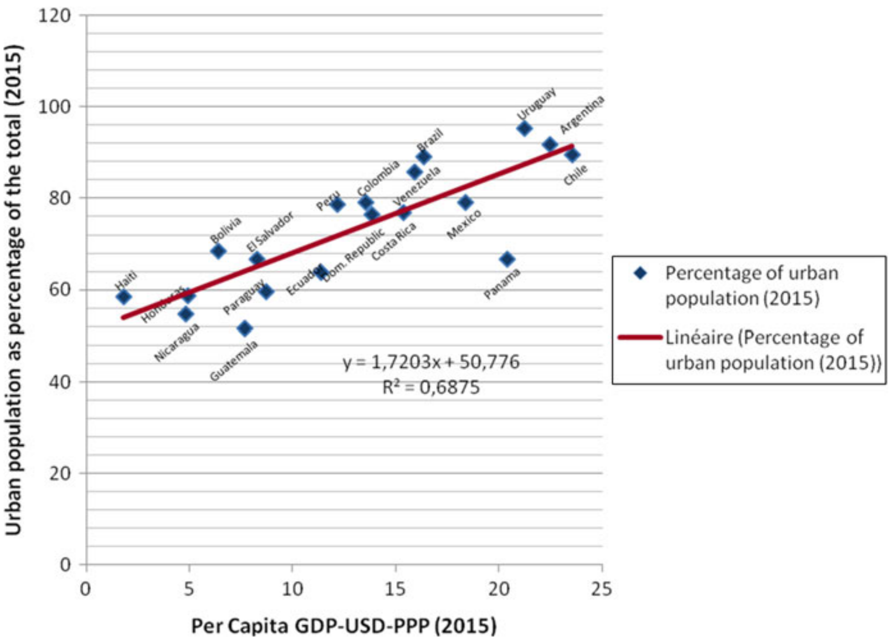



**Fig. 2.8** Links between urbanization level and GDP per capita 2015. *Sources*: International Monetary Fund (IMF) 2015. World Economic Outlook, April 2015. Uneven Growth, Short and Long Term Factors. IMF, Washington, DC. Available at http://www.imf.org/external/pubs/ft/weo/2015/01/pdf/text.pdf. Reviewed on 29 September 2015. United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: The 2014 Revision, Highlights (ST/ESA/SER.A/352). Available at: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf. Reviewed on 29 September 2015. Elaborated by Vladimir Arana

## 8 Conclusions

Most of the Latin American population lives and will live in towns and cities, reducing the rural population and reducing the population density in headwater areas. Rural populations are migrating to intermediate cities and to capital cities, in many cases to towns and cities under water stress.

A low population density in vast Latin American territories means a high population dispersion rate, which makes more difficult the presence of the state, or the provision of infrastructure and services, such as police stations, health clinics, environmental monitoring, or rural water supply and sanitation infrastructure.

Urban populations in Latin America are agglomerating in either marine coastal zones or, in the case of Mediterranean countries, a specific part of the country. This settlement process is mostly due to the Spanish colonial legacy, when towns and capital cities were founded to allow easier export of minerals and spices to the Spanish metropolis. This urbanization process is abandoning important headwaters and water sources.

Latin America has many shared water sources with transboundary interests. However, headwaters and water sources located in rural areas are now witnessing declining rural populations. On the other hand, headwaters located in important urban areas are suffering under pressures of urbanization and informal occupation that have a greater negative impact on environment and water resources. In other words, territories where flowing water originates will reduce their population, a key factor in maintaining agricultural, forestry, and pastoral activities that have a favorable impact on headwater conservation, ecoregional dynamics, and ecosystem service maintenance.

In many countries, populations located in headwater areas possess important traditional knowledge that can be used to help conserve natural resources and water dynamics. For this reason, rural depopulation means not only a population decline but also the fragmentation of societies that possess traditional knowledge that could be important in the conservation of water resources and protection of territories containing river basins. This process can be called basin social decapitalization.

Some of the causes of basin social decapitalization are the progressive transition of household economies to tertiary economies that increment and consolidate the countries' urban primacy. Also, the unbalanced services of urban Latin American areas compared to rural areas makes capitals and, mainly, intermediate cities more appealing to migrants who are looking for a better quality of life. In addition, companies with economies of scale from Asian and North American countries that receive significant subsidies from their governments generate products and commodities with lower marginal prices with which smaller-scale Latin American economies cannot compete, and so the Latin American countries find it more difficult to sell their agricultural surpluses on international markets. On the other hand, it is important to mention the strong relationship between the degree of urbanization and per capita GDP, which is indicative of the intense pressure that urban areas place on rural territories, which consolidates with public investments, especially in infrastructure mainly developed in urban areas.

Opportunities for growth in urban areas, including employment and quality of life, exert a strong pull on rural inhabitants. Governments could create incentives to maintain the population in rural areas, but no policies would create incentives like market-based initiatives, which would boost rural economies and spur sustainable development in rural areas and in headwater territories that are being gradually abandoned. The Latin American rural depopulation phenomenon is creating the need for a broader research agenda that will explore new state policies and strategies to ensure headwater and agricultural production, especially in urban areas.

# Chapter 3
# The State of Water Sources

Water sources in Latin America depend mainly but not exclusively on the hydrological cycle. However, the collection of water availability data in every stage of the hydrological cycle demands knowledge and resources beyond governments' capacities, so they focus their efforts on specific stages of the water cycle, in particular uses, and on specific aspects.

In this chapter the information used for analysis focuses on renewable water resources, which are defined as the annual average flow of rivers and aquifer recharge generated by precipitation. It distinguishes between the natural state (renewable natural resources), which refers to a state without human influence, and the current state.

To determine a country's water resources it is important to make a distinction between renewable and nonrenewable resources. Renewable water resources are calculated based on the water cycle. In this chapter, they represent the annual average flow of rivers in the long term (surface waters) and underground water. Nonrenewable water resources are the deep underground water bodies (deep aquifers) that have an unknown recharge in terms of time scale and human scale. The method used to calculate water resources is based on the water resources accountability approach (FAO 2003).

The total renewable water resources of a country are the renewable water resources generated internally (RWRGI) plus the external water resources. This considers the nonduplicated calculation of renewable water resources generated externally, which is the volume of water generated in countries upstream. To avoid a double accountability, only the RWRGI are considered in regional and continental assessments (FAO 2003).

Consumptive, or extractive, uses are those that extract or consume water from a place of origin. Within this use we find domestic or municipal, agricultural and livestock, industrial, mining, and thermal energy creation use. Nonconsumptive uses, in situ or nonextractive, are those activities that do not extract water, such as recreational activities, landscape appreciation, and activities that help maintain ecosystemic services (Gayoso 2001).



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It is important to make an analysis and comparison of the per capita availability of water resources by ecoregion since countries in the same ecoregion share common ecosystems and because they have similar climates and common determining hydrological factors and are in any case similar. The causes of renewable water resource depletion should be studied, though at this point we can mention some of the causes: competition among consumptive users, weak water conservation and management infrastructure, and climate change.

The Intergovernmental Panel on Climate Change (IPCC) (2007a, b) predicts the following phenomena for Latin America. (1) An increase in temperature and a related reduction in the humidity of the soil in the eastern part of the Amazon will lead to the progressive substitution of tropical forests by savannahs. (2) Semiarid vegetation will be replaced by arid land vegetation. (3) An important biodiversity loss will be irreversible, and many species will be extinct in many Latin American tropical areas. (4) Productivity and especially livestock production will be reduced drastically, negatively impacting food security; in mild temperatures, soya cultivation will improve its productivity, and the incidence of people being threatened by hunger will increase. (5) Changes in precipitation patterns and the disappearance of glaciers will reduce the availability of water for human, agricultural, and hydroelectric consumption. (6) Sea levels will rise, intensifying floods, storms, erosion, and other dangerous climatic coastal phenomena. (7) A deterioration in coastal conditions will negatively affect local resources and populations.

It is worth mentioning that the per capita water availability in Latin America will always be decreasing because the population there is always increasing; this does not negate the importance of this indicator, though. However, the volume of available water resources as a whole is a key asset for future development initiatives. The dependency ratio mentioned in this chapter makes reference – in rate and percentage – to the relationship between the dependent population and the productive population on which the first population depends (Wikipedia 2001).

## 1 Water Availability in Latin America

Water resource availability in Latin America is in an enviable situation compared with other regions of the world. Only South America has more than 30 % of the renewable resources of the planet: for example, the Amazon Basin, the Guaraní Aquifer System, and the Lake Titicaca Basin. These systems provide global ecosystemic services such as, for example, carbon sequestration, biodiversity production, and conservation. However, international cooperation agendas focus more on Africa and Asia, disregarding Latin American water resource conservation (PCES 2010).

Latin America has around 33 % of the world's freshwater sources. This region has important water resources. A surface that represents 15 % of the world's total surface receives around 30 % of the world's precipitation and generates around 33 % of the world's runoff. In addition, the region hosts slightly less than 10 % of the world's population, and this explains the per capita water availability of about 28,000 $m^3$/inhabitant/year, which is above the world average.

**Box 3.1** Latin America: total water resources by inhabitant and by subregion availability

| Subregion | Annual precipitation | | Renewable internal water resources | |
|---|---|---|---|---|
| | mm | km$^3$ | km$^3$ | m$^3$ by inhabitant (1997) |
| Mexico | 772 | 1512 | 409 | 4338 |
| Central America | 2395 | 1194 | 6889 | 20,370 |
| Greater Antilles | 1451 | 288 | 82 | 2 804 |
| Lesser Antilles | 1141 | 17 | 4 | – |
| Guyane Subregion | 1421 | 897 | 329 | 191,422 |
| Andean Subregion | 1991 | 9394 | 5186 | 49,902 |
| Brazil | 1758 | 15,026 | 5418 | 33,097 |
| South Subregion | 846 | 3488 | 1313 | 22,389 |
| Latin America and the Caribbean (LAC) | *1556* | *31,816* | *13,429* | *27,673* |
| World | – | 110,000 | 41,022 | 6,984 |
| LAC as percentage of world | | 29 | 33 | |

Source: FAO 2010a, b.

This analysis makes clear that the Andean and Amazon subregions contains the bulk of the region's runoff. However, these numbers hide the scarcity conditions that exist in the most populated areas of the region, like the Central Valley of Chile, the Cuyo region and southern of Argentina, the Peruvian coast, the Cauca and the Magdalena valleys in Colombia, the Bolivian Plateau, the Great Chaco, share by Bolivia, Argentina, and Paraguay, northeastern Brazil, the Central American Pacific coast , and a large portion of Mexico (FAO 2010a, b) (Box 3.1).

On the other hand, if we compare water availability data by country, we find that South American countries, and especially Brazil, Colombia, and Peru, contain most of the water in the region. However, if we analyze the availability of renewable total water resources per capita, we find that Peru leads in this indicator, followed by Bolivia and Chile, while Brazil is in eighth place.

Brazil has by far the largest volume of water resources in Latin America. However, this does not mean that water is accessible for everyone since, as stated earlier, the country does not rank among the first five countries on per capita water availability. This indicator simply divides the country's water availability by the number of inhabitants or the total population. It does not indicate either the exact amount of water that is used in economic activity or the volume of water needed to maintain the renewable status of these resources (Figs. 3.1 and 3.2).

A future critical aspect observed in this analysis may be the case of Mexico. This country has around one-fourth the water availability of a country like Peru but four times Peru's population and one-third higher per capita GDP, so consumption capacity is higher in Mexico, which means the Mexicans may have higher production and, hence, higher water consumption for productive uses. This may not only indicate a low per capita water availability but also that the pressure and competition for this valuable resource may increase in the short term.

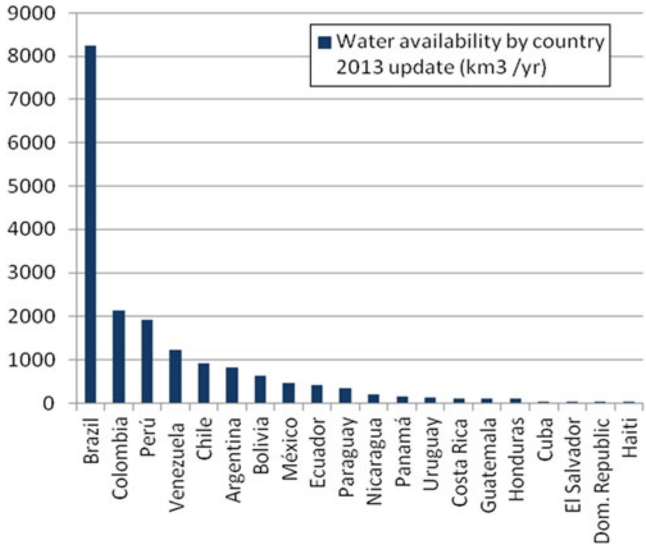



**Fig. 3.1** Water availability by country, 2013 update (km$^3$/year). Source: World Water. 2013. Available at: http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf Reviewed on 30 September 2015. Elaboration: Vladimir Arana

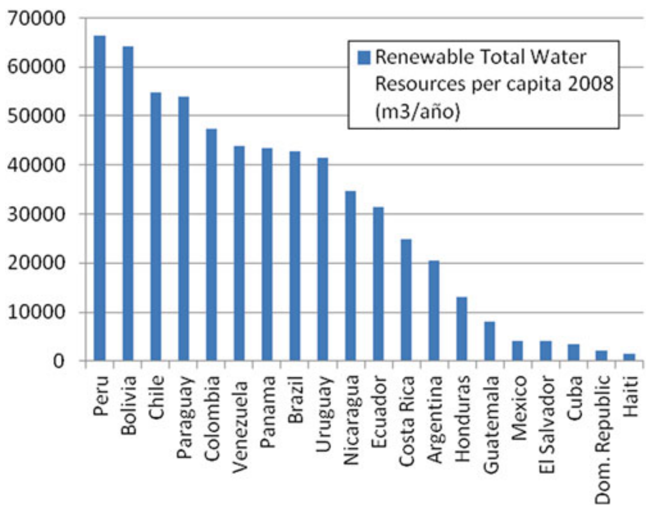



**Fig. 3.2** Renewable total water resources per capita 2008 (m$^3$/year). Source: AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

Another critical aspect can be observed in countries like Cuba, El Salvador, Dominican Republic, and Haiti, which have the lowest water resource availability and the lowest volume of renewable total water resources per capita. These conditions, combined with public resource investment capacities and management, may exacerbate the situation. It is important to keep an eye on these countries since their vulnerability to disasters is high and the availability of water is low. These combined factors could thus create a severe crisis in the short term.

In Latin America, countries that share hundreds of years of history with their neighbors have greatly varying amounts of available water. It is important to analyze whether or not it will be possible for countries to define and implement a collaborative approach to water resource management that would provide water to those in the region that have less of it. At this point we can state that poverty is a regional symptom with regional similarities and causes, while water is a common regional resource. One approach to combating poverty and promoting wealth creation will rely on access to water for the poor (Map 3.1).


**Map 3.1** Latin America: water availability by country, 2013 ($km^3$/year). Source: World Water. 2013. Water availability by country, 2013 update. http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf. Elaboration: Vladimir Arana

## 2 Water Availability in Andean Ecoregion (Bolivia, Colombia, Ecuador, Peru, Chile, Venezuela, Parts of Argentina)

In the Andean ecoregion, Bolivia and Peru have had the highest availability of renewable total water resources per capita since the year 2000. In 2003, both Peru and Bolivia had around 74,000 $m^3$ of water , while in 2020, Bolivia will have around 48,000 $m^3$and Peru will have around 54,000 $m^3$ (FAO 2003).

Chile's per capita water availability is in decline; it will go from around 60,000 $m^3$ in 2000 to around 46,000 $m^3$ in 2020, which represents a decrease of about one-third in the per capita water availability. This situation may sound the alarm for future strategic human and economic development, and it presents an urgent opportunity to find new cost-effective sources of water and to optimize the country's water consumption (FAO 2003).

Colombia and Ecuador also have decreasing availability of renewable total water resources per capita. Colombia will go from having around 50,000 $m^3$ in the year 2000 to having 42,000 $m^3$ in 2020, and Ecuador will go from having around 34,000 $m^3$ in 2000 to having 27,000 $m^3$ in 2020. Venezuela, on the other hand, is witnessing a severe decline in the availability of renewable total water resources per capita; it will go from around 51,000 $m^3$ in year 2000 to around 33,000 $m^3$ by 2020 (Fig. 3.3).

In the Andean ecoregion, Colombia and Peru contain more than half of the water resources, which means that sustainable water management in these two countries may ensure more than half of the ecosystemic services in this ecoregion. While the per capita water availability is decreasing in all the countries of this ecoregion, which is natural because the populations are growing, Venezuela and Chile are showing more accelerated trends (Fig. 3.4).

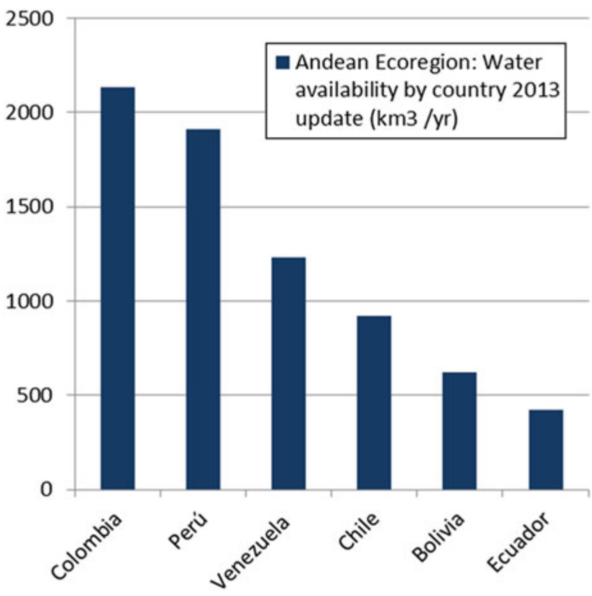



**Fig. 3.3** Andean ecoregion: water availability by country, 2013 update ($km^3$/year). Source: World Water. 2013. Available at: http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf Reviewed on 30 September 2015. Elaboration: Vladimir Arana

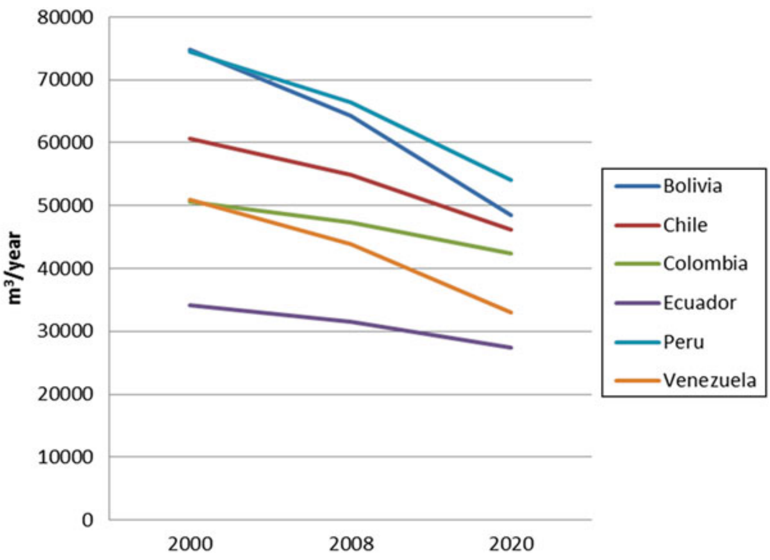



**Fig. 3.4** Andean ecoregion: water availability per capita, 2000–2020 ($m^3$/year). Source: AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

## 3 Water Availability in Amazon (Mainly Brazil), Dry Chaco (Mainly Paraguay), and Paraná-La Plata (Mainly Argentina and Uruguay) Ecoregions

The Amazon ecoregion has an average temperature of between 24 and 26 °C and around 1500–3000 mm of rainfall. This area is home to the world's largest tropical rain forest, occupying more than half of the Brazilian territory. The weather in this ecoregion is hot and humid. On the other hand, in the Dry Chaco (Paraguay) and Paraná-La Plata (Argentina and Uruguay) ecoregions, the weather is very variable, with temperatures ranging from 39 to 55 °C. In 2000, Brazil had per capita renewable total water resources of around 48,000 $m^3$, which will become around 34,000 $m^3$ in 2020 (FAO 2003). Paraguay will go from having around 61,000 $m^3$ in 2000 to having around 42,000 $m^3$ in 2020.

Uruguay will actually increase its per capita renewable total water resources indicator, going from having around 41,000 $m^3$ in 2000 to having around 42,000 $m^3$ in 2020. In 2000, Argentina had around 22,000 $m^3$ of per capita renewable total water resources and will have around 18,000 $m^3$ by 2020 (Fig. 3.5).

All these countries except Uruguay have a decreasing per capita trend. Uruguay's trend is explained by the very low population growth rate, the lowest in the region. The Andean ecoregion has less water as a total volume than the Amazon ecoregion. However, the pressure for water is higher in the latter. The Dry Chaco and Paraná-La Plata ecoregions have less water than the other South American ecoregions and an important level of per capita pressure on water resources.

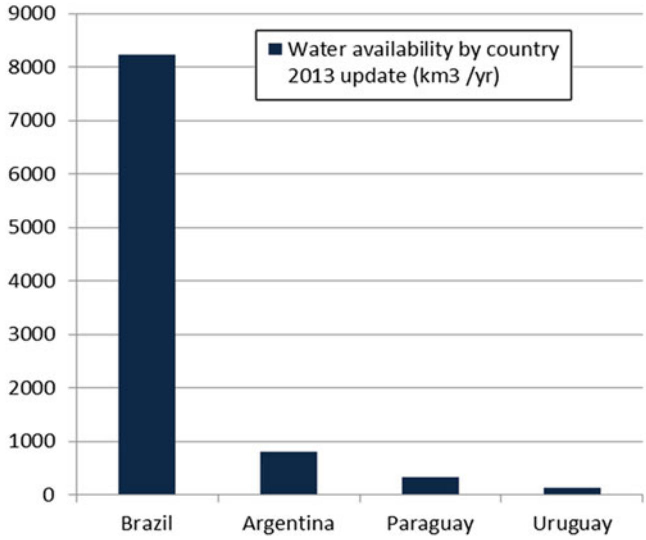



**Fig. 3.5** Amazon, Dry Chaco, Paraná-La Plata ecoregions: water availability by country, 2013 update (km$^3$/year). Source: World Water. 2013. Available at: http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf Reviewed on 30 September 2015. Elaboration: Vladimir Arana

Brazil has more than six times the water availability than Argentina, Paraguay, and Uruguay combined, that is, 8,233 km$^3$/year in Brazil versus 1,289 km$^3$/year in Argentina, Paraguay, and Uruguay combined (World Water 2013). Brazil (204,000,000 inhabitants) has around four times the population of Argentina (49,000,000), Paraguay (7,000,000), and Uruguay (3,000,000) combined (Wikipedia 2015) (Fig. 3.6).

## 4 Water Availability in Central American Cordillera (Mainly Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama) and Mexican Plateau Ecoregions (Mainly Mexico)

Around 80 % of Central America is mountainous, with most of the plain zones along the coast. In general, the volcanic system that traverses this subregion from north to south functions as a divider between the Pacific and Atlantic coastal basins. The weather in Central America is essentially tropical and is cooled by its proximity to the oceans, altitude, and topography. The Atlantic coast is more humid than the Pacific. The precipitation gets incremented from north to south and from east to west. The weather has influenced human

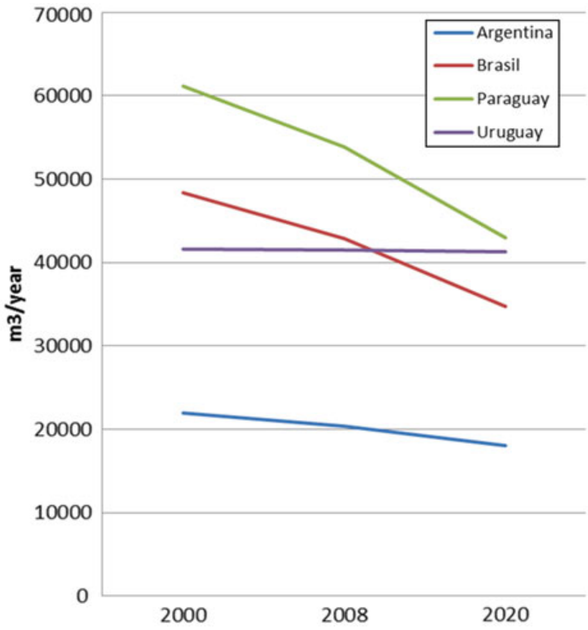



**Fig. 3.6** Amazon, Dry Chaco, Paraná-La Plata ecoregions: water availability per capita, 2000–2020 ($m^3$/year). Source: AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

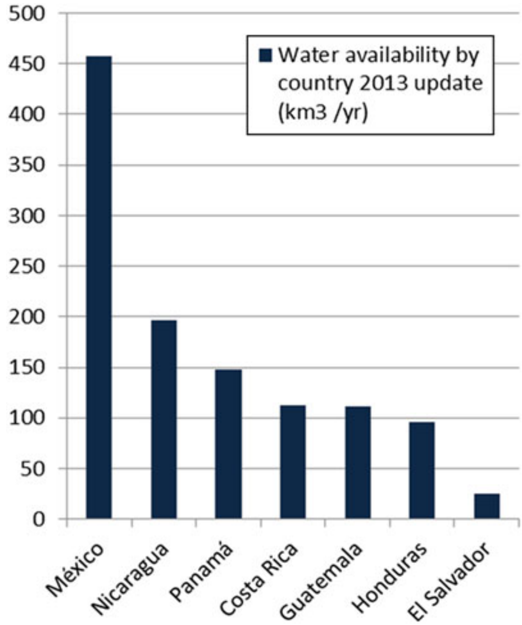
settlements, with most of the population living higher than 1000 m above sea level (FAO 2003).

Mexico is located in the Intertropical Convergence Zone, and humid masses penetrate from the Gulf of Mexico and the Pacific Ocean, which drives the water cycle on the continent. These two factors influence the country's weather and determine the lack of precipitation in the north and abundant rain in the south (FAO 2003) (Fig. 3.7).

Most Central American countries have a strong decreasing trend in per capita renewable total water resources, with the exception of El Salvador, which has a slow trend that will change from 4,024 $m^3$ in 2000 to 4,113 $m^3$ in 2020 (FAO 2003) (Fig. 3.8). The Central American Cordillera, as well as Andean ecoregion countries, has limited access to water since the dominant mountain chains make the extraction, treatment, and distribution of water, as well as resource conservation, more expensive.

Social dysfunction increments the dependency rate, poverty, and internal conflicts. Countries experiencing social dysfunction that already have an accelerated rate of per capita water consumption may dramatically increase their water stress since they have not yet met minimum requirements of water availability for those living in poverty. These countries may need to look at other alternatives for accessing drinking water while at the same time strengthening conservation and the use of these resources and promoting population policies that would help protect the resources.

**Fig. 3.7** Central American Cordillera and Mexican Plateau ecoregions: water availability by country 2013 update (m³/year). Source: World Water. 2013. Available at: http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf Reviewed on 30 September 2015. Elaboration: Vladimir Arana



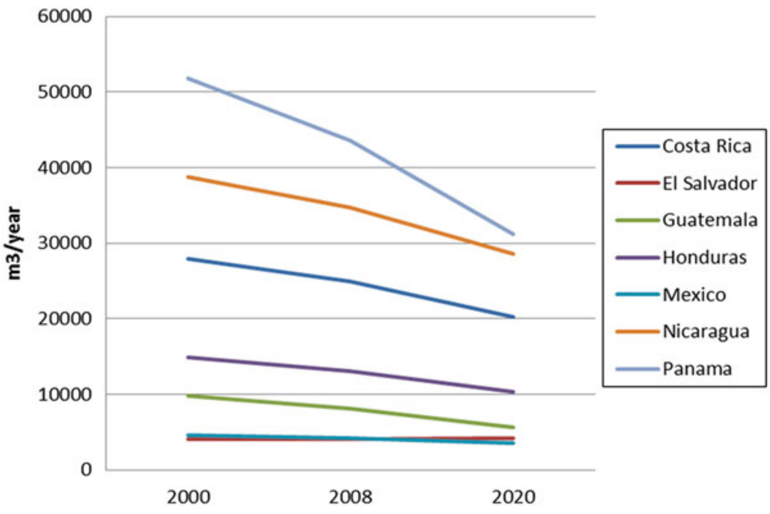
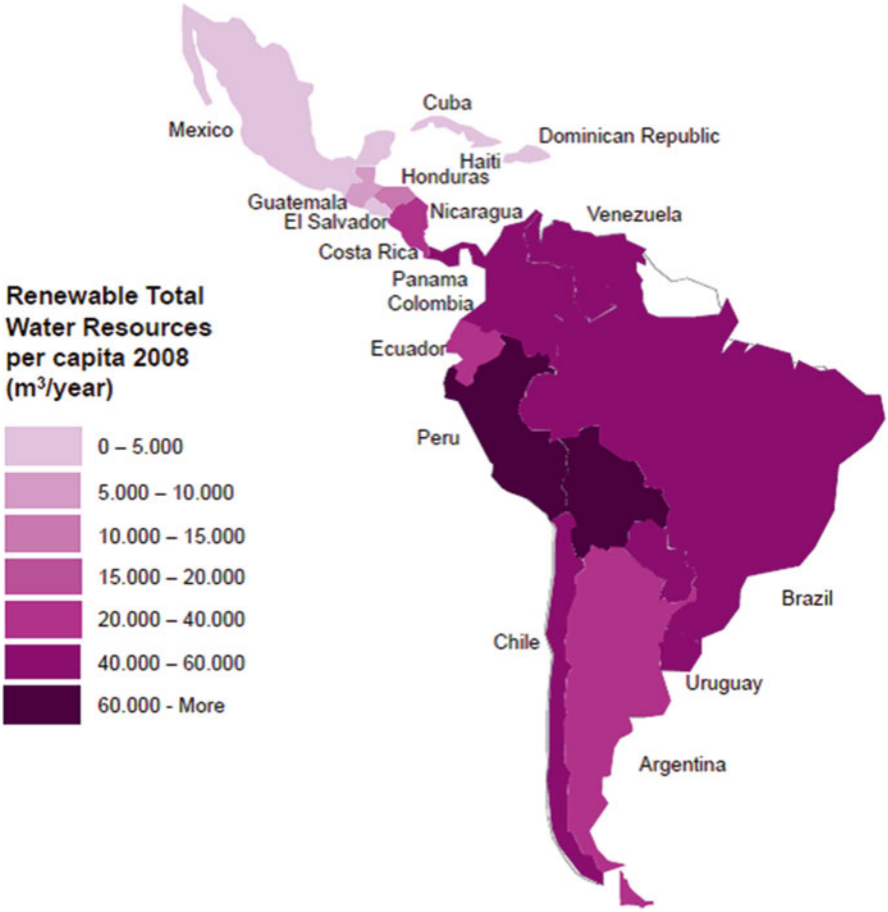




**Fig. 3.8** Central Cordillera and Mexican Plateau ecoregions: water availability per capita 2000–2020 (m³/year). Source: AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

# 5 Per Capita Water Availability in Latin America

Per capita water availability is higher in South America than in Central America, but this availability declines as you head north. Since South American countries have more water and more per capita availability, will an international collaboration mechanism be developed to provide freshwater from South America to Central America, or will water desalinization be the primary means of procuring water in the near term? The situation is even more complicated in the Caribbean countries, where water sources are even more limited and population pressures are growing steadily by the year. This lower water availability imposes limits on household economies and entrepreneurial economic growth, where water will become increasingly difficult or more expensive to find (Map 3.2).




**Map 3.2** Latin America: per capita water availability by country, 2013 ($m^3$/year). Source: AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

## 6 People and Water

In Latin America, even with a low correlation ratio, there is an important relationship between the per capita gross domestic product (GDP) and the per capita water availability, where a higher water availability means a higher per capita GDP. Even though this trend does not reflect a general rule for all countries, the distribution around the trend line is proportional. However, we will see cases that do not match the general trend, like Mexico and Argentina, countries that have low per capita water availability and some of the highest per capita GDP in the region. Countries like Bolivia and Peru, on the other hand, which have the highest per capita water availability in the region, still have a per capita GDP that is below average for the region (Fig. 3.9).

By analyzing the relationship between poverty and per capita water availability, which is another way to confirm the relationship between income and per capita water availability, we find that there is a relationship, though the correlation ratio is not that strong, showing a trend whereby lower per capita water availability means a higher poverty rate. Haiti has the lowest per capita water availability and the highest

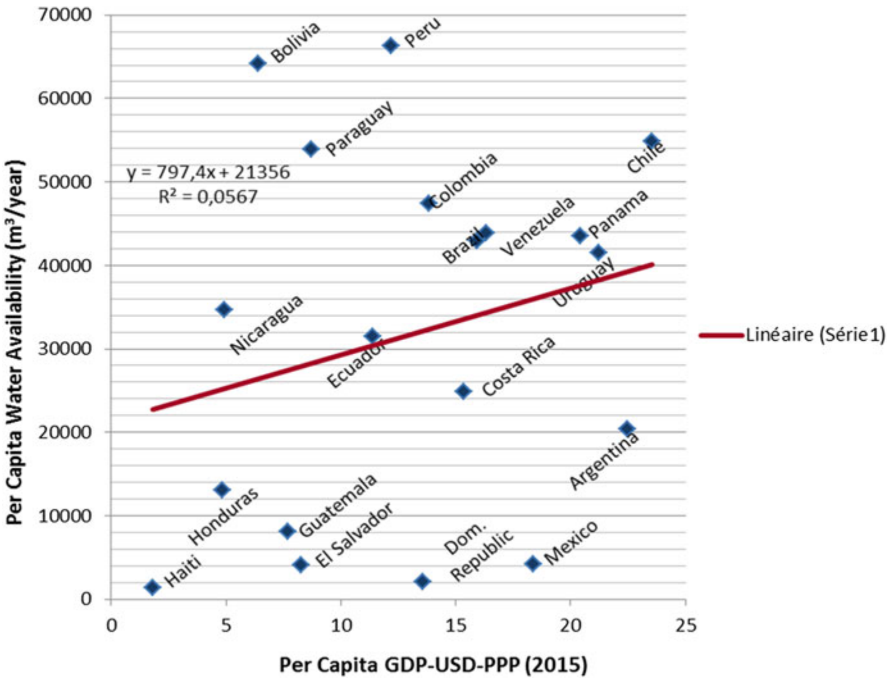



**Fig. 3.9** Latin America: links between per capita water availability and GDP per capita, 2015. Source: IMF – International Monetary Fund. 2015. World Economic Outlook, April 2015. Uneven Growth, Short and Long Term Factors. IMF, Washington, DC. Available at: http://www.imf.org/external/pubs/ft/weo/2015/01/pdf/text.pdf Reviewed on 29 September 2015. AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

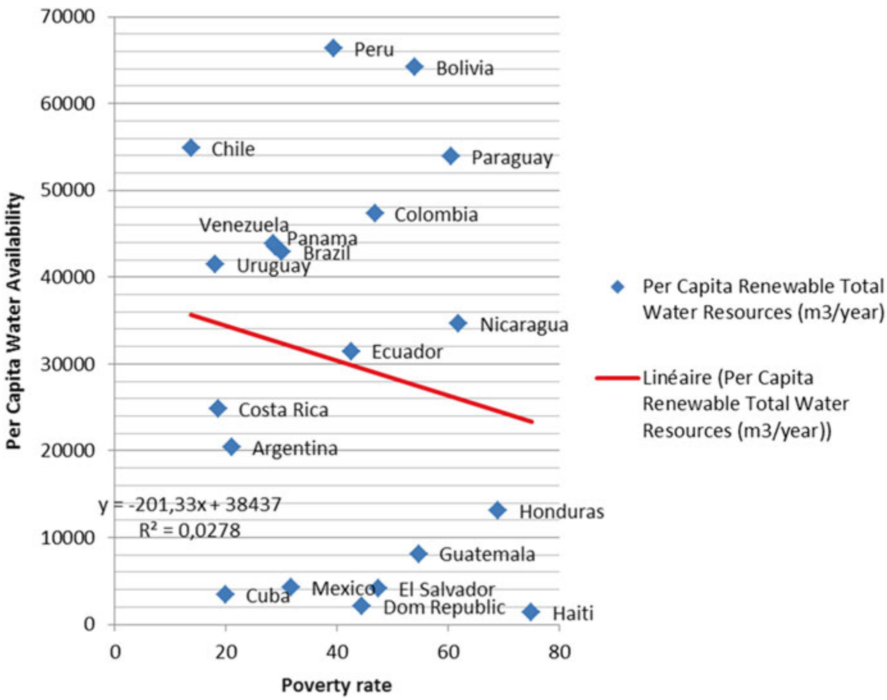



**Fig. 3.10** Latin America: links between poverty and per capita water availability ($m^3$/year), 2015. Source: CEPAL 2008. Panorama social de América Latina. Naciones Unidas, Santiago de Chile. Cuadro A1 p. 81 (edición en español World Water. 2013. Water availability by country, 2013 update. Available at: http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf Reviewed on 30 September 2015. Elaboration: Vladimir Arana

poverty rate. Though the trend may not hold in all countries, it captures the general tendencies in the relationship between poverty and water availability in the region (Fig. 3.10).

On the other hand the total volume of water in Latin American countries has a relationship with the per capita GDP, and even though the correlation is not that strong, the trend shows that the higher a country's water availability, the higher its per capita GDP. Brazil is a special case of this trend because it has by far the highest water availability in the region. Peru and Colombia, which have the next highest volumes of water after Brazil, are close to the average per capita GDP (Fig. 3.11).

On the other hand, water in Latin America is mostly used for agricultural producers versus for domestic or industrial purposes. On average, more than 72 % of the extracted water in the Latin American region is used for agricultural purposes. However, farmers in Latin America pay the least for their water. In Bolivia, Peru, and Uruguay, agricultural withdrawal is around 90 %, the highest in the region. Industrial withdrawal is less than 3 % in Bolivia, Dominican Republic, Panama, Peru, and Uruguay. Panama has more water used for domestic purposes, followed

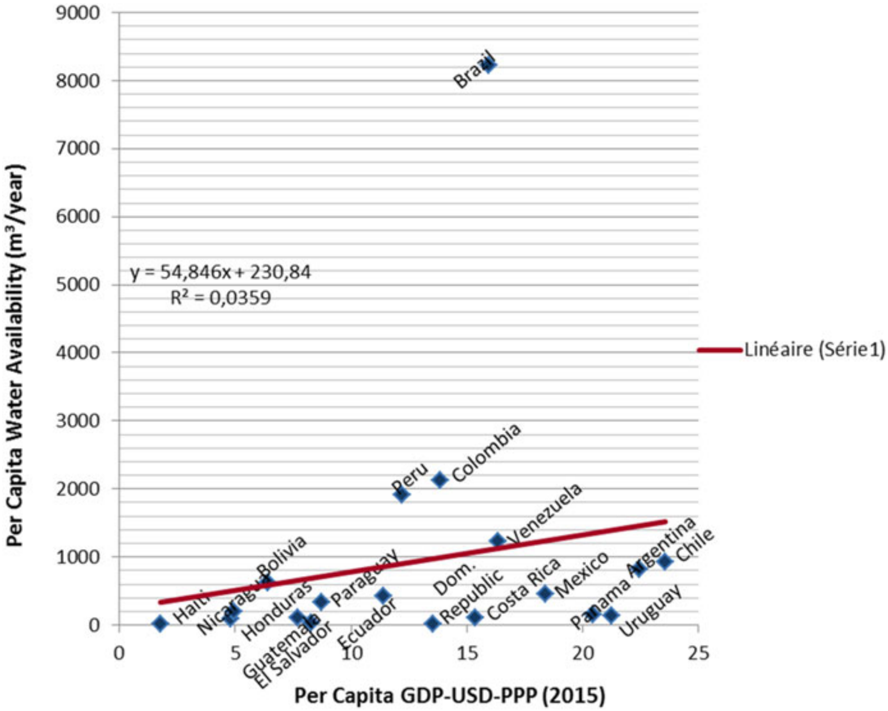



**Fig. 3.11** Latin America: links between countries' water availability and GDP per capita, 2015. Source: IMF – International Monetary Fund 2015. World Economic Outlook, April 2015. Uneven Growth, Short and Long Term Factors. IMF, Washington, DC. Available at: http://www.imf.org/external/pubs/ft/weo/2015/01/pdf/text.pdf Reviewed on 29 September 2015. World Water. 2013. Water availability by country, 2013 update. Available at: http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf Reviewed on 30 September 2015. Elaboration: Vladimir Arana

by Costa Rica and Cuba. Chile uses the least amount of water for domestic purposes, followed by Bolivia and Peru (Fig. 3.12).

Each Latin American country has its own water distribution policies and there is limited literature to explain how these policies were developed. Though most of the water in the region is used for agricultural purposes, some countries give most of their water to large entrepreneurial agricultural consortiums, while other countries give most of the water rights to individual farmers, especially indigenous communities. Individual farmers work mainly to sell their produce at local markets and use water less efficiently. In Latin America around 80 % of water is used for agricultural and industrial purposes and around 20 % for domestic purposes (Box 3.2).

In Latin America, agricultural activities strongly affect domestic water use. Analysis of the relationship between water withdrawal for agricultural and domestic usages reveals a negative correlation between agricultural and domestic water usages: greater water withdrawal for agriculture means lower water withdrawal for domestic

**Box 3.2** Latin America: average agricultural, industrial and domestic water withdrawal as percentage of total, 2013

| | Country name | Water withdrawal for domestic purposes (% of total) | Water withdrawal for industrial purposes (% of total) | Water withdrawal for agricultural purposes (% of total) |
|---|---|---|---|---|
| 1 | Argentina | 15.48 | 10.59 | 73.93 |
| 2 | Bolivia | 6.513 | 1.533 | 91.95 |
| 3 | Brazil | 23 | 17 | 60 |
| 4 | Chile | 3.576 | 13.39 | 83.04 |
| 5 | Colombia | 26.63 | 19.05 | 54.3 |
| 6 | Costa Rica | 32.34 | 11.06 | 56.6 |
| 7 | Cuba | 26.83 | 17.19 | 55.97 |
| 8 | Dom. Republic | 26.38 | 1.453 | 72.15 |
| 9 | Ecuador | 13.04 | 5.535 | 81.43 |
| 10 | Honduras | 19.6 | 7.094 | 73.3 |
| 11 | Haiti | 18.77 | 3.75 | 77.5 |
| 12 | Mexico | 14.25 | 9.066 | 76.69 |
| 13 | Nicaragua | 18.51 | 4.764 | 76.7 |
| 14 | Panama | 56.03 | 0.9643 | 43.01 |
| 15 | Peru | 9.18 | 2.116 | 88.73 |
| 16 | Paraguay | 15 | 6.382 | 78.62 |
| 17 | El Salvador | 22.38 | 10.06 | 67.56 |
| 18 | Uruguay | 11.2 | 2.186 | 86.61 |
| 19 | Venezuela, RB | 22.64 | 3.506 | 73.84 |
| | Average | 20.071 | 7.727 | 72.206 |

Source: World Bank. 2013. World Bank Open Data. Available at http://data.worldbank.org Reviewed on 29 September 2015. Elaboration: Vladimir Arana.

use. This correlation may indicate that the water withdrawal for agriculture is displacing the withdrawal for domestic purposes, which would mean that access to water was being relegated to prioritize agricultural use (Fig. 3.13).

Most Latin American countries use water for agricultural purposes, and agriculture as an activity contributing to GDP has several levels of importance. Water withdrawal for agricultural purposes is related to a higher participation of agriculture in the GDP, so higher water withdrawal for agriculture is associated with higher participation of the agricultural sector in the GDP. However, there are countries, like Chile and Mexico, that have high rates of water withdrawal for agriculture but the lowest contribution of agriculture to GDP. On the other hand, Paraguay and Nicaragua use the same percentage of water for agricultural withdrawal, but those countries' agricultural sector contributes around four times

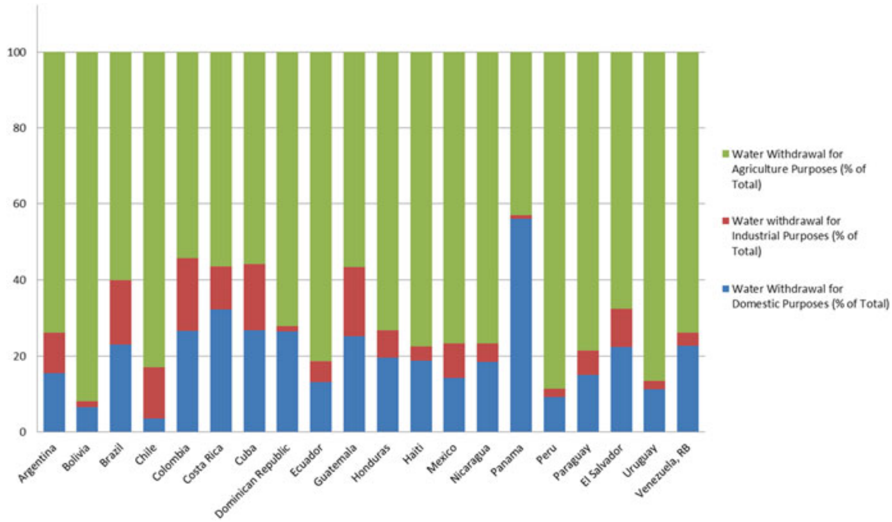



**Fig. 3.12** Latin America: agricultural, industrial and domestic water withdrawal as percentage of the total, 2013. Source: World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed on 29 September 2015. Elaboration: Vladimir Arana

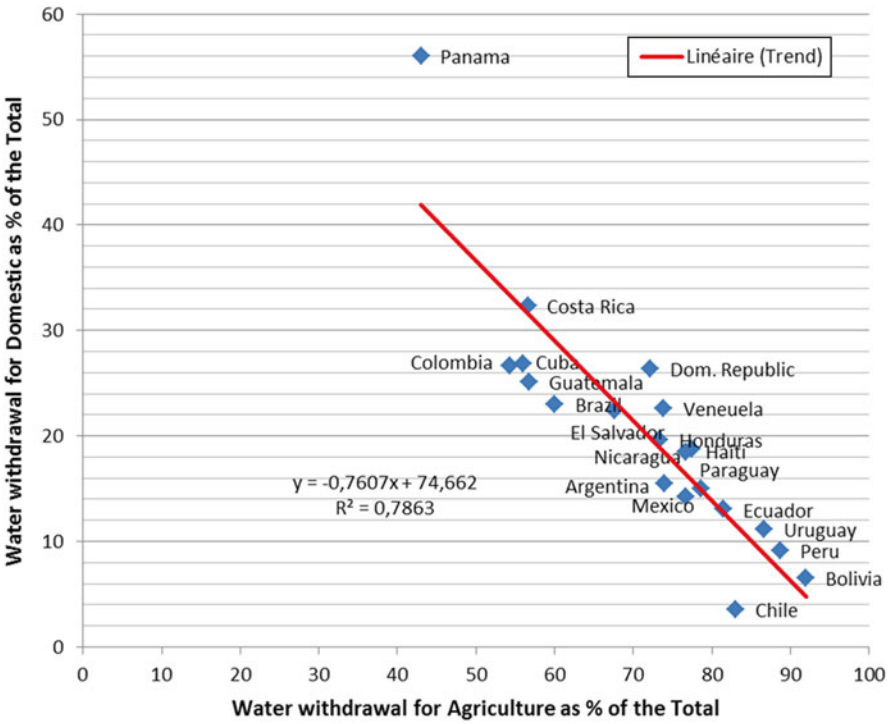



**Fig. 3.13** Latin America: links between water withdrawal for agriculture and water for domestic purposes, 2013. Source: World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed on 29 September 2015. Elaboration: Vladimir Arana

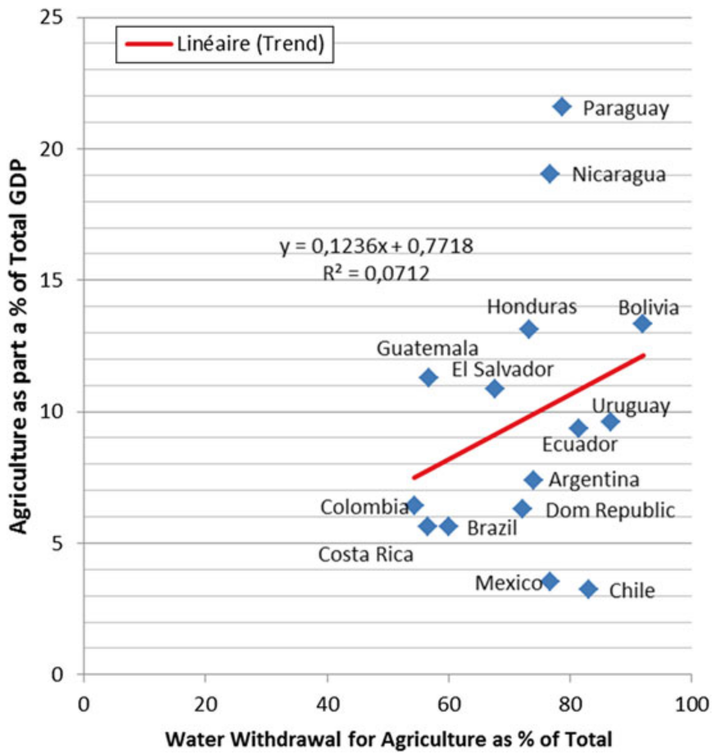



**Fig. 3.14** Latin America: links between water for agricultural withdrawal and contribution of agricultural sector to GDP, 2013. Source: World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed on 29 September 2015. Elaboration: Vladimir Arana

more to GDP than the same sector in Chile and Mexico contributes to its respective countries' GDP (Fig. 3.14).

## 7 Climate Change and Water

The Fourth Assessment Report submitted by the IPCC states that the $CO_2$ concentration in the atmosphere has risen to 379 ppm, an amount never reached in the last 650,000 years of our planet's history. Also, the concentration of methane and nitrous oxide has increased, sea level is 17 cm higher than in the early twentieth century, and the temperature is 0.7 °C degrees higher than in 1850. This report also states that as a consequence of these changes precipitation has increased in different regions; there are more droughts in the tropics and the subtropics, and the frequency of precipitation has increased as well. These conditions will impact agriculture, health, water availability, and general habitability on Earth (Honty 2007).

Some of the effects of climate change in Latin American countries include glacial retreat; increasingly lower water levels leading to a reduction in water availability for human consumption, agricultural, industrial, and energy generation uses; an increment of floods caused by sea level rise; phytoplankton reduction and, consequently, a diminished level of fishing yields and fishing resources; savannization of tropical forests as a consequence of the loss of soil water; and a loss of biodiversity and species extinction (Vargas 2008).

On the other hand, climate change will have an important impact on water supply systems, altering water supply infrastructure reliability by, for instance, weakening the quality and security of reservoirs and reducing water treatment and water distribution capacities, especially during peak hours (Arnell and Delaney 2006). It is important to clarify that climate change creates water shortages on the so-called supply side, which means less water availability from sources or aquifer recharges, rather than from the demand side, meaning a weak capacity to treat or distribute water during peak hours.

Latin America as a whole produces around 8 % of total global emissions, a very low percentage considering the size of the population and geographical extent of the area. This figure is even lower if we consider just energy sector emissions. Most of the greenhouse gases (GHG) from Latin America come not from the energy sector but from the burning of fossil fuels, deforestation, and agriculture. A UNEP report explains that the increment of the intensity and frequency of hurricanes in the Caribbean, changes in precipitation patterns, the rise of sea levels in Argentina and Brazil, and the retreat of glaciers in Patagonia and the Andes are phenomena that indicate the impact that global warming could have in the region (PNUMA-SEMARNAT, 2006). However, potential future impacts of climate and land-use changes could be severe and costly for this region. In addition, the release of carbon into the atmosphere as a consequence of massive and continued deforestation in Latin America would have the potential to alter the global carbon balance. On the other hand, some studies suggest that technologically simple adaptations could improve the capacity for carbon sequestration, as well as economic productivity, in some ecosystems (IPCC 2007a, b).

The countries most vulnerable to hydrometeorological phenomena are in the Caribbean Basin, but other regions are particularly vulnerable, including northeastern Brazil, the Peruvian and Chilean desert coasts, arid zones of Argentina that show important changes in rainfall patterns, and countries in the Andean region that show glacial retreat (Honty 2007).

Temperature changes are unpredictable, but somewhat of a trend can be observed in various phenomena. A look at the different countries' average temperature in aggregate and the per capita GDP reveals a trend whereby lower temperatures are linked to higher per capita GDP; of course, this does not hold for all parts of the Latin American region, but the correlation is relatively strong and may indicate that future rises in temperatures in the Latin American region may negatively impact per capita GDP there (Fig. 3.15).

On the other hand, it can be observed, with a lower correlation, that, regarding the relationship between countries' average temperature and per capita water avail-

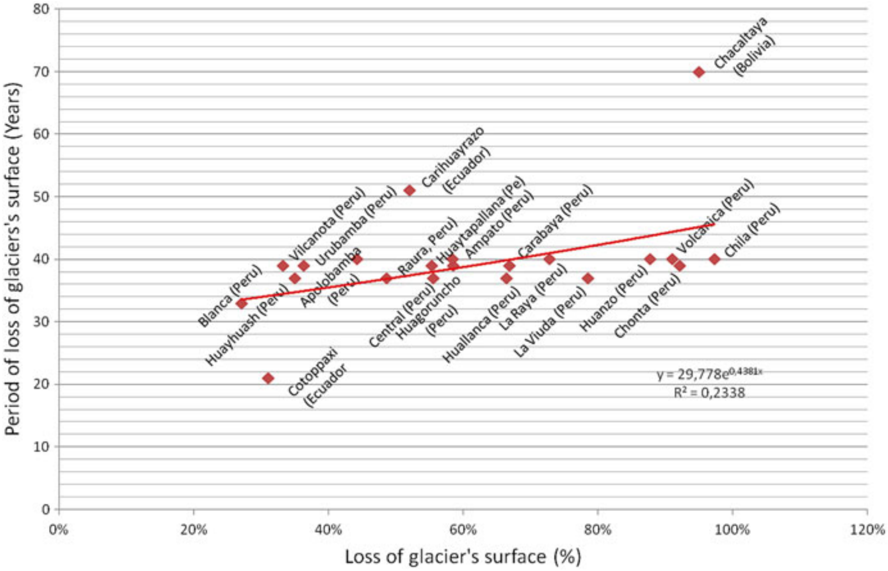



**Fig. 3.15** Latin America: links between countries' average temperature and GDP per capita, 2015. Source: IMF – International Monetary Fund 2015. World Economic Outlook, April 2015. Uneven Growth, Short and Long Term Factors. IMF, Washington, DC. Available at: http://www.imf.org/external/pubs/ft/weo/2015/01/pdf/text.pdf Reviewed on 29 September 2015. World Bank. 2011. World Bank Open Data. Available at: http://data.worldbank.org/data-catalog/cckp_historical_data Reviewed on 29 September 2015. Elaboration: Vladimir Arana

ability, countries with lower temperatures see a higher per capita water availability. This might mean that future temperature rises will be accompanied by reductions in per capita water availability (Fig. 3.16).

The regional climate distribution is defined by interactions among the predominant atmospheric circulation patterns and the region's topographical features, radiation budgets, and heat and water balances, which in turn depend on the vast range of soil/vegetation types of the region. The extensive central portion of Latin America is characterized largely by humid, tropical conditions; important areas, like Brazil, are subject to drought, floods, and freezes. Atmospheric circulation and ocean currents are causal factors of extensive deserts in northern Mexico, Peru, Bolivia, Chile, and Argentina.

The relationship between the El Niño Southern Oscillation phenomenon and changes in precipitation and temperature is well documented for countries of the Central American isthmus and South America. El Niño events associated with

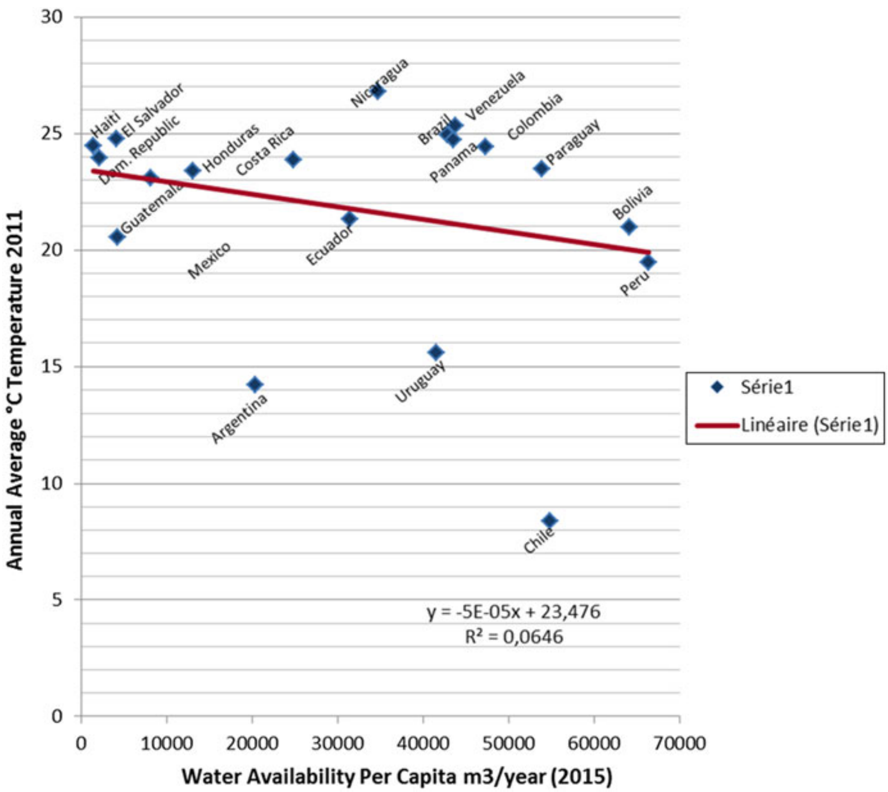



**Fig. 3.16** Latin America: Links between annual average temperature and per capita water availability, 2015. World Bank. 2011. World Bank Open Data. Available at: http://data.worldbank.org/data-catalog/cckp_historical_data Reviewed on 29 September 2015. AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

massive fluctuations in the marine ecosystems off the coasts of Ecuador, Peru, and northern Chile (home to some of the richest fisheries in the world) would have adverse socioeconomic consequences on fishing and fishmeal production. Experimental El Niño forecasts have been applied, with remarkable success, in Peru and Brazil to reduce economic disruptions in agriculture. Climate variability also leads to important changes in the distribution and intensity of rainfall and snow. This variability represents an additional stress on already limited freshwater availability in Chile and western Argentina. Latin American forests, which depend on water, occupy approximately 22 % of the region, and represent about 27 % of global forest coverage, have a strong influence on local and regional climate, play a significant role in the global carbon budget, account for an important share of all plant and animal species of the region, and are economically vital for national and international markets. Vulnerability studies indicate that forest ecosystems in many countries (e.g., Mexico, countries of the Central American isthmus, Venezuela, Brazil, Bolivia) could be affected by projected climatic changes. Deforestation in the Amazon rainforest is likely to have a negative impact on the recycling of precipitation through evapotranspiration. Rainfall would be markedly reduced, leading to important runoff losses in areas within and beyond this basin (IPCC 2007a, b).

Mountain ranges and plateaus play an important role in determining Latin America's climate, hydrological cycle, and biodiversity. They are source ecoregions of massive rivers, like the tributary rivers of the Amazonas and Orinoco basins, represent important central points of attention for biological diversification and endemism, and are highly susceptible to extreme events. The Latin American territories where water can be found in its solid form are represented by glaciers in the high Andes and three major ice fields in southern South America. Warming in high mountain regions will lead to the disappearance of significant snow and ice surfaces, in other words, the Latin American water stock will disappear.

It has been demonstrated that there is an important interdependency between deglaciation and the El Niño Southern Oscillation (ENSO), where temperature increase had a direct relationship in the 10- to 20-year series of the Zongo, Uruashraju, and Yanamarey glaciers. "The analysis, in parallel, of temperatures and precipitation provided evidence that temperature increases in the Andes Cordillera were largely dependent on the ENSO phenomena and on the evolution of tropical glaciers, which is marked by a fast retreat of ice on these highlands, where the ENSO events had a major influence" (Francou et al. 1995)

Other information that corroborates the trend toward exponential deglaciation in the region, and especially in Peru, is explained by the loss of glacial surfaces in Ecuador, Peru, and Bolivia (Vuille et al. 2007). Important information that confirms the deglaciation trends in South America is the analysis of the loss of glaciers' surface in the past seventy years. What can be concluded in this observation is that there is a strong positive trend towards deglaciation and that most of the 21 water towers analyzed in this trend have lost so far more than 50 % of the glaciers' surface in a period of approximately 70 years (Fig. 3.17).

The cost of climate change adaptation measures with respect to the water supply and sanitation sector in Latin America has not been calculated. However, more that 50 % of the population (poor people) will be seriously affected, and governments have not yet identified clear adaptation measures to provide the most basic resource that people will need in the event of a catastrophe: drinking water (Fig. 3.18).

By the 2020s, the net increase in the number of people subject to water stress as a result of climate change will likely be between 7 and 77 million (medium level of confidence), whereas in the second half of the century, the potential water availability reduction and the increasing demand from an increasing regional population could increase these figures to between 60 and 150 million (Magrin et al. 2007).

Two important factors that depend on climate change – forest cover, which can be measured as a percentage of a country's total area, and per capita water availability – are strongly related. Thus, the higher the per capita water availability, the greater the forest cover in a country. Thus, any effects of global warming in the region would show up in both water resource availability and forest cover (Fig. 3.19).

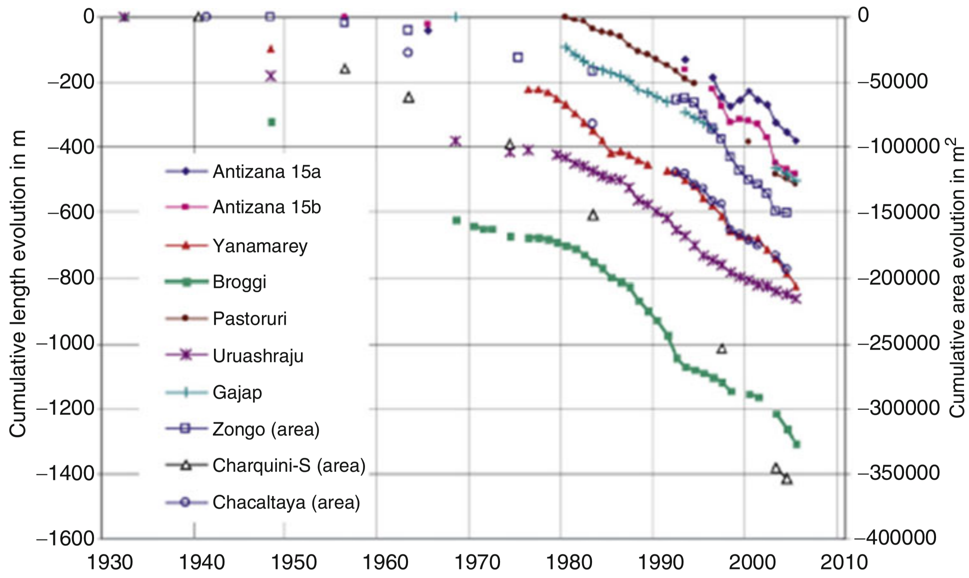



**Fig. 3.17** Andean Ecoregion: Loss of 21 glaciers' surface trends 1940-2010. Sources: ANA. 2014. Inventario de glaciares y lagunas de Peru. ANA, Lima. Caceres, Bolivar. 2010. Actualizacion del inventario de tres casquetes glaciares del Ecuador. IRD-Université Nice, available at http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers11-10/010052702.pdf Accessed on September 30th, 2015. Feldman, Stacy. 2009. Bolivia's Chacaltaya Glacier Melts to Nothing 6 Years Early. Inside ClimateNews, New York. Available at http://insideclimatenews.org/news/20090506/bolivias-chacaltaya-glacier-melts-nothing-6-years-early Accessed on September 30th, 2015. Elaborated by: Vladimir Arana

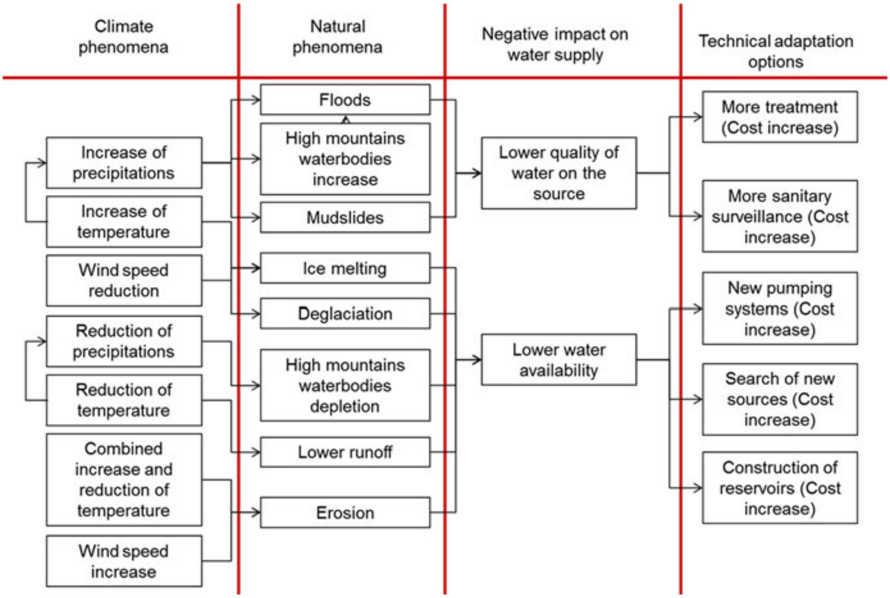



**Fig. 3.18** Latin America: impacts of climate change on water supply. Source: Arana, Vladimir. 2011a. Cities vulnerability in water supply and sanitation to address climate change. SURP, Lima. Available at: http://sinia.minam.gob.pe/modsinia/index.php?accion=verElemento&idElementoInformacion=1060&verPor=tema&idTipoElemento=2&idTipoFuente=. Reviewed on 30 September 2015

Major sectors in which the impacts of climate change could be important include natural ecosystems (e.g., forests, rangelands, and wetlands), water resources, coastal zones, agriculture, and human health. The relative importance of each of these projected impacts varies among countries.

## 8 Virtual Water

Latin America and the Caribbean's (LAC) gross virtual water export to the rest of the world, related to agricultural and industrial products, was 277 billion $m^3$/year (88 % green, 6 % blue, and 6 % gray) in the period 1996–2005. The virtual water export was dominated by five major products, contributing slight more than three-quarters of the total virtual water exports from LAC to the rest of the world. Soybean accounts for the largest share of virtual water export (36 %), followed by coffee (14 %), cotton (10 %), livestock products (10 %), and sugarcane (8 %). The water footprint of these major export products was largely based on rainwater: soybean (99 % green water), coffee (94 %), cotton (62 %), livestock products (92 %), and sugarcane (87 %). The gross virtual water import by LAC from the rest of the world, related to the importation of agricultural and industrial products, was 165 billion $m^3$/

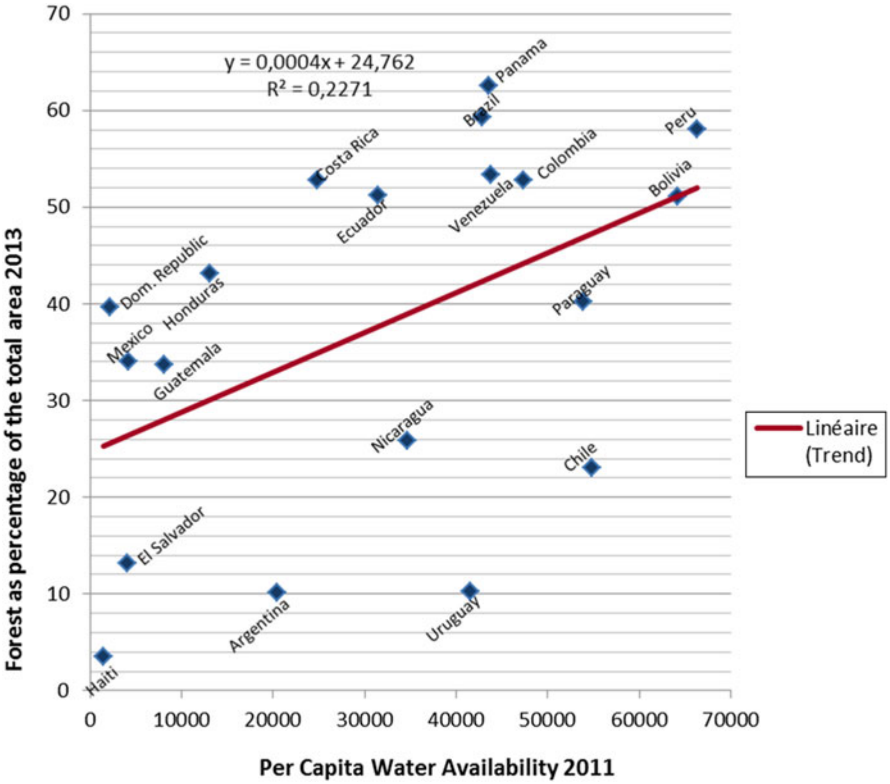



**Fig. 3.19** Latin America: links between forest cover and per capita water availability, 2013. World Bank. 2011. World Bank Open Data. Available at: http://data.worldbank.org/data-catalog/cckp_historical_data Reviewed on 29 September 2015. AQUASTAT, FAO 2015. Elaboration: Vladimir Arana

year (63 % green, 20 % blue, and 17 % gray). The largest share of virtual water imports relates to the import of cotton products (42 %) (mainly from the USA and Pakistan), followed by wheat (12 %) (mainly from the USA and Canada) and livestock products (11 %) (mainly from the USA). About 54 % of total virtual water imports goes to Mexico. About 50 % of the total virtual water imported to LAC related to crops, 83 % related to livestock, and 47 % related to industrial products (Mekonnen et al. 2015).

## 9 Conclusions

South America contains important volumes of water in basins; in fact, this region holds most of the water in Latin American, but the per capita renewable total water resources are gradually diminishing. This confluence of scenarios – water availability in basins and reduction of per capita water availability – is sending a message to governments that new alternatives must be sought to optimize basin performance and biophysical dynamics, new water sources must be found, and water losses must be reduced and consumption minimized.

Latin America holds around 33 % of the world's runoff, and water sources are concentrated in the Andean and Amazon ecoregions. Countries that have low water availability while at the same time severe dependencies and high poverty rates must urgent identify new structural options to prevent critical water stress.

The World Bank has elaborated a ranking of countries' water consumption uses and freshwater availability in billions of cubic meters (World Bank 2011). This does not necessarily mean that there is a reliable supply of drinking water. For example, Brazil has the highest level of water availability at around 5.418 billion $m^3$. At the same time, this country, with its important water reserves and with more than 13 % of the planet's freshwater, is home to more than 57 million people without potable water. Canada follows Brazil with 9 % of the world's freshwater and renewable resources, which large consist of underground water (Capital 2010).

Bolivia and Peru, although they will suffer the most serious loss of glaciers or water stocks in the region, will maintain the highest per capita water availability. This per capita primacy is relative and depends to a great extent on how the relationships between population and water reserves unfold and how economic activities develop, especially in emerging economies, because new investments will require ever more water and energy. However, in Latin America, "analysis shows that macroeconomic planning and economic development strategies cannot be done in an isolated way without considering the natural resources contractions. The natural capital is incrementally the natural factor for development, and any economic development investment has to seriously consider these contractions" (Blignaut and Van Heerden 2009).

It is one thing is to have water resources; it is quite another thing to access those resources. Latin American countries, because of their topography and geography and the large distances of their population and economic centers from water sources and headwaters, going forward will find it ever more costly to extract, treat, and distribute water for human consumption. This could explain why a country like Brazil, which has the highest volume of water reserves, suffers serious water deficits (WHO, UNICEF 2012).

Many causes explain the reduction in per capita water resources, and such an important subject deserves specialized research. Nevertheless, it can be noted that pollution and climate change are generally recognized by experts as the principal causes of per capita water availability shortages, and the situation is even more serious now as competition heats up for water resources, raising the specter of social unrest, and restrictions on these resources are being put in place. The Latin American region is now experiencing remarkable economic growth, which is putting more pressure on water resources. Agricultural use may be displacing water allocations for domestic purposes, and it may also be a contributor to water stress in urbanized areas. These situations demand specific public policies that would allow for the conservation of water resources, infrastructure enabling the efficient use of these resources, and a fair distribution of water.

Latin America will see its water resources, both quantitatively and qualitatively, affected by climate change, which will create scarcity in some countries and natural disasters in others. This phenomenon will require more broad-based research on the causes of water depletion and the alternatives for dealing with each specific case in each country, as well as feasibility studies that would attract investments to facilitate each country's adaptation to the new world of water scarcity and stress. In addition, the increment of temperature may negatively affect the countries' per capita GDP and per capita water availability.

Latin American water stocks are showing a trend toward depletion, especially in the Andes ecoregion, and this will affect the entire productivity dynamic and life support conditions of the region. Water stocks, water towers, or glaciers are disappearing at a fast rate, and these losses will be irreversible. Most Latin American countries' populations live in shared basins, which implies a stronger competition for water and may suggest a need to design new coordinated transboundary water use mechanisms.

Latin America exports large amounts of water abroad, and still the economic conditions in Latin American countries need to be improved. Latin America is the breadbasket of many other countries, and still a large segment of the population lives below the poverty line and does not have access to a reliable water supply or sanitation.

It is very difficult to obtain up-to-date information about water availability and management that may allow citizens and civil society, agencies, volunteers, and universities to participate in the elaboration and implementation of wide collaborative projects to improve water availability, including the monitoring of basins and ecoregions to generate water resources. Water stress will appear in the medium term in urbanized Latin American areas where populations will settle far from water sources and where poverty is becoming entrenched. Since the issue of water resources is a common one for many Latin American countries, it could generate multinational investment and opportunities to improve water resource production and management.

# Chapter 4
# Water Supply, Sanitation, Energy, and Industrial Constraints

Water coverage is an indicator that shows how many people have access to drinking water. However, this indicator depends on whether the water supply is delivered through pipes, on whether it comes from an improved or unimproved source, and on the quality and safety. In urban environments water is usually delivered through pipes, while in rural areas water may go through pipes in small towns, but it could also be supplied in canals if families obtain their water independently.

For the poorest, water has become the most important subject in the family expenditure structure, especially when water does not go straight to the home and the family must buy it from an intermediate provider, which increases the cost depending on the distance, competitiveness, and quality, or when family members must walk several kilometers to obtain the water. The situation in every country is different, and the rural water supply and sanitation have particular features depending on the local technical capacity, resource availability, political will, and management efficiency.

This chapter reviews the state of water, sanitation, and energy consumption and how they are related to poverty, economic growth, and other factors that determine their interdependency. The situation is different in every country, but Latin American countries as a whole share certain tendencies that in some cases are very strong and may define Latin American water trends in the coming years.

The World Health Organization (WHO) uses four classifications for water supply: (1) piped into premises, (2) other improved source, (3) other unimproved source, and (4) surface water (WHO-UNICEF 2015). These four classifications do not ensure that water is safe, constant, or with adequate pressure. The classification piped into premises could mean that the infrastructure is well placed and connected to a network that may ensure clean and safe water. However, this infrastructure depends on water treatment plants that have a limited treatment capacity. It has been the case in some cities that water sources were saturated with suspended particulate matter and polluters and treatment plants did not have the capacity to filter everything out, so dirt and pollutants pass through the sanitary network and easily arrive at the residential dwellings. Other improved sources, other unimproved sources, and surface water may not ensure the quality of water or may even be the source of diseases.



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In the case of sanitation, WHO also uses four classifications: (1) improved facilities, (2) shared facilities, (3) other unimproved, and (4) open defecation (WHO-UNICEF 2015). The first one – improved facilities – shows an appropriate sanitation infrastructure, but the other three do not represent appropriate sanitation services. Shared sanitation facilities are risky because poor people without services and with contagious diseases can transmit these diseases through shared sanitation facilities. Unimproved facilities could also be risky to local public health and to the environment, while open defecation affects human and animal health and the environment. In this research, water supply piped into premises and improved sanitation facilities are simply considered infrastructure that is available to people, and the correlations and analysis are based on the data provided mostly by WHO, the UNICEF Joint Program, and the World Bank.

The analysis is organized by ecoregion, and then several correlations related to Latin America as a whole are presented. These different approaches to considering the data demonstrate different dynamics and make it possible to sketch out some important conclusions.

In Latin America, wastewater usually ends up at treatment plants and in a larger proportion to oxidation ponds, a technology, stongly promoted during the sixties. However, this last wastewater treatment technologies was widely used in the highlands where solar radiation is low and where rain and cold weather are common phenomena, so they failed. In rural areas, especially in the Andes and in the Amazon, dry pit latrines were once used as a common technology at the family scale. In the Amazon, these kinds of latrines failed since the abundant rainfall would flood the region and cause waste to float and disperse during the rainy season. A key objective of communities located in rainy, higher areas is to prevent sanitary disasters during the rainy season.

In Latin American cities, industrial and domestic wastewater are in many cases sent directly to water bodies that subsequently feed water treatment plants that produce drinking water for larger populations or that will serve as a source of drinking water for populations located downstream. In Latin America, companies and other people engaged in economic activities also dispose of their wastewater using the sanitation infrastructure, greatly increasing the level of pollutants being carried away by the sanitation infrastructure, which finally arrives at wastewater treatment plants designed to treat domestic sewage. Only a few countries in Latin America have imposed limits on the amount of pollutants industrial companies and other kinds of enterprise can dispose of in urban sanitation facilities. Polluters that exceed these limits pay more since their excess pollution causes an accelerated degradation of the sanitation facilities and makes sewage treatment more expensive. This should not be seen as a hindrance to private investment but as the preservation of common infrastructure.

# 1 Access to Urban and Rural Drinking Water and Sanitation in the Andean Ecoregion

## *1.1 Ecuador*

Ecuador is witnessing a significant increase in urban water supply coverage, and special, but insufficient, attention has been given to rural water supplies, which increased from 24 % in 1990 (WHO, UNICEF 2012a) to 72 % in 2015, reaching 93 % urban water supply coverage in 2015 (WHO, UNICEF 2015). Ecuador may close the urban water supply gap in 3 to 5 years while in rural areas the gap is still 32 %. Still, 15 % of the rural population get their water directly from the surface (WHO, UNICEF 2015).

Urban sanitation in Ecuador is improving, going from 86 % in 1990 (WHO, UNICEF 2012a) to 87 % in 2015 (WHO, UNICEF 2015) and in rural areas it has gone from 48 % in 1990 to 84 % in 2010 (WHO, UNICEF 2015) and 81 % in 2015 (WHO, UNICEF 2015). In 2015 11 % of the rural population still had to practice open defecation, contributing to health insecurity and environmental pollution. Poverty in Ecuador, especially in rural areas, is pervasive and is demonstrated by a lack of sanitary services in rural areas (Fig. 4.1).

## *1.2 Colombia*

Colombia reduced its urban water supply coverage from 98 % in 1990 to 92 % in 2010 (WHO, UNICEF 2012b), raising the indicator again to 94 % in 2015, while the rural water supply for the same year was around 68 % (WHO, UNICEF 2015). In

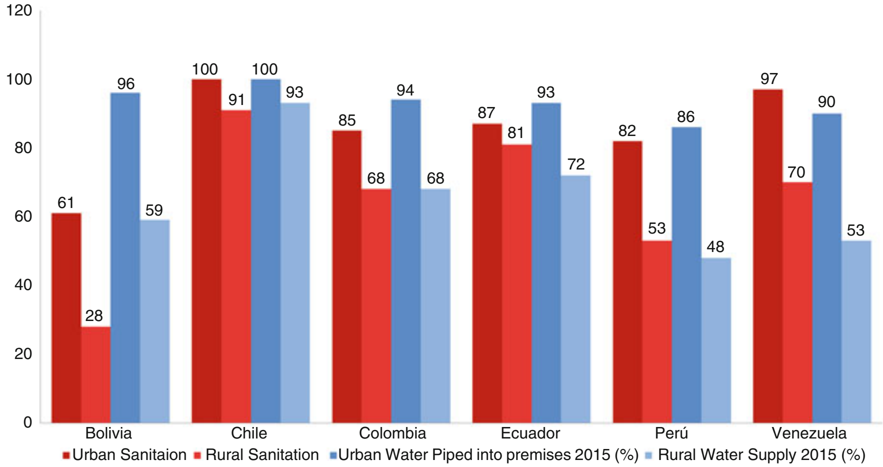


**Fig. 4.1** Andean ecoregion: urban and rural piped water supply and sanitation, 2015. Source: WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

2010, it was noticed that more people in rural areas were taking their water directly from the surface, which increased the risk of exposure to disease. The explanation given for this was that permanent rural migration was taking place owing to insecurity and terrorism, so families were settling wherever they could. At this time, 19 % of rural families took water directly from the sources (WHO, UNICEF 2015).

Colombia reduced its sanitation gap from 82 % in 2010 (WHO, UNICEF 2012b) to 85 % in 2015 (WHO, UNICEF 2015), and in rural areas the gap went from 63 % in 2010 (WHO, UNICEF 2012b) to 68 % in 2015 (WHO, UNICEF 2015). An alarming statistic is that 14 % of the rural population must still practice open defecation.

## *1.3 Venezuela*

Venezuela increased its urban water supply coverage from 87 % in 1990 to 90 % in 2005 (WHO, UNICEF 2012c) and in 2015 it maintained 90 % (WHO, UNICEF 2015). Rural water supply coverage went from 44 % in 1990 to 52 % in 2005 (WHO, UNICEF 2012c) and to 53 % in 2015 (WHO, UNICEF 2015), so Venezuela may soon close its rural water supply gap.

On the other hand, urban sanitation coverage went from 71 % in 2007 to 97 % in 2015 (WHO, UNICEF 2015), while rural sanitation went from 48 % in 2007 (WHO, UNICEF 2012c) up to 70 % in 2015 (WHO, UNICEF 2015). Venezuela's per capita GDP is above average but its rural sanitation level is low.

## *1.4 Peru*

Peru has made important progress in water supply coverage in urban areas, going from 74 % in 1990 to 83 % in 2010 (WHO, UNICEF 2012d), while in 2015 it reached 86 % (WHO, UNICEF 2015). In rural areas water supply coverage went from 13 % in 1990 to 46 % in 2010 (WHO, UNICEF 2012d) and to 48 % in 2015 (WHO, UNICEF 2015). On the other hand, surface water collection fell from 27 % in 1990 to 16 % in 2010 (WHO, UNICEF 2012d) and to 15 % in 2015 (WHO, UNICEF 2015).

On the other hand, urban sanitation coverage reached 81.9% in 2012, while in rural areas it rose to 21.3 % (Cornejo 2012). In 2015, urban sanitation coverage reached 82 % and in rural areas to 53 % (WHO, UNICEF 2015).

## *1.5 Bolivia*

Urban and sanitation coverage has also expanded in Bolivia. In urban areas water supply coverage went from 78 % in 1990 (WHO, UNICEF 2012e) to 96 % in 2015 (WHO, UNICEF 2015). In rural areas water supply coverage went from 14 % in

1990 (WHO, UNICEF 2012e) to 59 % in 2015 (WHO, UNICEF 2015). Through improvements in water supply coverage the collection of water directly from open sources has decreased from 42 % in 1990 (WHO, UNICEF 2012e) to 20 % in 2015 (WHO, UNICEF 2015). However, 20 % still represents a significant percentage of the population that does not have access to safe water. Major investments in infrastructure at all levels of government will be required to make even more progress in this area.

Regarding sanitation, in 2010, Bolivia's coverage was 35 % in urban areas and 10 % in rural areas (WHO, UNICEF 2012e). In 2015, urban sanitation was 61 % and in rural areas 28 %, while open defecation was around 46 %, one of the highest in the region (WHO, UNICEF 2015).

### *1.6 Chile*

In 2010, Chile had an urban water supply coverage of 99 % and rural coverage of 47 % (WHO, UNICEF 2012f). In 2015, it closed the urban water supply gap, reaching 100 %, while in rural areas the water supply coverage leapt to 93 % (WHO, UNICEF 2015). In 2010 the country eliminated the taking of water from the surface.

With respect to sanitation, since 2010 Chile has exercised important management of its effluents, reaching urban sanitation levels of 98 % (WHO, UNICEF 2012f), and in 2015 it eliminated the gap, reaching 100 % in that year (WHO, UNICEF 2015). In rural areas sanitation coverage went from 83 % in 2010 (WHO, UNICEF 2012f) to 91 % in 2015 (WHO, UNICEF 2015). Chile has the highest GDP in the region, but other countries with lower incomes have higher rural sanitation levels.

## 2 Access to Urban and Rural Drinking Water and Sanitation in Amazon Ecoregion

The Amazon ecoregion includes mostly Brazil and parts of Bolivia, Colombia, Peru, and Venezuela (Fig. 4.2).

### *2.1 Brazil*

Brazil has made modest increases in its water supply coverage since 1990, going from 93 % in that year to 96 % in 2010 (WHO, UNICEF 2012g) and to 98 % in 2015 (WHO, UNICEF 2015), that is to say, the country increased its urban water supply

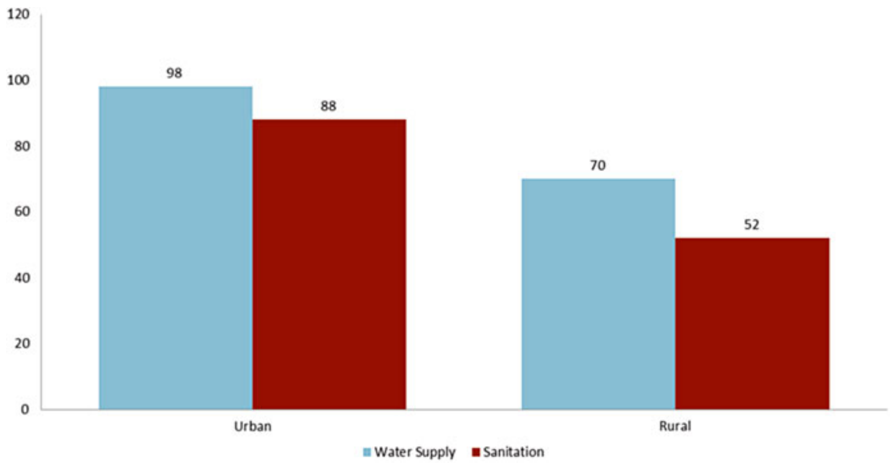


**Fig. 4.2** Amazon ecoregion: urban and rural piped water supply and sanitation, 2015. Source: WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

coverage by just 5 % over the course of 25 years. The rural water supply coverage went from 40 % in 1990 to 65 % in 2010 (WHO, UNICEF 2012g) and to 70 % in 2015 (WHO, UNICEF 2015), a 30 % increase in 25 years.

In urban sanitation, the country went from 85 % coverage in 2010 (WHO, UNICEF 2012g) to 88 % in 2015 (WHO, UNICEF 2015). In rural areas sanitation coverage went from 44 % (WHO, UNICEF 2012g) to 52 % in 2015 (WHO, UNICEF 2015).

# 3 Access to Urban and Rural Drinking Water and Sanitation in Dry Chaco and Paraná-La Plata Ecoregions

This section combines data from the Dry Chaco ecoregion, mainly Paraguay, and the Paraná-La Plata ecoregion, mainly defined by Argentina and Uruguay (Fig. 4.3).

## *3.1 Paraguay*

In Paraguay, the urban water supply coverage went from 59 % in 1990 to 85 % in 2010 (WHO, UNICEF 2012h) and to 93 % in 2015 (WHO, UNICEF 2015). The rural water supply coverage went from 0 % in 1990 to 35 % in 2010 (WHO, UNICEF 2012h) and 68 % in 2015 (WHO, UNICEF 2015). Paraguay's efforts have focused on reducing surface water access, which went from 12 % in 1990 to 4 % in 2010 (WHO, UNICEF 2012h) and 0 % in 2015 (WHO, UNICEF 2015).

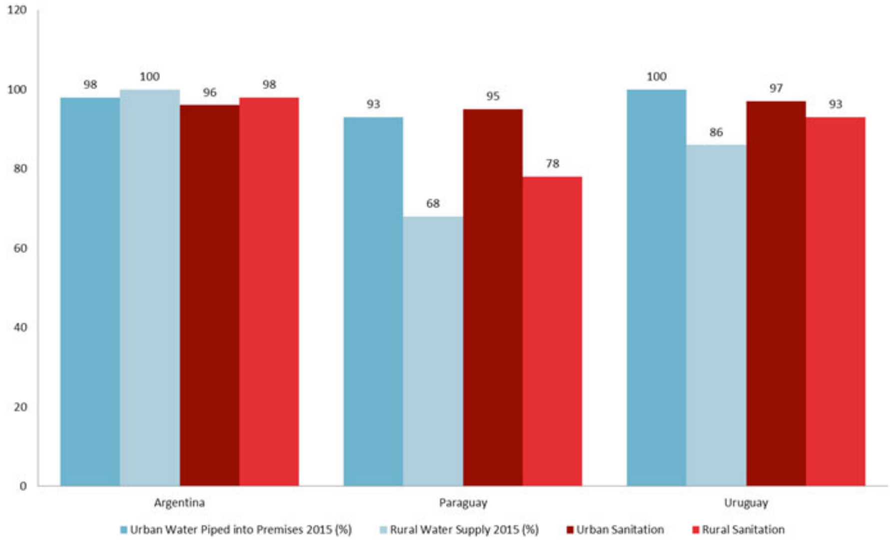


**Fig. 4.3** Dry Chaco and Paraná-La Plata ecoregion: urban and rural piped water supply and sanitation, 2015. Source: WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitations. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

On the other hand, urban sanitation coverage went from 90 % in 2010 (WHO, UNICEF 2012h) to 95 % in 2015 (WHO, UNICEF 2015). Rural sanitation went from 40 % in 2010 (WHO, UNICEF 2012h) to 78 % in 2015 (WHO, UNICEF 2015).

## *3.2 Argentina*

Urban water supply coverage in Argentina went from 76 % in 1990 to 83 % in 2005 (WHO, UNICEF 2012i) and 98 % in 2015 (WHO, UNICEF 2015). Rural water supply coverage went from 22 % in 1990 to 45 % in 2005 (WHO, UNICEF 2012i) and 100 % in 2015 (WHO, UNICEF 2015). Access to water directly from sources went from 13 % in 1990 to 5 % in 2005 (WHO, UNICEF 2012i) and disappeared in 2015 (WHO, UNICEF 2015).

Urban sanitation coverage in Argentina went from 91 % in 2005 (WHO, UNICEF 2012i) to 96 % in 2015 (WHO, UNICEF 2015). In rural areas sanitation coverage went from 77 % in 2005 (WHO, UNICEF 2012i) to 98 % in 2015 (WHO, UNICEF 2015).

### *3.3 Uruguay*

Uruguay has an urban predominance. In urban areas, families experienced improved water supply coverage, from 94 % in 1990 to 98 % in 2010 (WHO, UNICEF 2012j), and closed the gap to 100 % in 2015. Rural water supply went from 50 % in 1990 (WHO, UNICEF 2012j) to 86 % in 2015 (WHO, UNICEF 2015). In 2015, sanitation coverage was 97 % in urban areas and 93 % in rural areas (WHO, UNICEF 2015).

## 4 Access to Urban and Rural Drinking Water and Sanitation in Central American Cordillera Ecoregion

In this section we combine data from the Central American Cordillera ecoregion, composed of the countries of Costa Rica, Panama, Honduras, Nicaragua, El Salvador, Guatemala, and the insular states of the Dominican Republic, Haiti, and Cuba, and, where information is available, with data from the Mexican Plateau ecoregion, made up mainly of Mexico.

### *4.1 Costa Rica*

Urban water supply coverage in Costa Rica rose from 92 % in 1990 to 100 % in 2010 (WHO, UNICEF 2012k), maintaining this 100 % level in 2015 (WHO, UNICEF 2015). Rural water supply has gone from 91 % in 2010 (WHO, UNICEF 2012k) to 95 % in 2015 (WHO-UNICEF- Joint Monitoring Programme for Water Supply and Sanitations 2015). The percentage of families that take water directly from surface water has not changed since 2010 (WHO, UNICEF 2012k; WHO, UNICEF 2015), which is an important risk to national health; a pandemic could spread from populations that only have access to surface water.

On the other hand, in 1990 urban sanitation coverage reached 94 % and rural sanitation 83 % (WHO, UNICEF 2012k). In 2015, urban sanitation coverage hit 95 % and rural sanitation 92 % (WHO, UNICEF 2015). Since 2010, urban sanitation has become a challenge – increased by only 1 % in 25 years (Fig. 4.4).

### *4.2 El Salvador*

El Salvador reached 80 % urban water supply coverage in 2010 (WHO, UNICEF 2012l) and 88 % in 2015 (WHO, UNICEF 2015). However, the rural water supply did not follow the same trend; it went from 42 % in 2010 (WHO, UNICEF 2012l) to 59 % in 2015 (WHO, UNICEF 2015), so just over half the rural population has access to safe water.

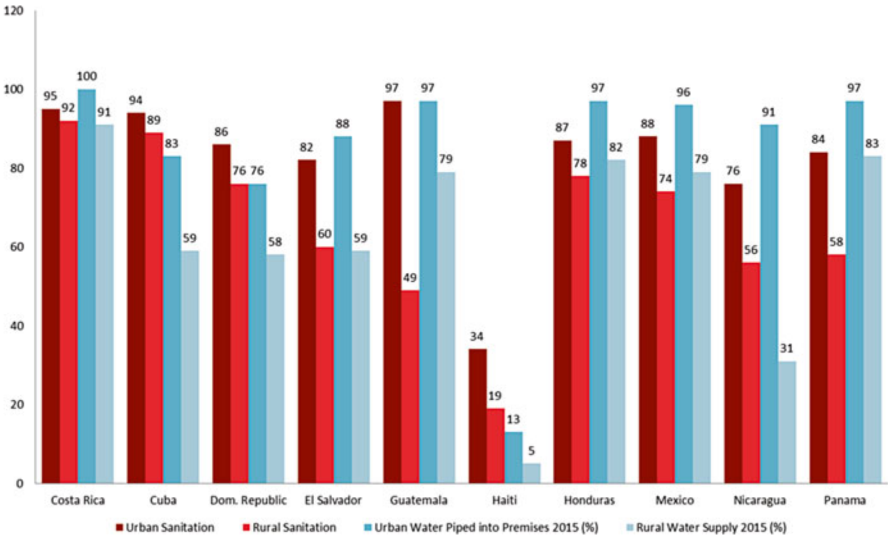


**Fig. 4.4** Central American Cordillera and Mexican Plateau ecoregion: urban and rural piped water supply and sanitation, 2015. Source: WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitations. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

However, while more people have access to safe water in the country, the percentage of people who obtain water from surface sources, the most risky kind of water for a rural population to access, increased from 7 % in 1990 (WHO, UNICEF 2012l) to 12 % in 2015 (WHO, UNICEF 2015).

In 2010, urban rural sanitation coverage reached 72 % and rural sanitation coverage rose to 31 % (WHO, UNICEF 2012l). In 2015, urban sanitation reached hit 82 % and rural sanitation reached the 60 % level, doubling the percentage of people in rural areas with access to sanitation services. The rural open defecation rate was 7 % in 2015.

## *4.3 Nicaragua*

In 2010, Nicaragua had a low rural water supply coverage level, reaching just 29 % of inhabitants. For the same year in urban areas, that number hit 89 % (WHO, UNICEF 2012m). In 2015, rural water supply coverage reached 31 % of the population, while urban water supply coverage increased to 91 % (WHO, UNICEF 2015). Still in 2015, about 6 % of the rural population obtained its water, untreated, from the surface.

With respect to urban sanitation, coverage went from 60 % in 1990 to 76 % in 2015. Sanitation in rural areas went from 26 % in 1990 to 56 % in 2015. However, 14 % of people living in rural areas were still defecating in open spaces. Nicaragua faces serious challenges in improving its rural water supply and sanitation coverage.

## *4.4 Guatemala*

In 2010, this country had an urban water supply coverage of 96 % and rural water supply coverage of 69 % (WHO, UNICEF 2012o). In 2015, urban water supply coverage reached 97 % and in rural areas 79 % (WHO, UNICEF 2015). However, still 7 % of the rural population gets its water from the surface, usually from untreated sources (WHO, UNICEF 2015).

In 2010, urban sanitation coverage reached a level of 87 % and rural sanitation reached 70 % (WHO, UNICEF 2012o). In 2015, urban sanitation coverage was around 97 % and rural sanitation around 79 %. Still in 2015, 9 % of the rural population practiced open defecation as the only option for carrying out those bodily functions (WHO, UNICEF 2015).

## *4.5 Honduras*

In 2010, this country's urban areas had 95 % water supply coverage while that number among rural inhabitants was 74 % (WHO, UNICEF 2012p). In 2015, the country had 97 % urban water supply coverage and 82 % rural water supply coverage (WHO, UNICEF 2015).

In 2015, 3 % of the rural population was still getting its water from surface sources (WHO, UNICEF 2015), while in 1990, only 1 % of the rural population got its water from such sources (WHO, UNICEF 2015). This situation is a bit odd because generally this indicator goes down over time when, as in the case of Honduras, water supply services expand and when the urbanization process increases. Different hypotheses may be used to explain this phenomenon, for instance, perhaps rural infrastructures are slowly crumbling or perhaps the rural population is migrating to other rural areas without services.

On the other hand, urban sanitation in 2010 reached 85 % and rural sanitation hit 69 % (WHO, UNICEF 2012p). In 2015, urban sanitation coverage reached 87 % and rural sanitation 78 %. It is important to mention that 11 % of the rural population still practices open defecation.

## *4.6 Panama*

Panama has seen accelerated urbanization, and in 2005 its urban water supply coverage was 93 % and rural water supply coverage was 79 % (WHO, UNICEF 2012q). In 2015 the urban water supply reached 97 % and rural water supply was 83 %.

However, in 2015 5 % of the rural population was still getting its water from surface sources (WHO, UNICEF 2015).

In 2005, Panama had an urban sanitation coverage of 75 % and a rural sanitation coverage of 51 % (WHO, UNICEF 2012q). These numbers improved a bit in 2015, where urban sanitation reached 84 % and rural sanitation 58 %. Open defecation is still a reality: in 2015 around 9 % of the rural population defecated in open spaces (WHO, UNICEF 2015).

## 5 Access to Urban and Rural Drinking Water and Sanitation in Mexican Plateau Ecoregion

This ecoregion is basically comprised of the country of Mexico.

### *5.1 Mexico*

In 2010, Mexico had 93 % urban water supply coverage and 74 % rural water supply coverage (WHO, UNICEF 2012q). In 2015, the urban water supply coverage hit 96 % and the rural water supply coverage 79 % (WHO, UNICEF 2015).

On the other hand, urban sanitation went from 76 % in 1990 (WHO, UNICEF 2012q) to 88 % in 2015 (WHO, UNICEF 2015), while rural sanitation went from 34 % in 1990 (WHO, UNICEF 2012q) to 74 % in 2015 (WHO, UNICEF 2015). Still, 4 % of the rural population practices open defecation (WHO, UNICEF 2012q). These percentages are important since Mexico has as on average 20 times more people than any other Central American country, so 5 % of the Mexican population would mean the entire population of Nicaragua, El Salvador, or Costa Rica. So when 4 % of the rural population practices open defecation in Mexico, that is more than 1 million people.

## 6 Latin American Situation and Trends

Latin America has devoted more effort to developing its urban water supply coverage than its rural coverage. In some cases, like Nicaragua, the difference between urban and rural water supply coverages is around 60 %; in Peru, the difference is around 38 %, and in both Venezuela and Bolivia it is 37 %. Argentina is the only country that has a rural population with a higher rate of piped water, 100 %, than its urban population has, 98 %. However, other Latin American countries show a slight difference between their urban and rural water supplies, but always with urban primacy: Chile 7 % difference, Haiti 8 % difference. Of course, we cannot compare Chile and Haiti, when Chile has 100 % urban water supply coverage while Haiti has only 15 % urban water supply coverage (Fig. 4.5).

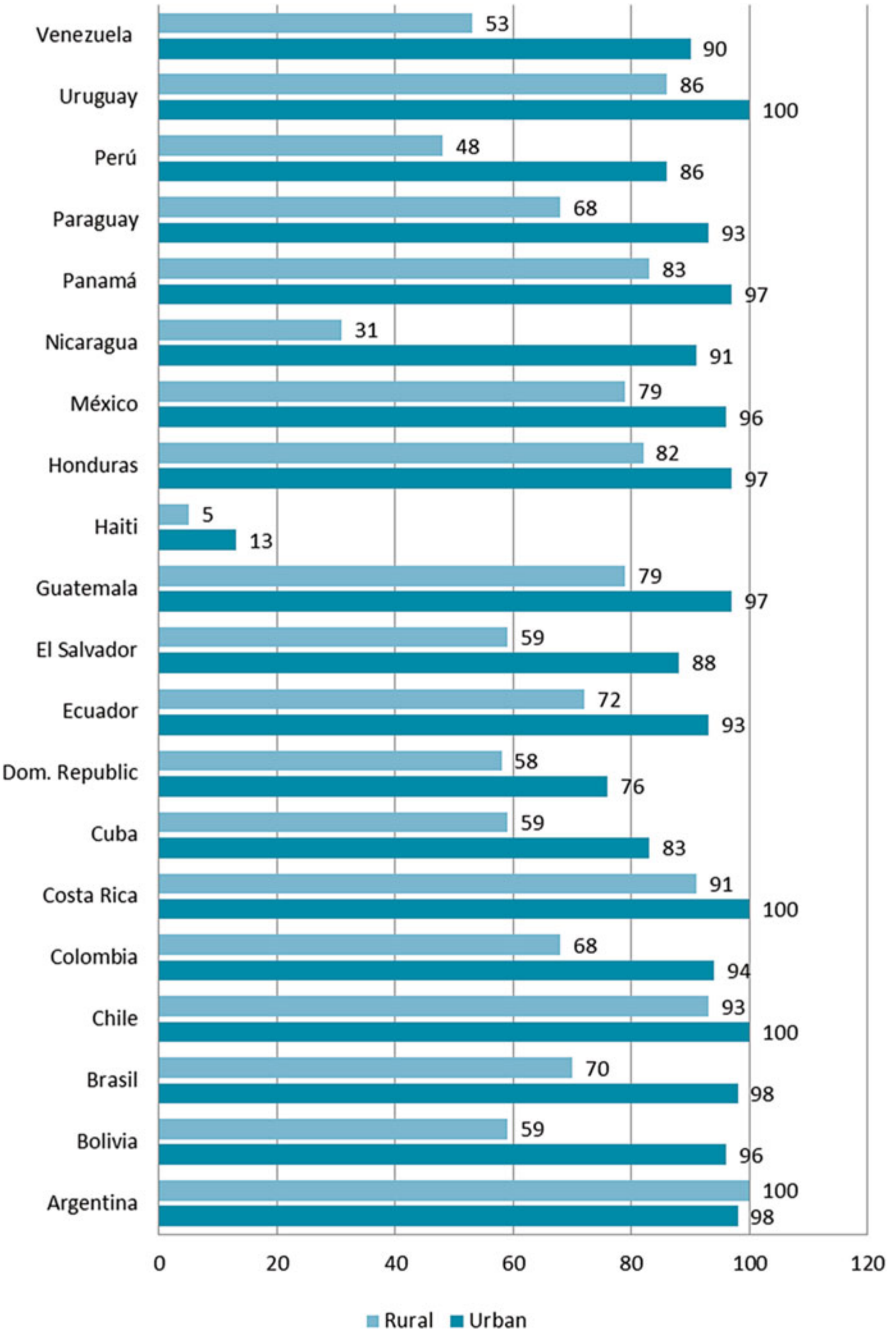


**Fig. 4.5** Latin America: urban and rural piped water supplies, 2015. Source: WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitations. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

In less served areas of a country, i.e., the rural areas, priority has been given mostly to water supply infrastructure, with some exceptions, such as Costa Rica, Ecuador, Paraguay, Dominican Republic, Uruguay, and Venezuela, where sanitation services have been better provided than rural drinking water. In some places, only rural sanitation is provided. This is the case in the Dominican Republic and Haiti, where the difference in rural piped sanitation in relation to drinking water is around 18 % in both countries, where Haiti has much lower levels of these rural infrastructures (Fig. 4.6).

Thus, as we see, most of the public investment has gone and is still going to rural drinking water versus rural sanitation projects. In rural areas, which are the areas in Latin America that are more impacted by poverty, a comparison was made between

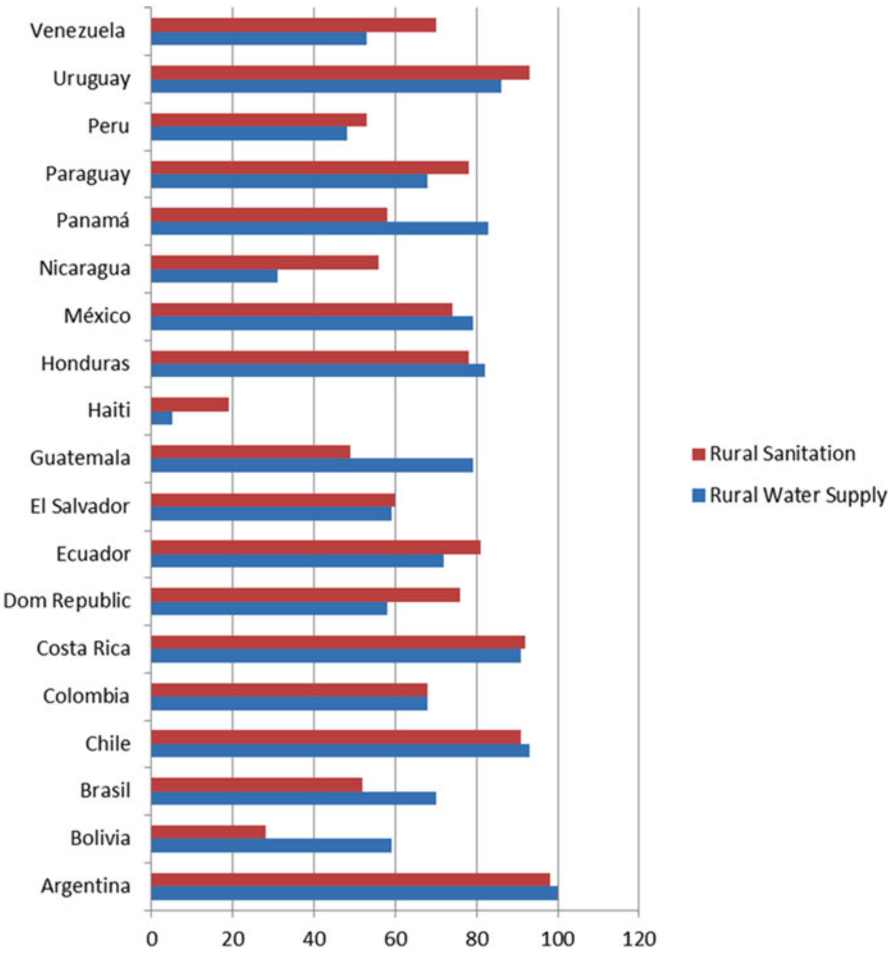


**Fig. 4.6** Latin America: rural piped water supply and sanitation, 2015. Source: WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitations. 2015. Available at: http://wssinfo.org Reviewed 18 September2015. Elaboration: Vladimir Arana

levels of access to rural drinking water versus sanitation infrastructure. It was determined that the correlation between sanitation and poverty was stronger than the relationship between drinking water and poverty. Thus, the entrenchment of poverty is caused mainly by a lack of sanitation rather than a lack of drinking water. This analysis should help to dispel the myth that the absence of a water supply was the main cause of rural poverty (Fig. 4.7).

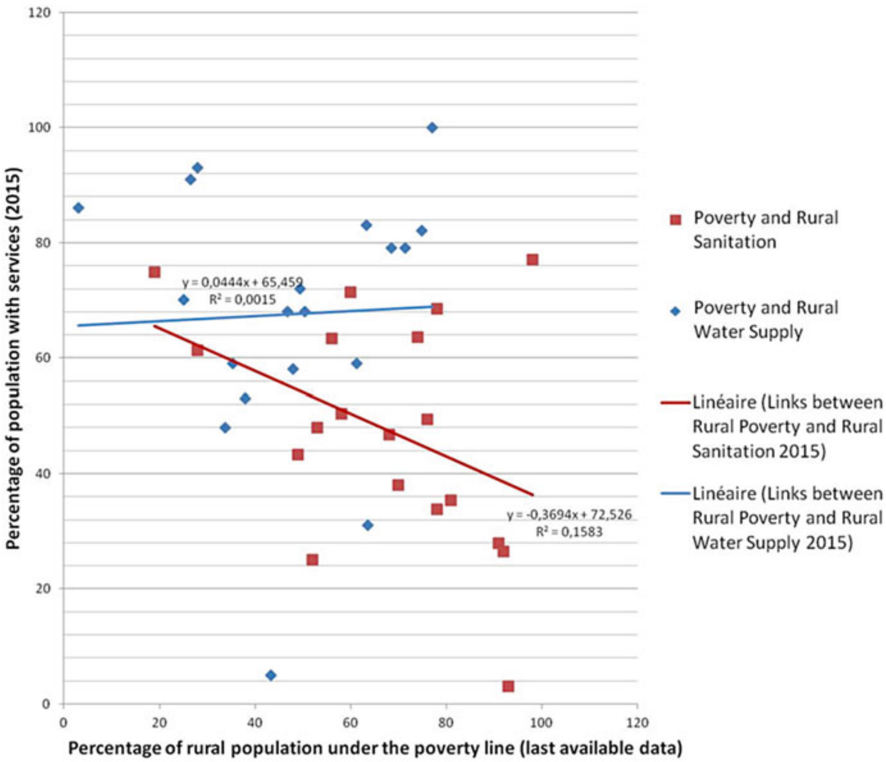


**Fig. 4.7** Latin America: Links between poverty and rural water supply and sanitation, 2015. Sources: World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. World Bank. 2015a, b. World Development Indicators – Poverty Rates at National Poverty Lines. Available at http://wdi.worldbank.org/table/2.7# Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. The International Fund for Agricultural Development (IFAD). 2009. Dar a la población rural pobre de la República Bolivariana de Venezuela la oportunidad de salir de la pobreza. Available at: http://www.ifad.org/operations/projects/regions/PL/factsheet/venezuela_s.pdf Reviewed 30 September 2015. CEPAL 2008. Panorama social de América Latina. United Nations, Santiago de Chile. The International Fund for Agricultural Development (IFAD). 2011. Habilitando os pobres rurais a superar a pobreza no Brasil. Available at: http://www.ifad.org/operations/projects/regions/PL/factsheet/brazil_p.pdf Reviewed 30 September 2015. Elaboration: Vladimir Arana

On the other hand, if we correlate water availability by country with the provision of urban and rural drinking water, we will find that the provision of urban drinking water is more dependent on countries' water availability than rural water supply. As can be observed, the correlation is higher in urban water supply than in rural water supply, which may mean that the regional trend is to give the priority in water resource utilization to urban populations than to rural populations. This analysis is supported by the fact that in most Latin American countries, most of the population lives in urban areas, and this trend will continue in coming years (Fig. 4.8).

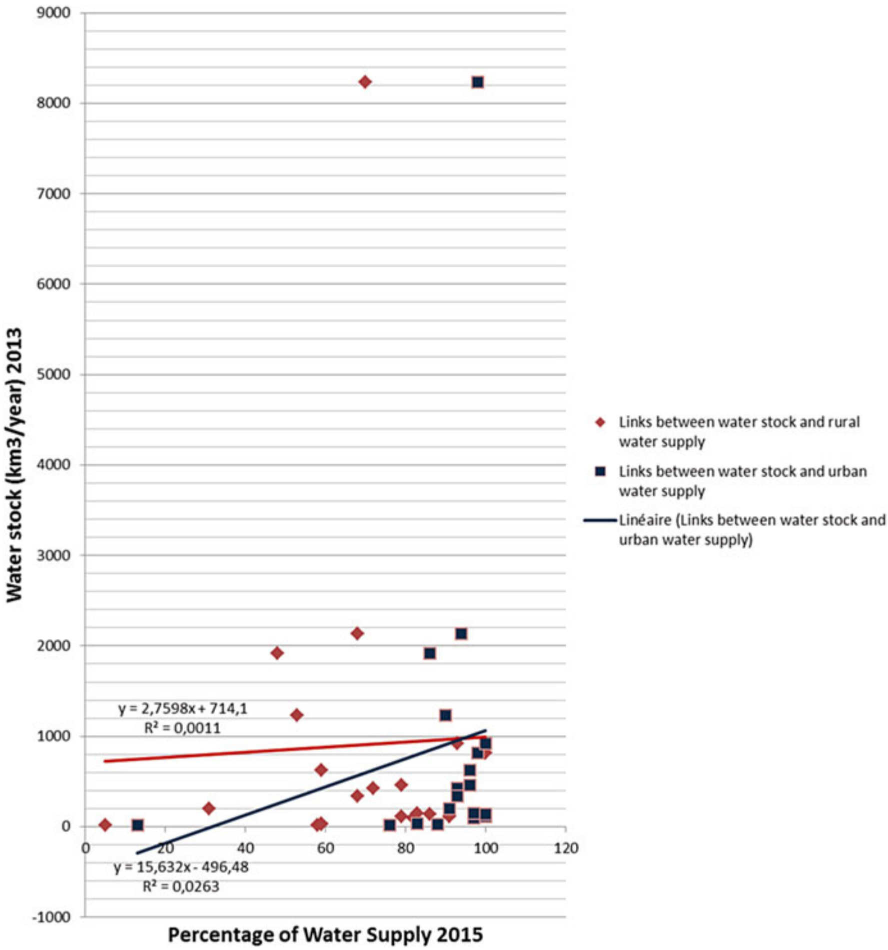


**Fig. 4.8** Latin America: Links between urban and rural water supply and countries' water stock, 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. World Water. 2013. Water availability by country, 2013 update. Available at: http://worldwater.org/wp-content/uploads/sites/22/2013/07/ww8-table1.pdf Reviewed 30 September 2015. Elaboration: Vladimir Arana

Another important indicator is the per capita water availability and how this indicator is linked to urban and rural drinking water supplies. What we observe is that the correlation is stronger when it links per capita water availability with urban drinking water than with rural drinking water. Thus, it may be understood that if water resource loss increases and population grows, the impact will be greater in urban areas than in rural areas because urban areas are more dependent on water availability (Fig. 4.9).

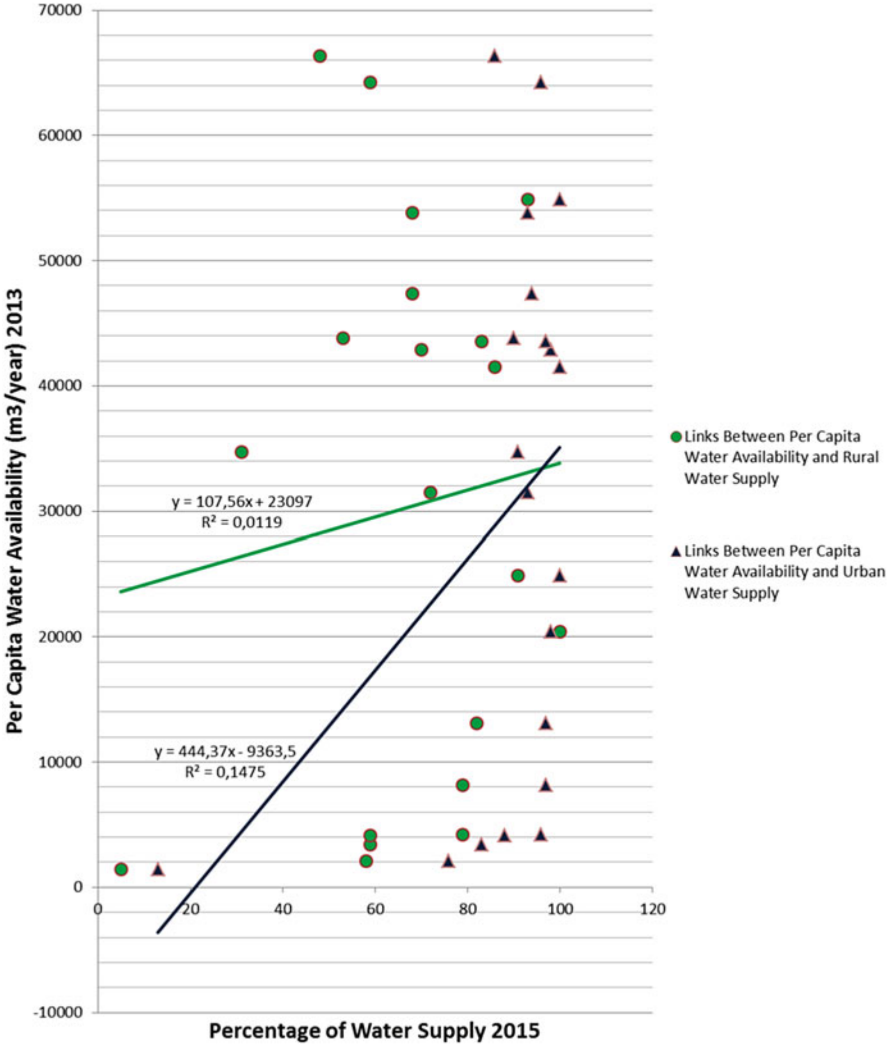


**Fig. 4.9** Latin America: links between per capita water availability 2008 and urban and rural water supply 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitations. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Aquastat-FAO 2015. Elaboration: Vladimir Arana

It is also important to analyze the effect of water and sanitation on the gross domestic product (GDP). In Latin America, the correlation between total access to sanitation and GDP is slightly higher than the correlation between total drinking water supply and GDP, where *total* refers to the national provision. This confirms what was revealed by analysis correlating these infrastructures with rural poverty, where rural poverty had a stronger correlation with sanitation than with water supply. Thus, at this point, in Latin America investing in sanitation tends to make countries less poor and richer than investing in water supplies, even though the countries' water availability and public investment are more oriented to drinking water infrastructure (Fig. 4.10).

The correlations between GDP and access to drinking water, on one side, and GDP and sanitation, on the other side, are strong, though the one between GDP and sanitation is stronger. The trends in both correlations analyses are quite close and show an important regional trend (Fig. 4.11).

On the other hand, it is widely known that a lack of water supply and sanitation increases the pervasiveness and gravity of disease. Worldwide, 1.6 million people die every year from diarrheal diseases (including cholera) attributable

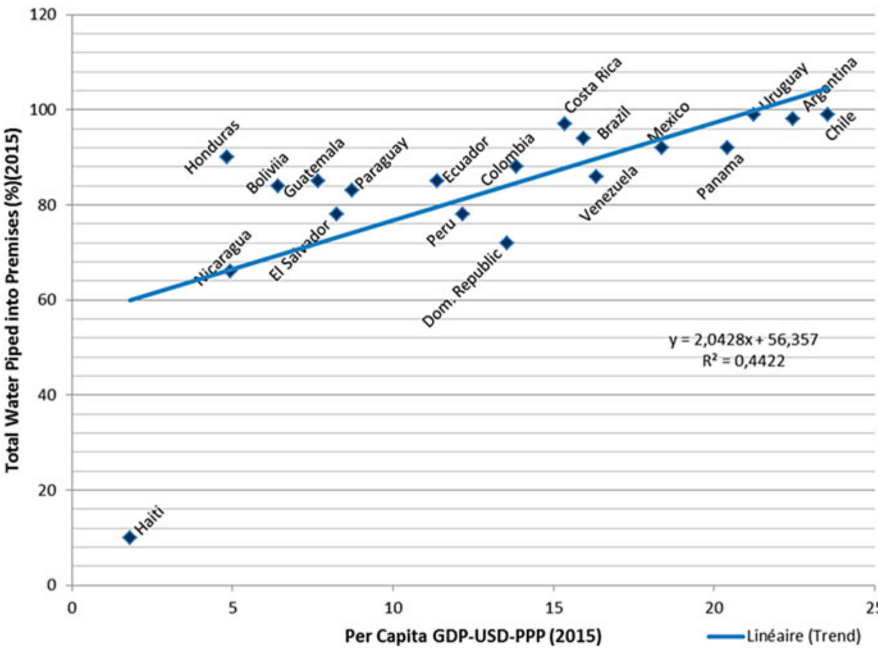


**Fig. 4.10** Latin America: links between per capita GDP and piped water supply, 2015. Source: United Nations – Department of Social and Economic Affairs. 2015. World Population Prospects Revision 2015. World Population Division. Available at: http://esa.un.org/unpd/wpp/DVD/ Reviewed 18 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

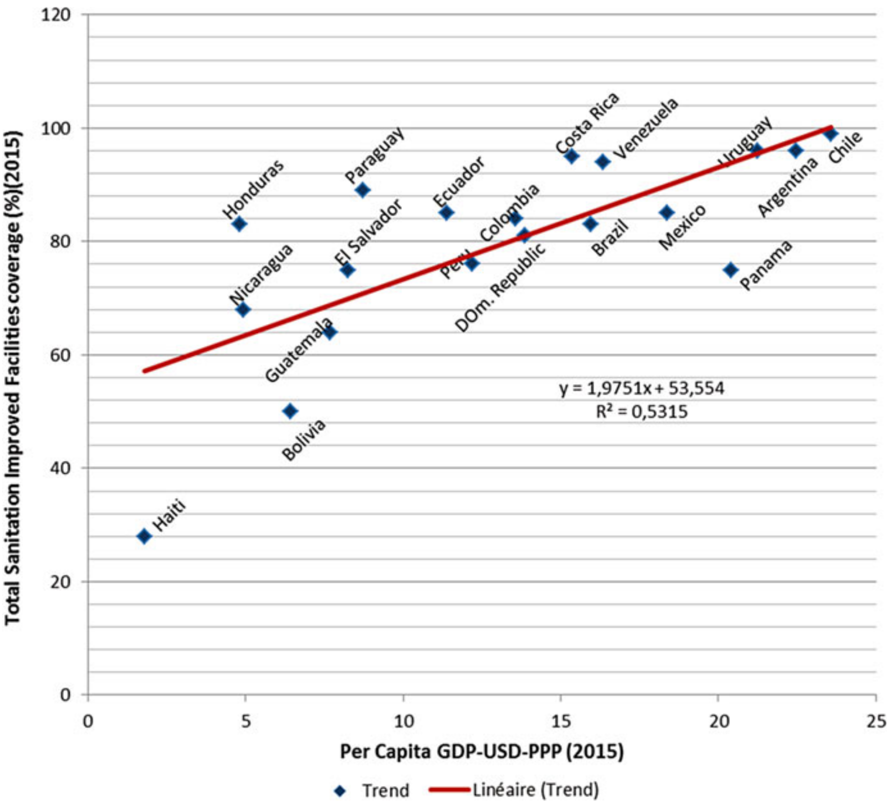


**Fig. 4.11** Latin America: links between per capita GDP and piped sanitation, 2015. Source: IMF – International Monetary Fund 2015. World Economic Outlook, April 2015. Uneven growth, short and long term factors. IMF, Washington, DC. Available at: http://www.imf.org/external/pubs/ft/weo/2015/01/pdf/text.pdf Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

to a lack of access to safe drinking water and basic sanitation; 90 % of these people are children under age 5, mostly in developing countries. Annually, 160 million people are infected with schistosomiasis, which causes tens of thousands of deaths every year. Trachoma threatens 500 million people, of which 146 million are at risk of blindness and 6 million are visually impaired. Intestinal helminths (ascariasis, trichuriasis, and hookworm infection) plague the developing world as a result of inadequate drinking water, sanitation, and hygiene, with 133 million suffering from high-intensity intestinal helminth infections, and there are around 1.5 million cases of clinical hepatitis A every year (WHO 2010). In Latin America and the Caribbean (LAC), roughly 77,600 children under the age of 5, over 200 children every day, die each year from diarrhea and its complications (UNICEF-WHO 2006).

Thus, it has been demonstrated that there is a close relationship between diseases, like diarrhea, where a lower level of water supply and sanitation, mostly among the poor, generates more cases of death by diarrhea. However, this disease rate increment in the less served population is not reflected in an analysis that correlates per capita health expenditures (in US dollars) and total water supply. Analysis of this last relationship shows that countries with more access to water supply and sanitation are those that spend more money per capita on health. This can be explained by two reasons. The first reason is that greater access to water and sanitation is linked to higher incomes or higher per capita GDP, so people with higher incomes spend more on the prevention of diseases and on the best available medical care and medicines. The second reason is that, no matter how terrible or severe a disease is for a poor person, he or she will not be able to afford the costs of treatment anyway, so if the poor have some disease, then they may have no choice but to stay sick or find alternatives like medicinal plants or nonprofessional physicians (Fig. 4.12).

As shown earlier, there is a strong relationship between urbanization and GDP in Latin America. As can be seen, most urbanized countries in the region have a higher GDP than those with smaller urban populations. However, a high GDP accompanied by a higher degree of urbanization does not necessarily mean equal access to water and sanitation.

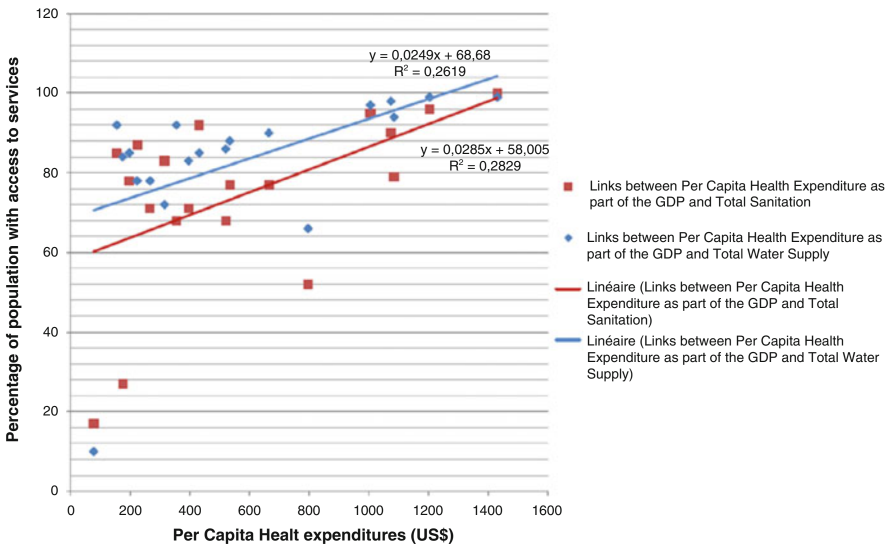


**Fig. 4.12** Latin America: Links between per capita health expenditures (USD) and total water supply, 2015. Source: World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitations. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

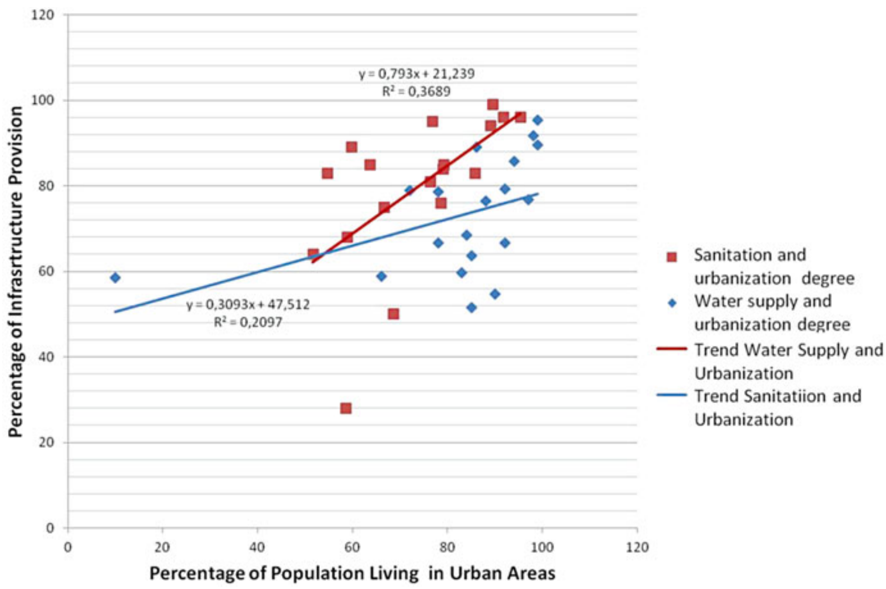


**Fig. 4.13** Latin America: Links between degree of urbanization and piped water supply and sanitation, 2015. United Nations, Department of Economic and Social Affairs, Population Division (2014). World Urbanization Prospects: 2014 Revision, Highlights (ST/ESA/SER.A/352). Available at: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitations. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

Thus, analysis of the relationships between the degree of urbanization in Latin American countries with provision of water supply and sanitation infrastructures shows a stronger correlation with sanitation than with water supply. Thus, more urbanization may lead to a higher level of sanitation than water supply provision. In general, in slums or informal Latin American settlements, sanitation, even precarious sanitation, emerges before water supply infrastructure (Fig. 4.13).

On the other hand, a high population density does not necessarily mean higher levels of water supply and sanitation infrastructure. The following analysis shows that the higher a country's population density, the lower the levels of water supply and sanitation infrastructure. The correlations have important degrees, and that between water supply and population density is greater. Thus, the Latin American trend shows that a higher population density is related to lower degrees of water and sanitation provision. This seems to be confirmed by the fact that the higher a country's population density, the larger the precarious areas in its cities (Fig. 4.14).

However, it is important to mention that the correlation between total water supply and population density is higher than the correlation between sanitation and population density. Of course, there are, as always, countries that are closer to the trend line than others, but one country that is rather far from the trend line in both cases is Haiti, which has very low levels of access to water and sanitation and highest population density per square kilometer in the region (Fig. 4.15).

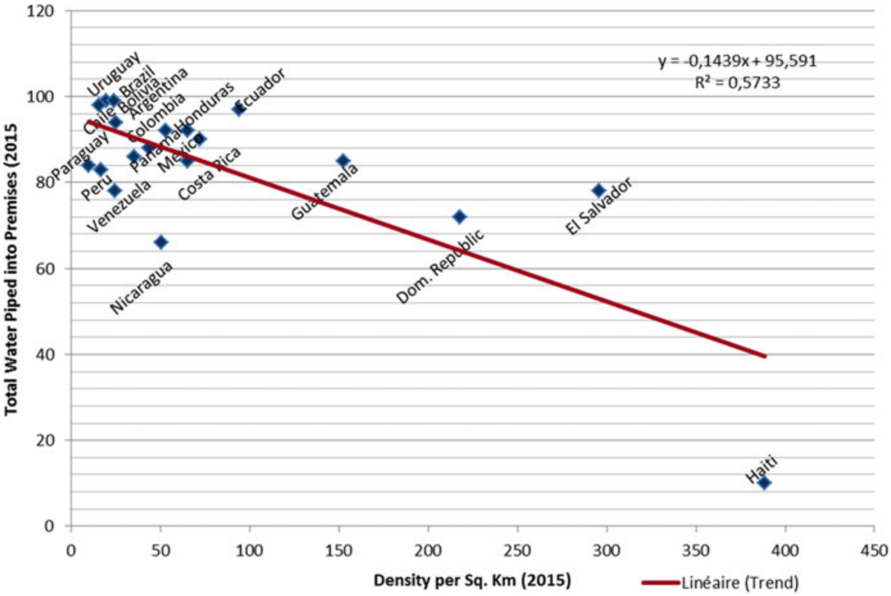


**Fig. 4.14** Latin America: links between density per square kilometer and piped water supply, 2015. Source: United Nations – Department of Social and Economic Affairs. 2015. World Population Prospects, 2015 revision. World Population Division. Available at: http://esa.un.org/unpd/wpp/DVD/ Reviewed 18 September 2015. Elaboration: Vladimir Arana

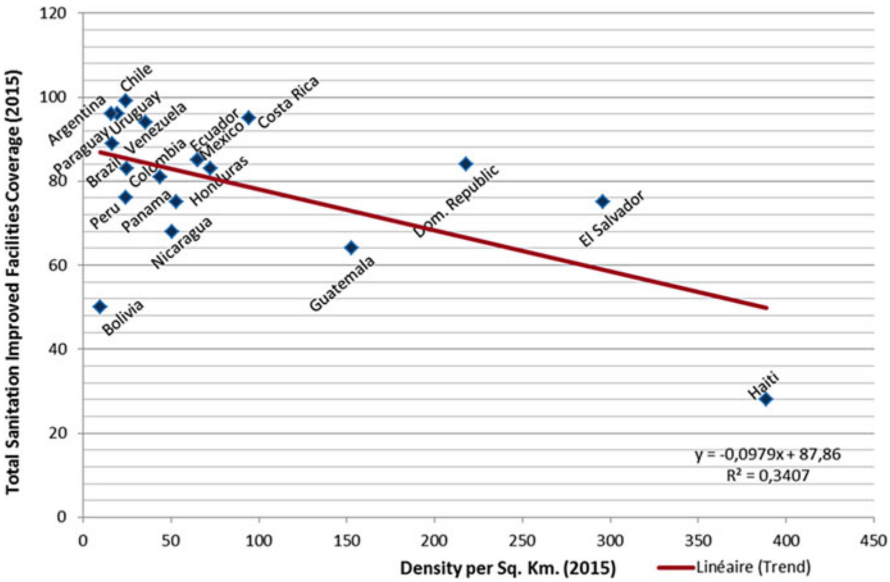


**Fig. 4.15** Latin America: links between density per square kilometer and piped sanitation, 2015. Source: United Nations – Department of Social and Economic Affairs. 2015. World Population Prospects, 2015 revision. World Population Division. Available at: http://esa.un.org/unpd/wpp/DVD/ Reviewed 18 September 2015. Elaboration: Vladimir Arana

The slight trend whereby a higher presence of precarious areas in cities is linked to a higher population density in Latin America is explained by the special socioeconomic characteristics of this region. The correlation is not very strong, so such a situation could easily be changed. However, it does show that population density and precarious situations are somehow related in the region. In other industrialized latitudes, higher densities may be associated with higher land values and, consequently, with well-preserved urban spaces. To explain this phenomenon, it is important to observe the rural–urban Latin American processes that in most cases occurred in the historical centers of the countries' capitals, which at some point became unsafe, dangerous, and highly deteriorated. Poverty pushed people to migrate and seek new horizons and opportunities, increasing the urban areas' population density and exacerbating the deterioration (Fig. 4.16).

There are similar trends between per capita energy consumption and water supply and sanitation. However, the correlation is stronger in the relationship between per capita energy consumption and sanitation. Energy has been a key condition in providing infrastructure. Without energy, construction machinery cannot operate and infrastructure could not be made. In Latin America, after informal settlements

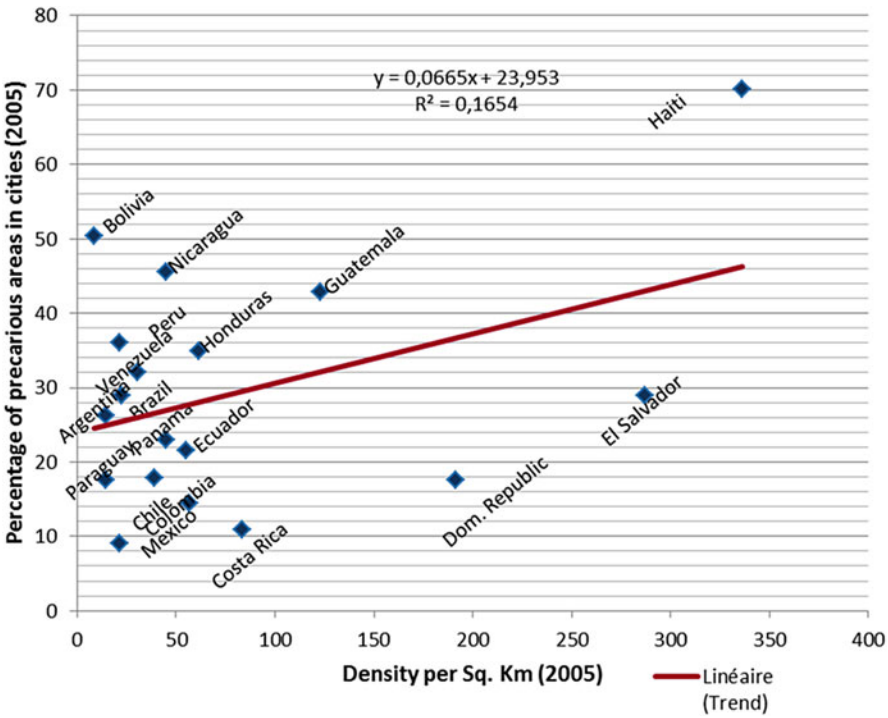


**Fig. 4.16** Latin America: links between density per square kilometer and precarious areas in cities, 2005. Source: United Nations – Department of Social and Economic Affairs. 2015. World Population Prospects, 2015 revision. World Population Division. Available at: http://esa.un.org/unpd/wpp/DVD/ Reviewed 18 September 2015. Elaboration: Vladimir Arana

are recognized by their governments, the first infrastructure is electricity, followed by water and sanitation. Whereas water, in informal settlements, could be provided through trucks that distribute water a few times a week, sanitation must be established immediately, and since sanitary infrastructure works through gravity, energy is needed not for its operation but during its construction. This may explain why per capita energy consumption has a stronger correlation with sanitation than with water supply infrastructure (Fig. 4.17).

In Latin America energy is provided in a very contrasting way. For instance, the Dominican Republic consumes 28 times more energy per capita than Haiti – and they are neighbors. Chile consumes five times more energy than its neighbor Bolivia, and Venezuela's per capita energy consumption is triple that of its nieghbor Colombia. What countries like the Dominican Republic, Chile, and Venezuela have in common is in the 1980s they sharply expanded their respective energy frontiers, which allowed for higher production levels and per capita GDP (Fig. 4.18).

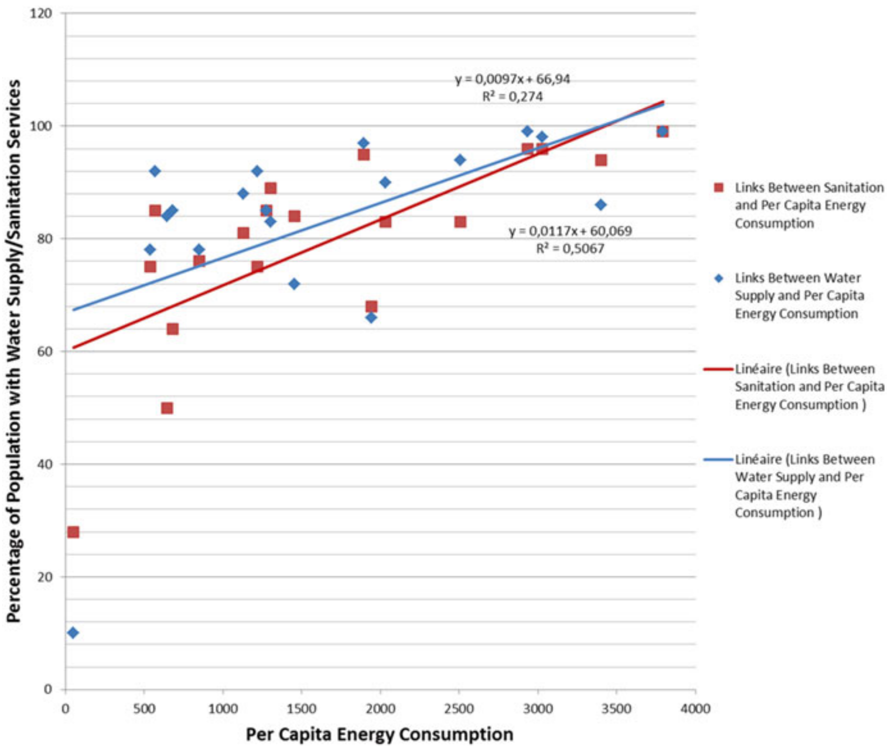


**Fig. 4.17** Latin America: links between per capita energy consumption (kWh) and total water supply and sanitation, 2015. Source: World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

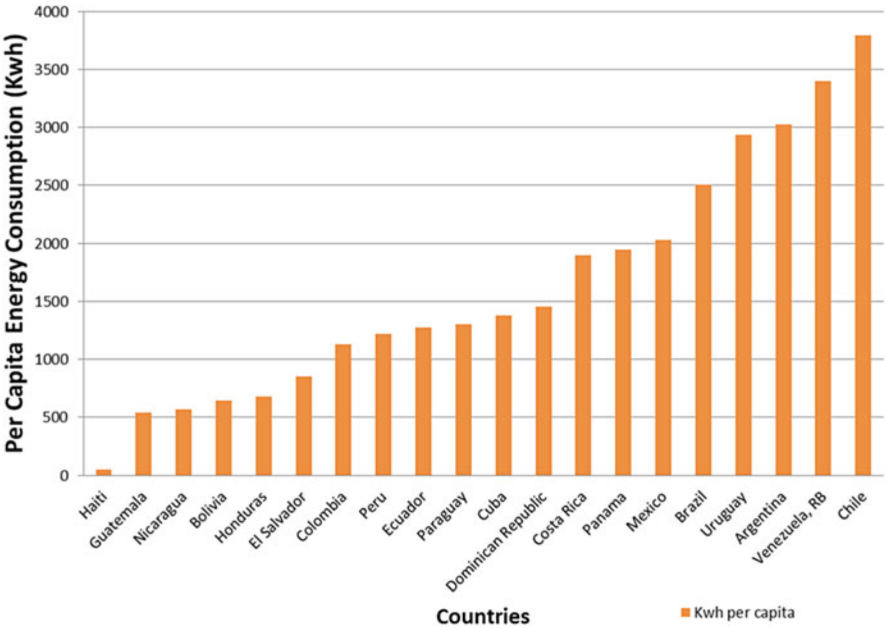


**Fig. 4.18** Latin America: per capita energy consumption (kWh) 2015. Source: World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

Water supply and sanitation are without a doubt key aspects of human development and constitute very important factors for increasing per capita GDP. However, the correlation between per capita energy consumption and GDP is close to one and stronger than the influence of water supply and sanitation on GDP. The Latin American countries with higher per capita energy consumption are Chile, Venezuela, Argentina, and Uruguay, and these countries, except Venezuela, have a higher per capita GDP. It is widely known that in Venezuela political and economic constraints have an important impact on production. Panama, Mexico, and Brazil show the same positive correlation between per capita GDP and per capita energy consumption. Countries like Haiti, Nicaragua, and Honduras have the lowest per capita energy consumption, correlated with the lowest per capita GDP. Thus far, in Latin America, wealth depends, in decreasing order, on energy provision, sanitation, and water supply (Fig. 4.19).

On the other hand, the correlations between exports and water supply and per capita energy consumption are very low. So no specific dependency level between these factors can be determined. Thus, these important infrastructures have a stronger impact on GDP than on exports. The export values are the current value of exports (FOB, Free On Board) converted to US dollars and expressed as a percentage of the average for the base period (2000). UNCTAD's (United Nations Conference on Trade and Development) export value indexes are reported for most economies. For

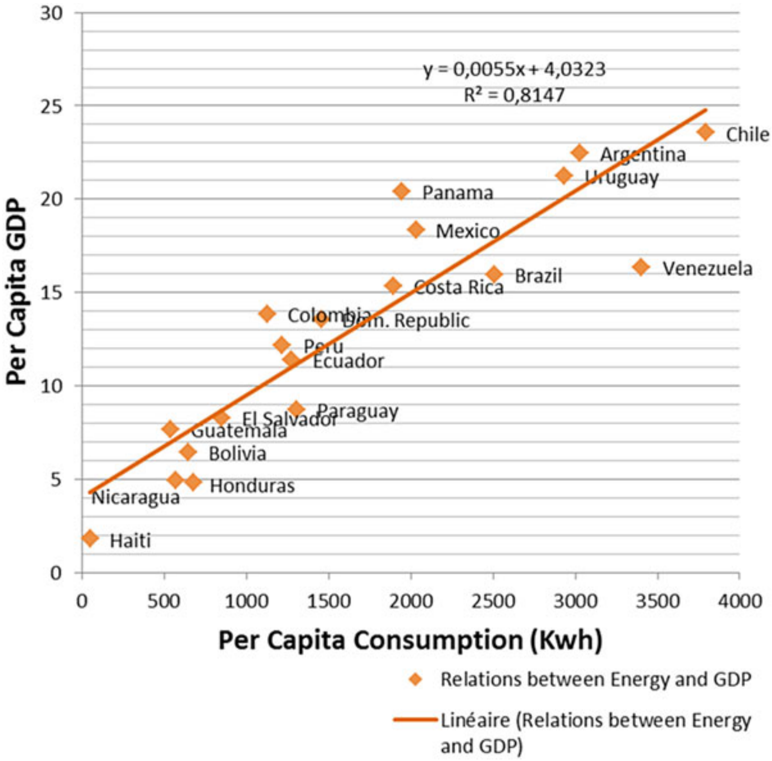


**Fig. 4.19** Latin America: links between per capita energy consumption (kWh) and per capita GDP, 2015. Source: IMF – International Monetary Fund 2015. World Economic Outlook, April 2015. Uneven growth, short and long term factors. IMF, Washington, DC. Available at: http://www.imf.org/external/pubs/ft/weo/2015/01/pdf/text.pdf Reviewed 29 September 2015. World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

selected economies for which UNCTAD does not publish data, the export value indexes are derived from export volume indexes (line 72) and corresponding unit value indexes of exports (line 74) in the IMF's International Financial Statistics (World Bank 2013) (Fig. 4.20).

In recent years, exports have not been doing well in Latin America. In the first quarter of 2015, the contraction of exports from Latin America (using data that excludes Venezuela) accelerated markedly: the year-on-year growth rate through March was estimated at −9.1 %. In 2014, exports of goods had already fallen 2.7 % and ended the year at USD 1.04 trillion. The region's foreign sales have gone from a stage of stagnation that began in mid-2012 to one of contraction. Several factors, including the appreciation of the US dollar and the drop in commodity prices, mainly petroleum, drove this change in trend, in the context of a generalized slowdown of global trade (−11.6 % year-on-year in the first quarter of 2015). The reduction of

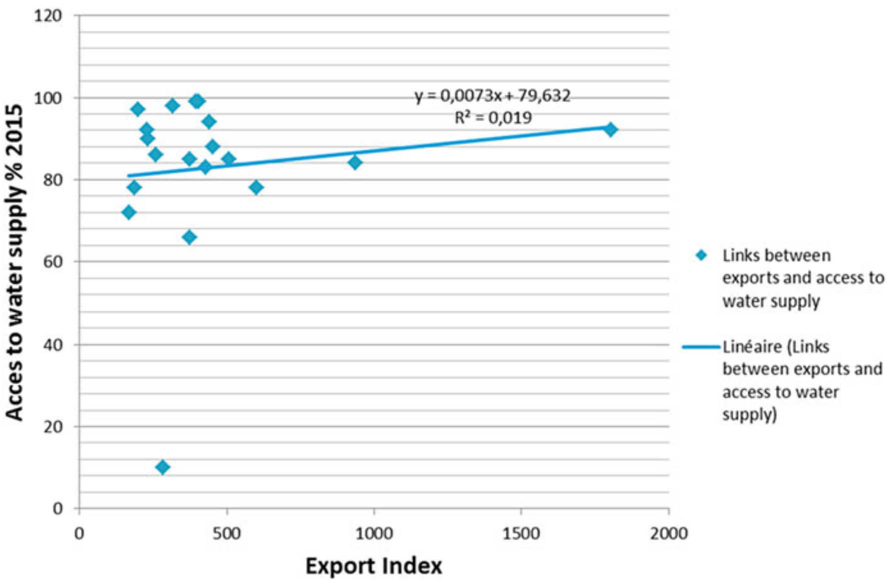


**Fig. 4.20** Latin America: links between access to water supply and export index, 2015. World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

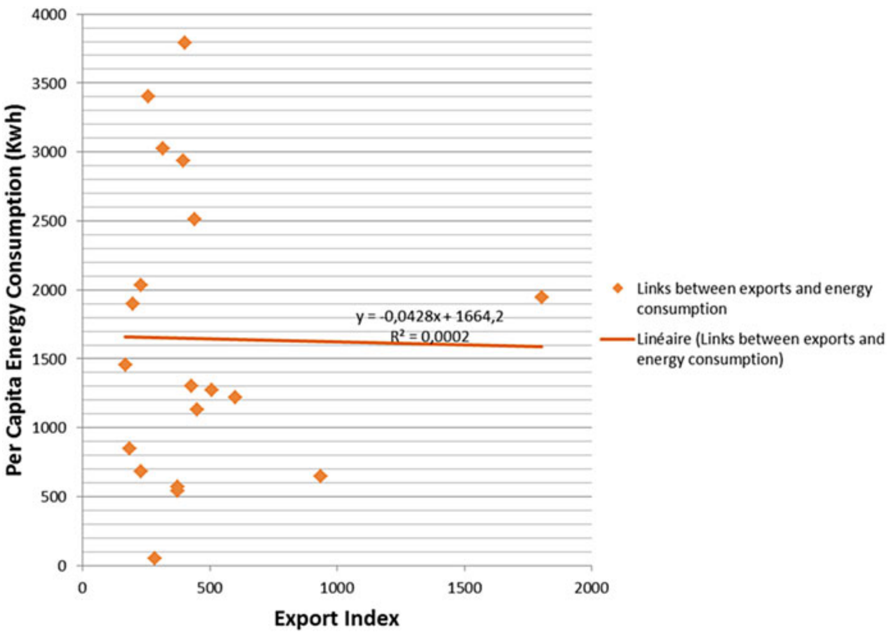


**Fig. 4.21** Latin America: links between per capita energy consumption (kWh) and export index, 2015. World Bank. 2013. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. Elaboration: Vladimir Arana

regional exports and, consequently, the nations' industrialization reflects the evolution of demand from principal trading partners: in the first quarter of 2015, Chinese imports from the region fell 28 % year-on-year, those of the USA fell 6 %, and European imports fell 3 %. In this context, only three countries in the region showed positive export growth: Honduras, El Salvador, and Guatemala (Giordano et al. 2014).

Other factors beyond the existence of water supply, sanitation, and energy infrastructure also affect exports and the industrial development that supports these exports (Fig. 4.21).

## 7 Conclusions

Latin America suffers from a significant gap in water supply and sanitation, and the situation is especially critical in rural areas. The high rate of population dispersion is a determining factor in the provision of infrastructure like water supply and sanitation, and the distances between populations increase transaction costs when it comes to the construction of these systems and their maintenance. The rural population scale is another weakness that discourages local or national contractors from building water supply and sanitation systems in rural areas. Despite this situation, some countries have managed to expand their rural water supply and sanitation infrastructure at a faster pace than in urban areas as a result of political decisions that led to increased budgets for basic rural infrastructure. In addition, they increased public investment in water supply and sanitation projects whose implementation requires strong technical capacities at every stage of production, from region-specific design concepts , preparation of technical design dossiers, and construction adapted to local features with respect to materials and equipment, to monitoring and evaluation of processes.

Urban areas grow in an informal way, and informal land possession makes difficult the work of water supply and sanitation services. Also, some governments have not been able to intervene in all urban areas, especially in intermediate cities and peripheries because of budgetary weaknesses or political priorities. This situation has forced urban families to obtain water through unsafe alternatives.

In Latin America water supply and sanitation are provided in urban areas through public enterprises, private companies, municipalities, and community organizations. In rural areas, it is mainly community management organizations that are responsible for organizing these services, even though the infrastructure is basically built by the state.

In general and at different paces the region has seen increased water supply coverage. However, there are exceptions that have reduced this coverage in the last 20 years. This can be the result of weak investments, seismic phenomena, population migratory processes, or internal conflicts.

An interesting aspect of the analysis presented here is the correlation between water supply, sanitation, and poverty, which is stronger in the relationship between sanitation and poverty than in that between water supply and poverty. Thus, the tendency is for increases in poverty to be more closely related to a lack of sanitation than to insufficient water supplies. Thus, the lack of sanitation is entrenches poverty more than a lack of water supplies.

Latin American countries are very dependent on water resources, especially urban water supplies. The correlation between countries' water resources and urban water supply shows an important tendency and a higher correlation than with rural water supply. Of course, water for human consumption could be obtained from desalinization or other sources, but at the present time in Latin America alternative technologies for obtaining water for domestic use do not exist. On the other hand, when per capita water availability is reduced, urban water supplies are reduced faster than rural water supplies, and this has been demonstrated by the stronger correlation between per capita water availability and urban water supply versus per capita water availability and rural water supply.

More water, more income: that is the conclusion of the analysis of the correlation between per capita GDP and total water supply in Latin America. However, more sanitation, creates even more income, since the correlation between per capita GDP and sanitation is higher than that between per capita GDP and water supply.

A higher level of water supply impacts on health expenditures in the same way as lower sanitation levels do. Even though the correlation with sanitation is higher than with water supply, the difference is only slight.

Urbanization in Latin America provides more sanitation than water supply. The correlation between sanitation and urbanization is higher than that between water supply and urbanization, which shows that urbanization impacts positively on services. However, clearly, urbanization is a different phenomenon than population density.

In Latin America a higher population density in a country does not mean more water or sanitation. The analysis presented here showed that a higher population density, which in Latin America could be associated with high levels of precarious living conditions, is related to lower levels of service. This is explained by the fact that in Latin America, a higher population density tends to be an indicator of more precarious living conditions in cities. More energy allows for greater water supply and sanitation services since the correlations between per capita energy consumption and water supply and sanitation are high and positive.

More energy allows for more income. The correlation between per capita energy consumption and per capita GDP is close to one, so the level of dependency between this two factors is quite important. More water supply or higher energy consumption does not substantively impact a country's exports.

There are some exceptional cases in Latin America where countries with the highest GDP in the region still have important gaps in water supply and sanitation. In some countries, urban coverage duplicates rural coverage, which explains the significant quality-of-life difference between urban and rural areas, which makes urban areas still more attractive than rural one. Higher GDP does not mean more investment in rural areasparticularly when policymakers do not consider urban populations and needs in their policies. Another explanation is that work is far more difficult in rural than in urban areas and very difficult in, for instance, areas in the Amazon, where rivers and streams are the only means of travel or transport.

Rural sanitation is very different than urban sanitation. Rural sanitation requires small-scale technologies, whereas urban sanitation requires treatment plants. In Latin America, rural sanitation is one the most neglected services. This neglect impacts human health, environmental conditions, poverty, and economic opportunities. Several causes impact weak sanitation and affect differently the different countries of the region. In most countries, the authorities attribute the lack of rural sanitation to economic constraints, never to public inefficiency.

# Chapter 5
# Quality, Sustainability, and Investment Levels

According to the Water Virtual Information Center, drinking water quality is defined by several factors: (1) coverage, meaning that water must reach everyone without restrictions; no one should be excluded from access to good-quality water; (2) quantity, referring to people's needs and enough water to meet those needs, such as drinking, cooking, personal hygiene, home maintenance, and laundry; (3) quality, in simple terms, this means water free of contaminants that do not transmit diseases; (4) continuity, which refers to a permanent water supply; the ideal situation is to have water available 24 h/day; discontinuity, or just an hourly supply, could create problems with storage, which could affect water quality, or corrosion of water pipes; (5) cost, which reflects the fact that, though water is a common good, it is also a commodity that has costs associated with its procurement and distribution; these costs may include treatment, maintenance, repair, and administrative costs; and (6) water culture, which can be defined as a set of customs, values, and attitudes that a person or society has toward water, which enable them adopt the necessary actions to obtain it, treat it, protect it, and reuse it in a sustainable way (Centro virtual de información del agua 2010).

Of all these aspects described by the Water Virtual Information Center, only a few are taken into consideration in national statistics in Latin America, and some are just considered in studies or projects implemented at different times and at different latitudes so they may not be valid use as a whole, discouraging comparisons or disallowing the identification of trend and factor correlations.

This chapter focuses on water supply quality, specifically (1) drinking water quality and (2) water service provision quality. Since most Latin American countries do not produce up-to-date information on water supply and water management quality, it is difficult to compare data among countries. These limitations and other unavailable information related to the chemical and biological aspects of water made it necessary to find other indicators that might reveal the effects of water quality.

The World Health Organization (WHO) considers that around 88 % of diarrheic diseases are caused by inappropriate water and deficient sanitation and hygiene



V. Arana, *Water and Territory in Latin America*,
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(WHO 2004), so the good or bad quality of water could be determined by comparing the existence of diarrheic diseases, but especially deaths by diarrhea, with water supply and sanitation coverage. Countries with high water supply and sanitation coverage, or any case above the average, and that have high indicators of death by diarrhea may have water quality issues that might require special attention.

Water and sanitation play a crucial role in the transmission of diarrheal disease. These environmental factors contribute to approximately 94 % of the four billion cases of diarrhea that WHO estimates occur globally each year. Children under the age of 5 in developing countries bear the greatest burden and account for the majority of the 1.5 million deaths attributed to diarrhea annually. In Latin America and the Caribbean (LAC), roughly 77,600 children under the age of 5, over 200 children every day, die each year from diarrhea and its complications (Fricas and Martz 2007).

Diarrhea can cause severe dehydration and poor absorption of nutrients, which in turn makes affected individuals more susceptible to infectious diseases. Diarrhea in early childhood is associated with impaired growth, physical fitness, and cognitive development, which can lead to diminished future school performance and lower economic earning power. Severe diarrhea that is not treated appropriately can also lead to death. Safe drinking water and improved sanitation play a significant role in reducing the risk of diarrheal diseases.

LAC's population of 554 million still includes 50 million people who lack access to safe drinking water – 34 million of whom reside in rural areas – and 125 million who lack access to improved sanitation. Untreated water sources are vulnerable to contamination and are a major source of disease transmission; unimproved sanitation is a major source of contamination for clean water sources. According to WHO, diarrhea morbidity could decrease by 32 % with improved sanitation, including pit latrines, septic tanks, and composting toilets, and by 6 to 25 % with improved water supplies, such as protected dug wells, public taps, and tube wells (Fricas and Martz 2007) (Map 5.1).

So, while Brazil and Mexico have the highest number of people who die by diarrhea, the number is very low in proportion to the population of each country. Countries like Colombia and Peru also have a serious number of deaths by diarrhea but it is insignificant when measured as a rate of deaths per 100,000 (Map 5.2).

The rate of death by diarrhea (per 100,000) is higher in Haiti, where it is double the second highest position, followed by Guatemala and Honduras. The lowest rate of diarrhea is held by Chile, followed by Cuba, Uruguay, and Argentina. Some countries have incremented the level of water supply and sanitation, and that maintains important rates of death by diarrhea (per 100,000). This means that investment in such basic infrastructure as water supply and sanitation does not immediately eradicate the disease from a country; only after several years are the positive impacts, like elimination of diseases or even increments in income, evident and measurable. Investment in water and sanitation should not be seen as a political indicator but as an indicator of development (Fig. 5.1).

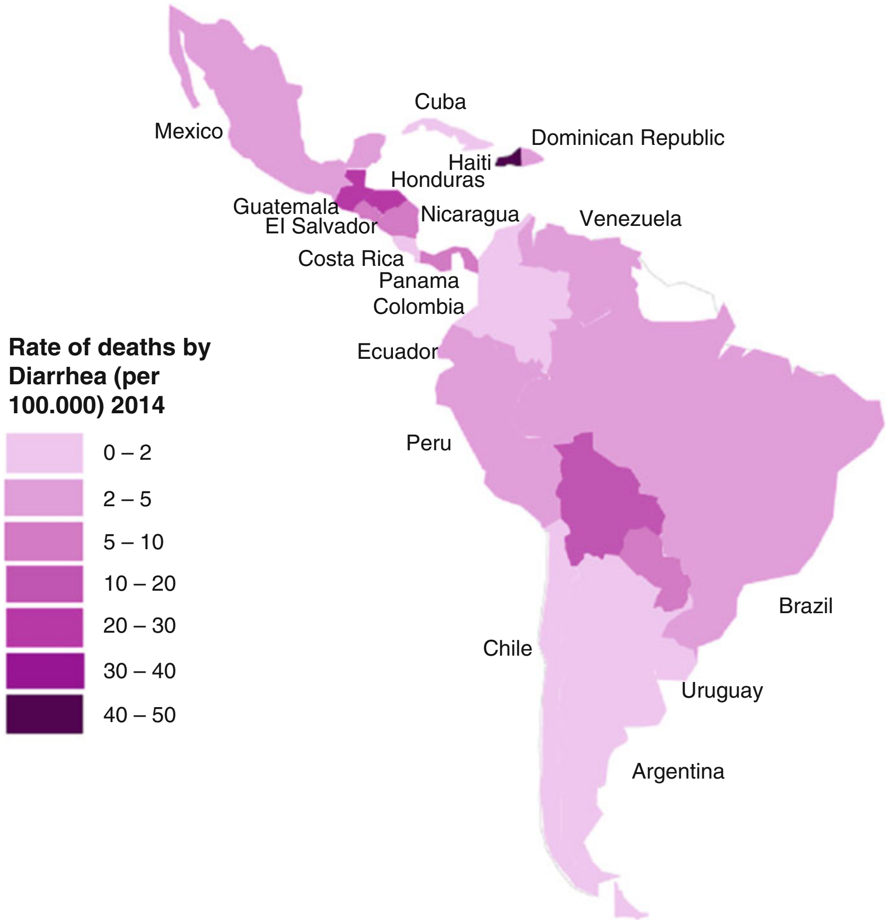
On the other hand, the evaluation of water supply and sanitation quality considers dysfunctional situations such as systems that do not use disinfection or that are affected by intermittency. These factors have important impacts on the rate of death by diarrhea (Map 5.3).


**Map 5.1** Latin America: Spatial distribution of deaths by diarrhea in 2007. WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO 2012. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015

## 1 Ecosystem Services and Their Role in Water Supply and Basin Management

Ecosystem services are those processes generated by ecosystems that maintain their biophysical dynamics and that benefit people and the environment itself. Examples include basin hydrological regulation, conservation of biodiversity, carbon sequestration, genetic resource provisioning, and landscape beauty.

Water purification is an ecosystem service that depends on filtration and absorption by soil particles and living organisms in the water and soil. Human activities that compact soil, contaminate water, or alter the composition of organisms degrade




**Map 5.2** Latin America: Spatial distribution of rate of death by diarrhea (per 100,000), 2014. Source: World Health Rankings. 2014. Diarrhoeal Diseases—Death Rate per 100,000. Available at: http://www.worldlifeexpectancy.com/cause-of-death/diarrhoeal-diseases/by-country/ Reviewed 30 September 2015

the purification process and can accelerate the movement of unfiltered water through the system and into water supplies. Some ecosystems that provide these services are as follows.

Wetlands: Wetlands remove anywhere from 20 to 60 % of metals in water, trap and retain 80–90 % of sediment from runoff, and eliminate 70–90 % of entering nitrogen. Many types of plants are specially adapted to different kinds of wetlands, and a large percentage of imperiled plants and animals depend on wetlands for at least part of their life cycle.

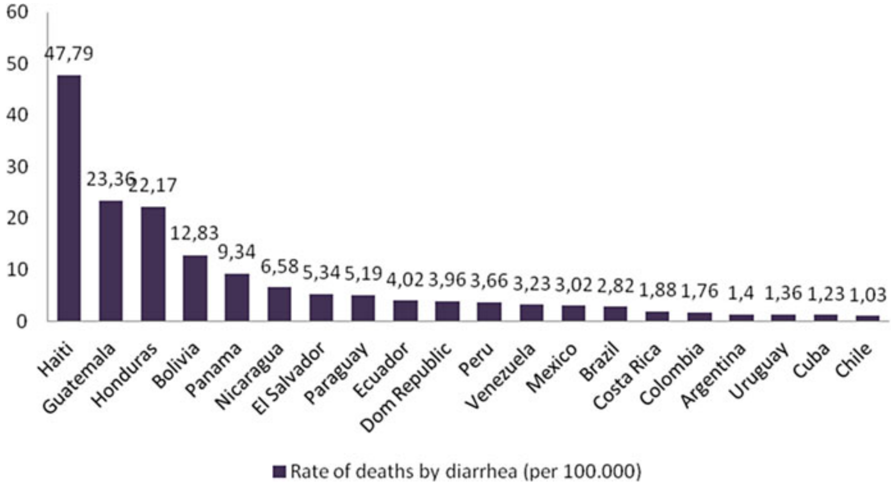



**Fig. 5.1** Latin America: Rate of death by diarrhea (per 100,000) 2014. Source: World Health Rankings. 2014. Diarrhoeal Diseases—Death Rate Per 100,000. Available at: http://www.worldlifeexpectancy.com/cause-of-death/diarrhoeal-diseases/by-country/ Reviewed 30 September 2015. WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015

Riparian forests: Riparian (streamside) forests act as so-called living filters that intercept and absorb sediments and store and transform excess nutrients and pollutants carried in runoff from adjacent lands. They can reduce the nitrogen concentration in water runoff and floodwater by up to 90 % and reduce phosphorus by as much as 50 %.

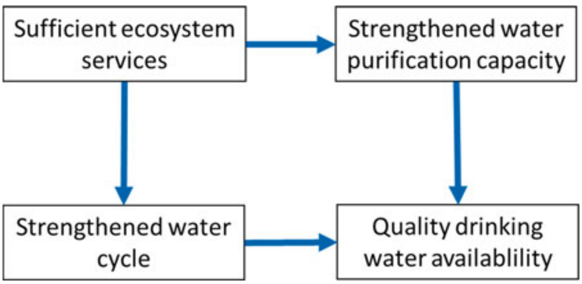
Microorganisms: Microorganisms are the natural chemical engineers of an ecosystem. Bacteria and other organisms utilize or break down nutrients, metals, and other chemical contaminants in water.

Constructed wetlands: Constructed wetlands mimic some of the filtration power of natural systems. They can be cost-efficient for small communities but cannot replace natural wetlands and may not provide many other wetland services, such as flood control and fish and wildlife habitat (ESA 2000) (Fig. 5.2).

Ecosystem services promote natural phenomena that allow water condensation, accumulation storage, and distribution in natural ways benefiting the water cycle, which is a major determinant of water availability. At the same time, natural processes, like infiltration, soil absorption, or microorganism activity, help purify water. Thus, ecosystem services impact the quantity and quality of water, and if these services disappear, the quantity and quality of water will be seriously and adversely affected. Ecosystem services are the reason why basins have water and why basins are capable of providing clean drinking water.


**Map 5.3** Latin America: Spatial distribution of water supply systems that use disinfection, 2007. WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015

**Fig. 5.2** Ecosystem services' impact on potable water availability



There is established but incomplete evidence that changes being made to ecosystems are increasing the likelihood of nonlinear changes in ecosystems (including accelerating, abrupt, and potentially irreversible changes) that have important consequences for human well-being. Examples of such changes include disease emergence, abrupt alterations in water quality, the creation of so-called dead zones in coastal waters, the collapse of fisheries, and shifts in regional climates. Over the past 50 years, humans have changed ecosystems more rapidly and more extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, freshwater, timber, fiber, and fuel. This has resulted in a substantial and largely irreversible loss in the diversity of life on Earth (Millennium Ecosystem Assessment 2005).

This analysis allows us to affirm that the maintenance of ecosystem services is positive for the quality and availability of water, so better functioning ecosystem services mean higher water quality, which could result in reduced water treatment costs. Since ecosystem services contribute to providing drinking water, it is also important that the benefits of obtaining drinking water and sanitation services be returned to the ecosystem in ways that help continue maintaining these services.

What is proposed is that part of the resources collected from billing for drinking water and sanitation services be allocated for maintaining ecosystem services. It is known that the revenue collected from billing may not be enough to maintain ecosystem services and that subsidies from the state, either central or local governments, may also be allocated for this purpose (Fig. 5.3).

## 2 Water Withdrawal, Income, and Consumption

Water withdrawals, or water abstractions, are defined as freshwater taken from ground or surface water sources, either permanently or temporarily, and conveyed to a place of use (OECD 2015). The water withdrawal data obtained for the analysis are a percentage of the internal water resource availability. The countries that extract less water from their total availability are Colombia (0.51 %), Bolivia (0.68 %), Panama (0.75 %), and Peru (0.83 %). With the exception of Panama, the other three are countries that have more water resources in Latin America. On the other hand the countries that extract more water from their own resources are the Dominican Republic (26.06 %), Mexico (19.63 %), El Salvador (13.55 %), and Argentina (12.93 %). This percentage represents the percentage of water from the country's total availability, so it could be high if the country is small and has very limited water resources, such as the Dominican Republic for example, or the country is putting a lot of pressure on water resources, for example Mexico (Fig. 5.4).

However, withdrawing more does not necessarily mean that more people receive water supply services. For instance, countries like Honduras or Nicaragua have much lower rates of water withdrawal and higher water supply levels than the Dominican Republic. Costa Rica, which withdraws less water than Venezuela, Guatemala, and Ecuador, has a higher level of water supply (Fig. 5.5).

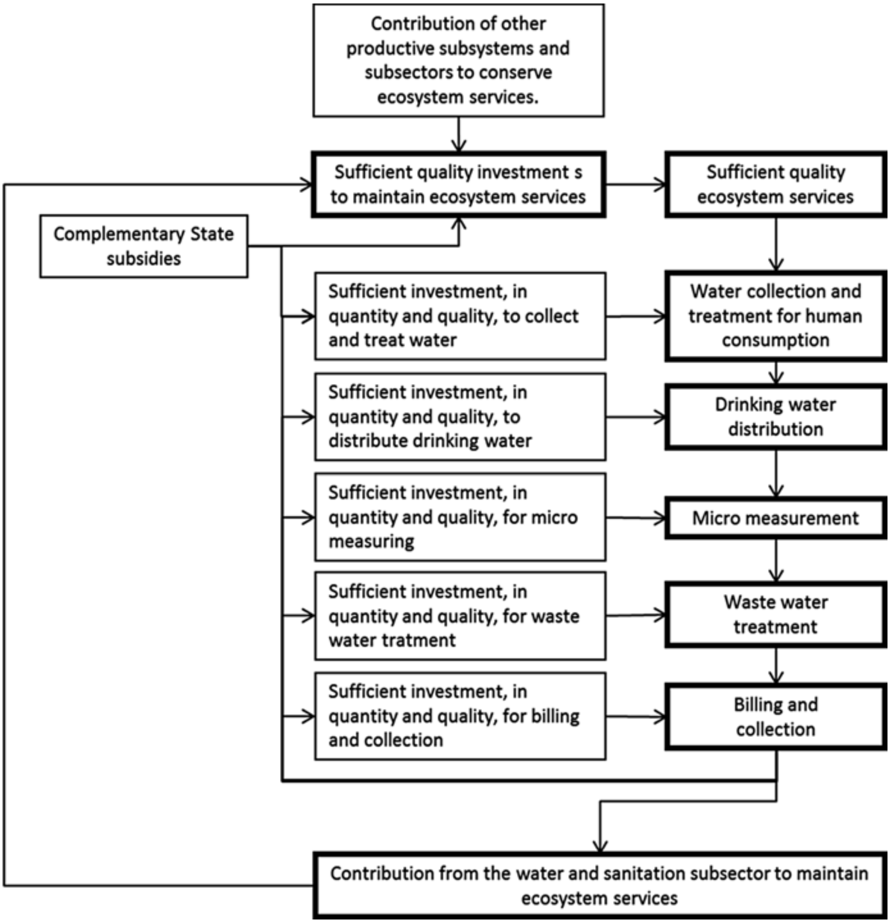



**Fig. 5.3** Provision of ecosystem services to allow drinking water supply and contribution to maintain those services

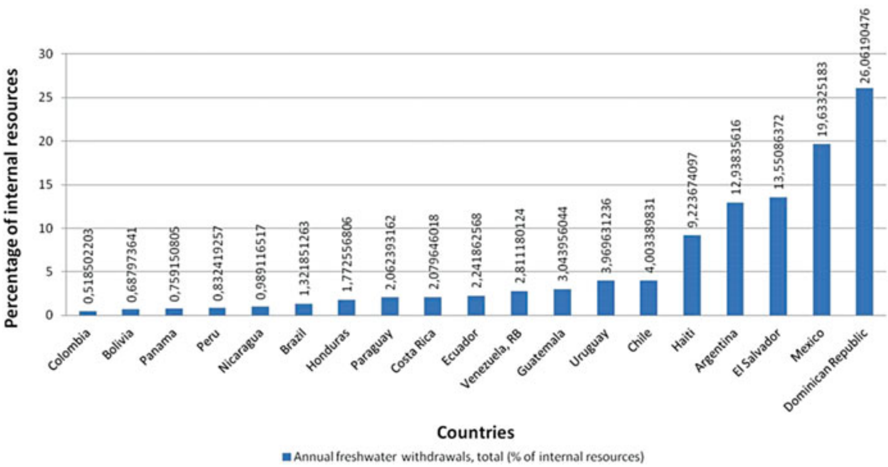



**Fig. 5.4** Latin America: Annual total freshwater withdrawal of internal resources as a percentage, 2014. Source: World Bank. 2013a, b. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. Elaboration: Vladimir Arana

Extracting more water makes someone richer, but not that much, and this is reflected in the correlations made between per capita GDP and the annual total freshwater withdrawal, where there is a tendency to increment the per capita GDP when the percentage of extraction rises. Nevertheless, this correlation has a very low ratio (0.0187), which means that this tendency is not that solid (Fig. 5.6).

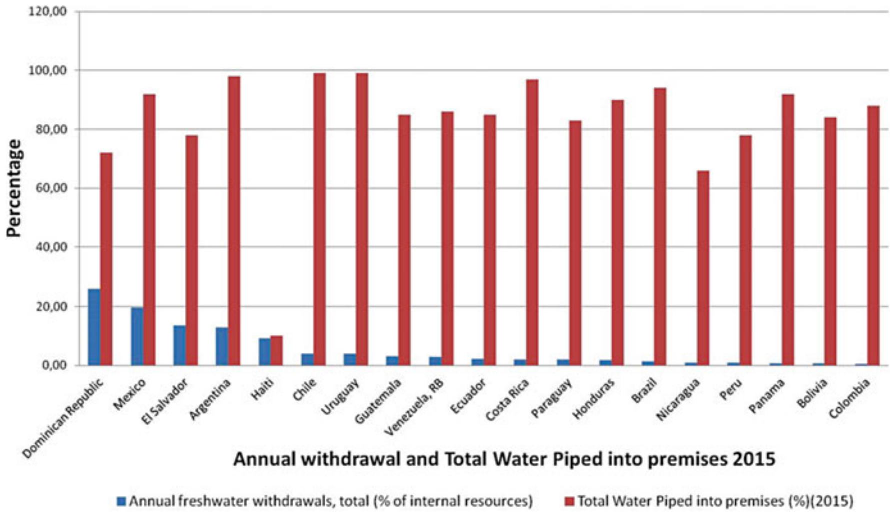



**Fig. 5.5** Latin America: Annual total freshwater withdrawal of internal resources as a percentage (2014) and total piped water supply (2015). Source: World Bank. 2013a, b. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. WHO-UNICEF – Joint Monitoring Programme for Water Supply and Sanitation. 2015. Available at: http://wssinfo.org Reviewed 18 September 2015. Elaboration: Vladimir Arana

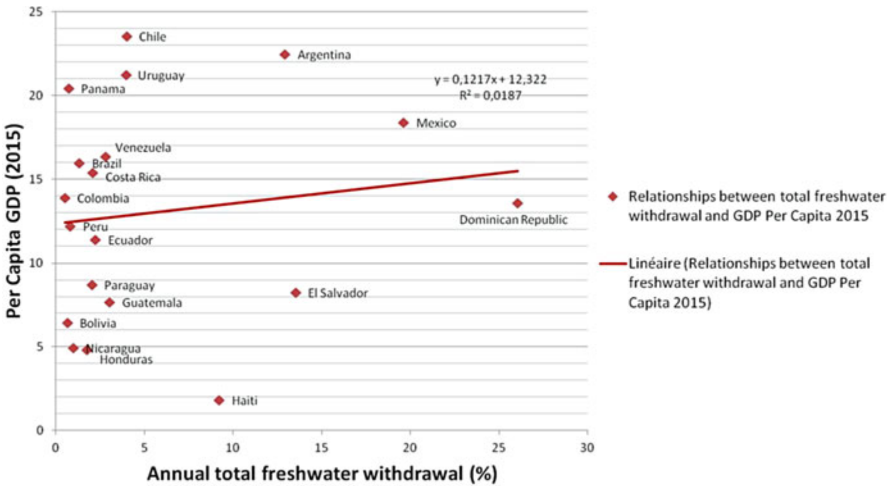



**Fig. 5.6** Latin America: Relations between annual total freshwater withdrawal of internal resources as a percentage (2014) and per capita GDP (2015). Source: World Bank. 2013a, b. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. Elaboration: Vladimir Arana

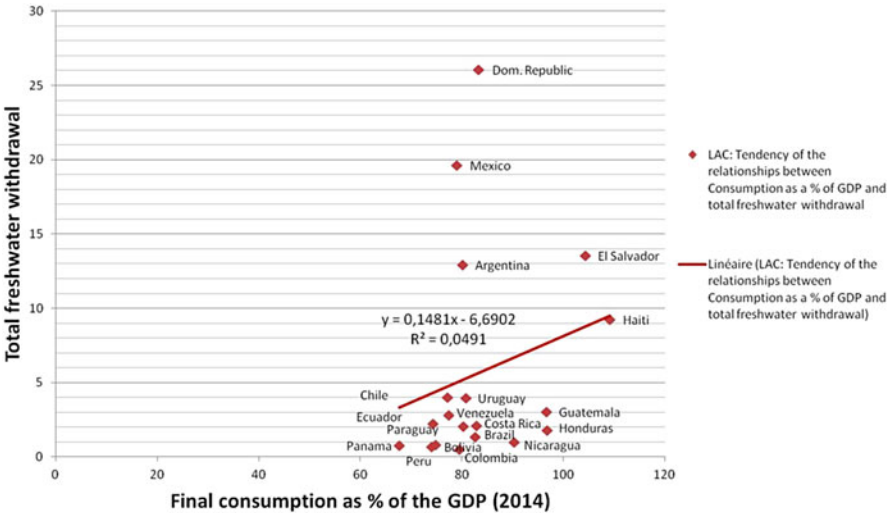



**Fig. 5.7** Latin America: Correlations between annual total freshwater withdrawal of internal resources as a percentage (2014) and final consumption as a percentage of GDP (2014). Source: World Bank. 2013a, b. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. Elaboration: Vladimir Arana

On the other hand, water withdrawal and consumption show a stronger correlation than GDP per capita and water withdrawal. There is a slight tendency, with a weak correlation (0.049), for consumption to increase when water withdrawal increases. Thus, some people in a society must be obtaining specific additional economic benefits when water withdrawal increases to justify the additional withdrawal. However, this increased consumption due to incremented water withdrawal creates no significant improvement in the country's wealth (Fig. 5.7).

The analysis of the correlation between annual total freshwater withdrawal and the rate of death by diarrhea shows that the increment of water withdrawal does not significantly reduce, or increment, deaths. Thus, the incidence of death by diarrhea does not change with increased levels of water extraction since this tendency has a very low correlation (0.0008). Hence, the volume of extraction of a country's water resources does not change the quality of water or the quality of life that depends on water consumption. This tendency may be explained by the fact that most of the water withdrawn in Latin American countries is used for agricultural purposes and less for domestic purposes (Fig. 5.8).

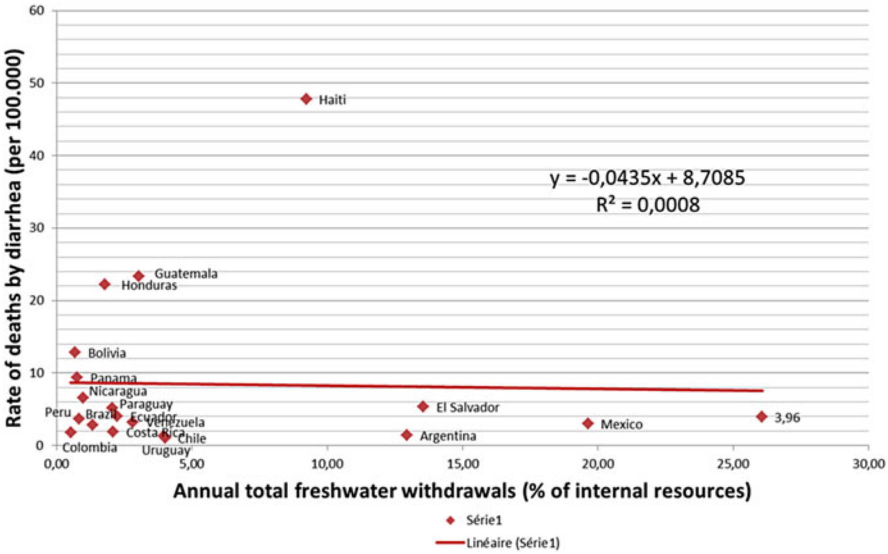



**Fig. 5.8** Latin America: Correlations between annual total freshwater withdrawal of internal resources as a percentage (2014) and rate of death by diarrhea (per 100,000) (2014). Source: World Bank. 2013a, b. World Bank Open Data. Available at: http://data.worldbank.org Reviewed 29 September 2015. Elaboration: Vladimir Arana

## 3 Impact of Water Quality in Andean Ecoregion (Ecuador, Colombia, Venezuela, Peru, Bolivia, Chile, and Parts of Argentina)

In Ecuador the annual number of deaths by diarrhea is around 1700. However only 60 % of water supply systems use disinfection, and no information was found on the populations affected by the intermittency and hours of supply (WHO 2007). The absence of disinfection in water supplies represents a permanent risk factor for disease that could rapidly increase (OPS-OMS 2001).

In Colombia, no information was found on service intermittency. However, it was found that the country has around 21 h of water supply, while 83 % of water supply systems use disinfection (OPS-OMS 2001). Colombia has the seventh highest number of deaths by diarrhea (WHO 2007).

Venezuela has 1400 deaths by diarrhea annually (WHO 2007), around 98 % of water supply systems use disinfection, and water supply service continuity is around 17 h (OPS-OMS 2001). In Bolivia, 26 % of water supply systems use disinfection (OPS-OMS 2001), a very low index compared to other countries, and no data were found on intermittency. This situation generates around 3700 deaths by diarrhea annually (WHO 2007). Chile, on the other hand, has a very low number of deaths by diarrhea, around 200 a year. This is due to the high water supply and sanitation standards. All water supply systems use disinfection, and the country has a water supply availability of 24 h (OPS-OMS 2001). Peru has the highest level of deaths by

**Box 5.1** Andean ecoregion: Quality of water supply, deaths by diarrhea, disinfection, intermittency, 2007

| Country | Deaths by diarrhea | Systems using disinfection (%) | Population affected by intermittency (%) | Average number of hours with water supply |
|---|---|---|---|---|
| Ecuador | 1700 | 60 | NA | NA |
| Colombia | 2300 | 83 | NA | 21.3 |
| Venezuela | 1400 | 98 | NA | 17 |
| Bolivia | 3700 | 26 | NA | NA |
| Chile | 200 | 100 | 0 | 24 |
| Peru | 3900 | 80 | 99.9 | 13.7 |

Source: WHO. 2007. Countries profiles of Environmental Burden of Disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of Improved Drinking-Water Sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015. OPS-OMS. 2001. Informe regional sobre la evaluación 2000 en la región de las Américas: Agua potable y saneamiento, estado actual y perspectivas. OPS, Washington, DC.

diarrhea in this group of countries, around 3900 every year (WHO 2007), 80 % of water supply systems use disinfection, and the average number of hours of water supply is 13.7 (OPS-OMS 2001) (Box 5.1).

## 4 Impact of Water Quality in Amazon Ecoregion (Brazil, Parts of Colombia, Peru, and Bolivia)

Brazil has a large population spread out over an extensive area, where 15,000 people die every year from diarrhea. However, this represents only around 0.01 % of the total population (WHO 2007). No information was found on the rate of death by diarrhea or the intermittency and hours of water supply. However, in 2011, the Brazilian NGO Mata Atlantica published a report in which it was stated that around 30 % of the water supply sources were polluted (Hispantv 2011) (Box 5.2).

## 5 Impact of Water Quality in Dry Chaco Ecoregion (Paraguay, Parts of Bolivia, and Argentina)

In Paraguay, 700 people die from diarrhea every year (WHO 2007), 100 % of water supply systems use disinfection, and water supply service intermittency is around 12.6 % (OPS-OMS 2001). The case of Paraguay is interesting because, with full disinfection and the lowest intermittency levels, this country should not see so many deaths from diarrhea. This situation might be a result of the fact that infrastructures are very old and some pollutants, like heavy metals or other suspended particulate matter, cannot be eliminated by traditional disinfection systems. Also, this ecoregion might be affected by the possible presence of the rotavirus (Box 5.3).

**Box 5.2** Amazon ecoregion: Quality in water supply, deaths by diarrhea, disinfection, intermittency, 2007

| Country | Deaths by diarrhea | Systems using disinfection (%) | Population affected by intermittency (%) | Average number of hours with water supply |
|---|---|---|---|---|
| Brazil | 15,000 | ND | ND | ND |

Source: WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015. OPS-OMS 2001. Informe regional sobre la evaluación 2000 en la región de las Américas: Agua potable y saneamiento, estado actual y perspectivas. OPS, Washington, DC.

**Box 5.3** Dry Chaco ecoregion: Quality in water supply, deaths by diarrhea, disinfection, intermittency, 2007

| Country | Deaths by diarrhea | Systems using disinfection (%) | Population affected by intermittency (%) | Average number of hours with water supply |
|---|---|---|---|---|
| Paraguay | 700 | 100 | 12.6 | ND |

Source: WHO. 2007. Countries profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015. OPS-OMS. 2001. Informe regional sobre la evaluación 2000 en la región de las Américas: Agua potable y saneamiento, estado actual y perspectivas. OPS, Washington, DC.

**Box 5.4** Paraná-La Plata ecoregion: Quality in water supply, deaths by diarrhea, disinfection, intermittency, 2007

| Country | Deaths by diarrhea | Systems using disinfection (%) | Population affected by intermittency (%) | Average number of hours with water supply |
|---|---|---|---|---|
| Argentina | 400 | 98 | NA | 24 |
| Uruguay | 80 | 100 | 0 | 24 |

Source: WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015. OPS-OMS. 2001. Informe regional sobre la evaluación 2000 en la región de las Américas: Agua potable y saneamiento, estado actual y perspectivas. OPS, Washington, DC.

## 6 Impact of Water Quality in Paraná-La Plata Ecoregion (Uruguay, Parts of Argentina, and Paraguay)

In Argentina, 98 % of water supply systems use disinfection, there is a permanent supply of drinking water, and coverage is 24 h (OPS-OMS 2001). However, the country has around 400 diarrhea deaths every year (WHO 2007).

In Uruguay, on the other hand, all water systems use disinfection and water supply coverage is 24 h (OPS-OMS 2001). Still, the country has around 80 diarrhea deaths a year (Box 5.4).

## 7 Impact of Water Quality in Central American Cordillera Ecoregion (Panama, El Salvador, Guatemala, Honduras, Nicaragua, Costa Rica, and Parts of Mexico)

Costa Rica uses disinfection in 100 % of its water supply systems. The country has 24 h water supply coverage, and 100 people die from diarrhea every year (WHO, UNICEF 2012).

El Salvador uses disinfection in 100 % of its water supply systems. More than 65 % of the population is affected by the intermittency in water supply provision, as a result of which around 800 people die by diarrhea every year (WHO, UNICEF 2012).

Nicaragua uses disinfection in 100 % of its water supply systems. More than 11 % of the population is affected by the intermittency in water supply provision, as a result of which around 1200 people die by diarrhea every year (WHO, UNICEF 2012). Guatemala uses disinfection in 25 % of its water supply systems. The country has 12 h of continuity of water supply, and 2900 people die by diarrhea every year (WHO, UNICEF 2012), the highest number of people in this ecoregion. Guatemala is on the verge of a sanitation disaster. Honduras uses disinfection in 51 % of its water supply systems. The country has 6 h of continuity of water supply, and 1500 people die by diarrhea every year (WHO, UNICEF 2012). Panama uses disinfection in all its water supply systems. The country has 20 h of continuity of water supply, and 200 people die by diarrhea every year (WHO, UNICEF 2012) (Box 5.5).

**Box 5.5** Central America Cordillera ecoregion: Quality in water supply, deaths by diarrhea, disinfection, intermittency, 2007

| Country | Deaths by diarrhea | Systems using disinfection (%) | Population affected by intermittency (%) | Average number of hours with water supply |
|---|---|---|---|---|
| Costa Rica | 100 | 100 | 0 | 24 |
| El Salvador | 800 | 100 | 65.2 | ND |
| Nicaragua | 1200 | 100 | 11.4 | ND |
| Guatemala | 2900 | 25 | 90 | 12 |
| Honduras | 1500 | 51 | 97.7 | 6 |
| Panama | 200 | 100 | 25.4 | 20 |

Source: WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015. OPS-OMS. 2001. Informe regional sobre la evaluación 2000 en la región de las Américas: Agua potable y saneamiento, estado actual y perspectivas. OPS, Washington, DC.

## 8 Impact of Water Quality in the Mexican Altiplano Ecoregion (Mexico)

Mexico has 4800 deaths by diarrhea a year, 89 % potable water coverage, and 85 % sanitation coverage (WHO UNICEF 2012).

Mexico uses disinfection in 95 % of its water supply systems, and no information is available on the population affected by the intermittency or number of hours of water supply. Every year in Mexico, 4800 people die by diarrhea (WHO, UNICEF 2012) (Box 5.6).

## 9 Quality of Services in Latin America

Water supply services and sanitation in Latin America are not the best; they are not the worst either, but the impact on health and on the lives that these shortfalls make are critical. Low income is also important because the lack of water supply and sanitation are not the only causes of diseases and deaths. If we compare the correlations between the per capita GDP and the rate of deaths by diarrhea we find that the relationship is somewhat strong, which means the tendency is solid. So the tendency could be expressed as something like: "Less income, more deaths by diarrhea" (Fig. 5.9).

The provision of water supplies and sanitation services also strongly impacts the rate of death by diarrhea, and the correlation is higher than that between per capita GDP and the rate of death by diarrhea. Thus, here as well the tendency is also very solid, so a conclusion of this analysis may be expressed as follows: Less water and sanitation are related to even more deaths by diarrhea than a lower income (Fig. 5.10).

More or less the scenerio is the same when we compare the percentage of systems that use disinfection with the rate of death by diarrhea. The tendency is strong and shows the impact of a lack of disinfection on people's live. Death by diarrhea should not be a major threat to human lives in the twenty-first century, but unfortunately it is (Fig. 5.11).

**Box 5.6** Mexican Altiplano ecoregion: Quality in water supply, deaths by diarrhea, disinfection, intermittency, 2007

| Country | Deaths by diarrhea | Systems using disinfection (%) | Population affected by intermittency (%) | Average number of hours with water supply |
|---|---|---|---|---|
| Mexico | 4800 | 95 | ND | ND |

Source: WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015. OPS-OMS. 2001. Informe regional sobre la evaluación 2000 en la región de las Américas: Agua potable y saneamiento, estado actual y perspectivas. OPS, Washington, DC.

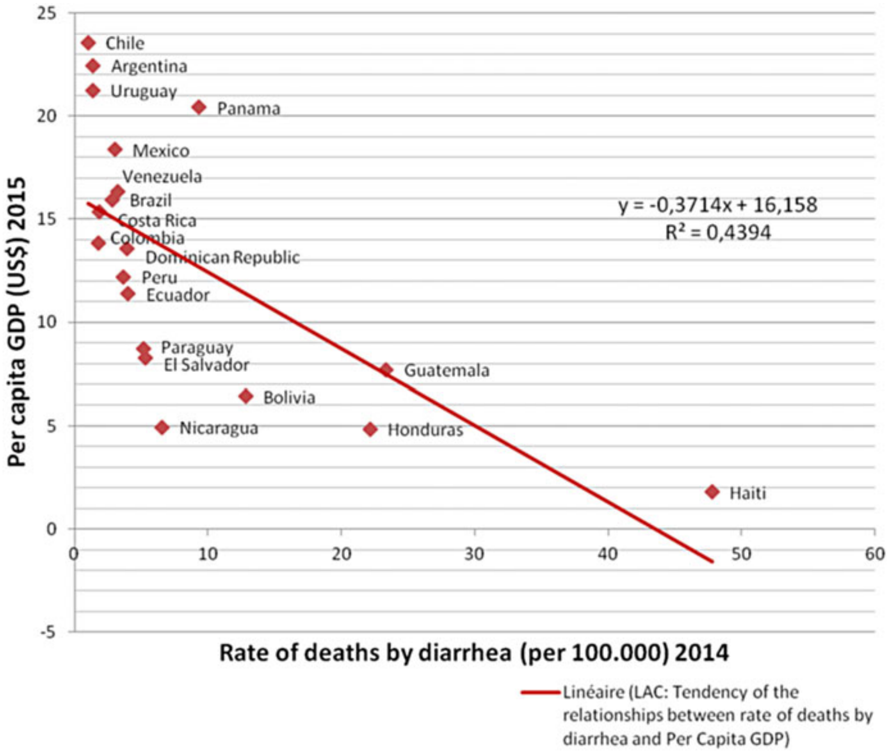



**Fig. 5.9** Latin America: Correlations between deaths by diarrhea (per 100,000) (2014) and per capita GDP (2015). Source: World Health Rankings. 2014. Diarrhoeal Diseases—Death Rate Per 100,000. Available at: http://www.worldlifeexpectancy.com/cause-of-death/diarrhoeal-diseases/by-country/ Reviewed 30 September 2015. WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015

## 10 Sustainability of Services in Latin America

In Latin America, the ecosystem services approach is relatively new; it is also called hydrological environmental services or environmental services (Carnevale et al. 2006) in exchange for what has been referred to as, for example, payment for environmental services or compensation for ecosystem services, with a special focus on environmental management, protected areas conservation, climate change adaptation, forest development, or ecosystem biophysical dynamics impact. Despite all the economic development that has taken place in the region in recent decades, Latin American countries are just beginning to develop strategies and legislation to maintain ecosystem services and enhance the contribution from productive activities (FAO-OAPN 2009).

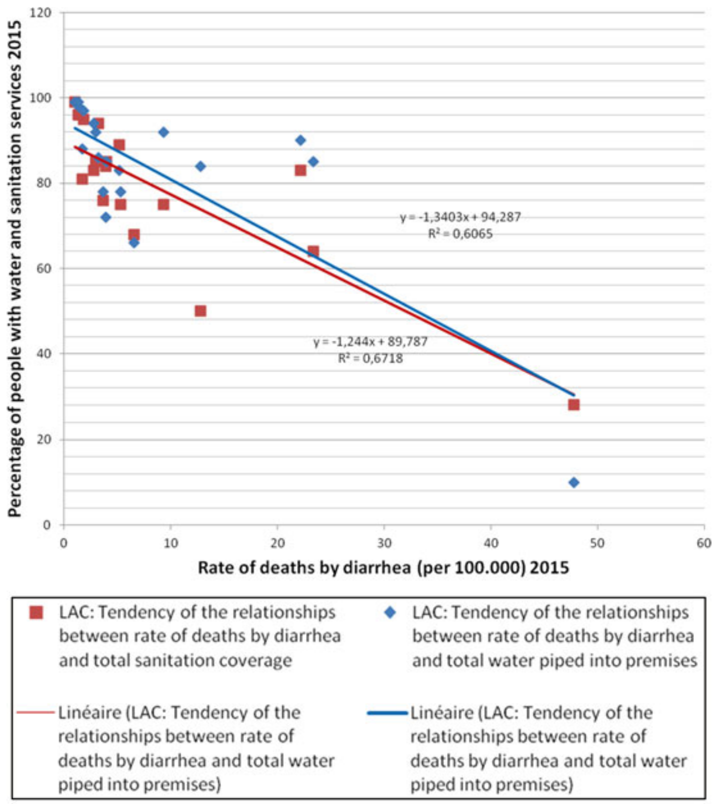



**Fig. 5.10** Latin America: Correlations between rate of death by diarrhea (per 100,000) (2014) and percentage of people with access to water supply and sanitation services (2015). Source: World Health Rankings. 2014. Diarrhoeal Diseases—Death Rate Per 100,000. Available at: http://www.worldlifeexpectancy.com/cause-of-death/diarrhoeal-diseases/by-country/ Reviewed 30 September 2015. WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015

Different Latin American countries have different experiences, and those experiences are reflected in the ecosystem services agenda. In Mexico, "despite efforts to achieve water resource management (WRIM), this has not happened because of several limitations. The analysis that was coducted in the period 2003–2009 in Mexico and in the federal district, the Payment for Environmental Services program had many operative, legislative, institutional, and economic constraints. So ultimately it did not achieve the initially established environmental and social goals, such as a reduction in forest coverage loss to benefit water collection, to contribute to poverty reduction, and to create self-sustaining environmental services markets" (Perevochtchikova and Vázquez 2010).

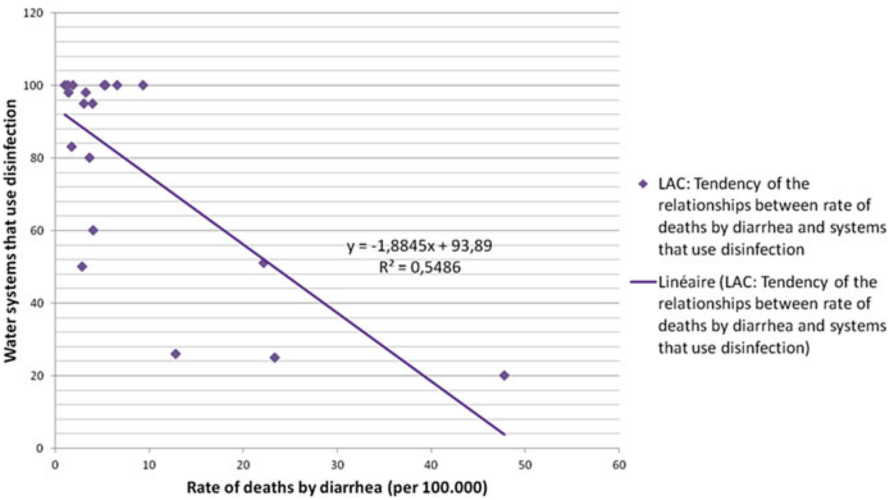



**Fig. 5.11** Latin America: Correlations between rate of death by diarrhea (per 100,000) (2014) and the percentage of systems using disinfection. Source: World Health Rankings. 2014. Diarrhoeal Diseases—Death Rate Per 100,000. Available at: http://www.worldlifeexpectancy.com/cause-of-death/diarrhoeal-diseases/by-country/ Reviewed 30 September 2015. WHO. 2007. Country profiles of environmental burden of disease. WHO, Geneva; WHO, UNICEF. 2012a. Joint Monitoring Programme for Water Supply and Sanitation. Estimates for the use of improved drinking-water sources. Available at: http://www.wssinfo.org Reviewed 30 September 2015

In Ecuador, the Group Sciences of the Earth from the University of Cuenca developed, between 2008 and 2010, a long-term initiative to study the (1) relationships between climate and hydrology, (2) water production capacity, (3) the impact of forest coverage on water production, (4) the interrelations between water, aquatic organisms, and vegetation as ecosystem health indicators, and (5) responses to climate change. The goal of this project was to promote the sustainable development of water resources and highland basin conservation (Grupo Ciencia de la Tierra y el Ambiente 2011). This valuable experience could be incorporated into national government policies. The government is still working on strengthening their policies on ecosystem services.

Several organizations, especially conservation and agricultural development organizations, study the cases of Bolivia, Brazil, Colombia, Ecuador, Peru, and Venezuela, which have put in place legislation related to water and forests and to ecosystem services (IA et al. 2007). Compensation for ecosystem services is a new subject in environmental policy, and clear national mechanisms are still being worked out.

Paraguay and Peru have implemented respectively the Assessment and Payment for Environmental Services Law and the Payment for Ecosystem Services Law, and other countries in the region are moving in the same direction. Brazil and Argentina are under a lot of pressure from civic organizations to establish ecosystem services payment legislation. In Brazil, Bill 5.487/09 has come up against many obstacles at the federal level.

In Fuquene, Colombia, the Andean Basin project has been working to reduce organic matter in Fuquene Lake, helping farmers to obtain loans and change their agricultural practices by environmentally friendly and sustainable practices, and at the same time experimenting with a payment for environmental services (Porras and Neves 2006), but in a way that is not connected with drinking water demands. Other Latin American cases show similar scenarios, where ecosystem services or environmental services projects do not explain how these services generate biophysical conditions to generate sufficient drinking water, in the right quality and quantity.

On the other hand, more research is needed on the internalization of responsible water use. Water tariffs in Latin America do not discriminate if a household consumption is basic or abundant and there are no incentives, disincentives, or incremental costs for consuming high volumes of water. Some water supply companies have launched water conservation campaigns with little in the way of positive results.

No studies were found by Latin American water supply companies identifying their vulnerability to climate change. Since most of the Latin American population lives in cities and the effects of phenomena like climate change are becoming increasingly stronger, it is very important to identify very clearly all the climate change vulnerabilities and carefully assess corresponding adaptation measures.

## 11 Investment in Basins, Water, and Sanitation

Hydrographic basins offer many services to society. Freshwater supplies for domestic, agricultural, and industrial uses depends largely on the produced flows that help regulate basins (FAO 2010a, b). In addition, there is an important relationship between water in basins and drinking water supplies, where a larger availability of renewable water resources is linked to higher water supply coverage (WHO, UNICEF 2015; Aquastat 2011).

Water use for human consumption, or drinking water, is one of the consumptive uses of water. A consumptive use is one in which water is not sent back immediately to the water cycle. For instance, irrigation is a consumptive use, while energy generation through river water turbines is not a consumptive use as long as water is not retained and immediately discharged in the same river. In agriculture, consumptive uses are those involving water that evaporates from the soil, water transpired by plants, and water that constitutes plant tissues (Lingsley and Franzini 1978).

In recent decades, two hydrological environmental management concepts, complementary to each other, have been used to promote an integrated and holistic approach: the ecosystems approach and water resources integrated management. These two concepts are holistic, the first one based on ecosystems management and the second one based on water management. The importance of water for society, the integrated and holistic vision, and modern water management concepts lead us to a common idea: the obligation to protect water functions for society in such a way as to protect nature, which provides these benefits (Quintero, 2010).

If this obligation is combined with the "user pays" principle, then water for consumptive and nonconsumptive uses should be valued and accounted for through ecosystem services payment mechanisms, compelling users, including drinking water users and other productive users, contribute to maintaining the ecosystem services on which we all depend.

The "water polluter pays," "pollutant cleaners receive compensation," and "water user pays" or "water volume enhancer receives compensation" principles are based on the so-called user/polluter/payer trilogy that is part of the basin management approach. Under this approach, water tariffs may make it possible to finance (through loans and donations) community projects that could positively impact ecosystem services (Dourojeanni 2010).

However, this approach may have its critics, who want to "promote the idea of water as a commodity of great economic value, able to become a sustainable source of income. So then, water is decoupled from its human rights dimension, a vital character. The argument to consider water as a commodity is that its use will be more rational and careful. This argument has one valid point: we tend to protect what is more costly to obtain. However, the consequences could be severe if water use is governed by the law of supply and demand. Water tariffs and charges could be dangerous mechanisms from the moment tiered pricing is imposed based on its concession, use, and supply terms (Betto 2010).

Basin ecosystem service maintenance may require contributions from (1) the water supply and sanitation sector, (2) other consumptive and nonconsumptive users, and (3) complementary subsidies from the state. This approach to maintaining ecosystem services would be a key first aspect that would strengthen sources to allow for the provision of water supply and sanitation. A second aspect would be the financial sustainability of water supplies, including water collection and treatment, distribution, micromeasuring, billing, and collection. A third aspect, also key to increasing financial returns, would be wastewater treatment and reuse.

A key issue is to have a clear, simple, and precise method of identifying the investment needed to maintain ecosystem services. However, there are presently no methods that would allow us to identify the costs of maintaining basin ecosystem services.

There is also little reference to costs or benefits made by basin water organizations, for instance, the costs of multiple-use hydraulic infrastructures, draught effects, underground water overexploitation, urban and rural drainage, or water pollution. In other words there are no quantitative figures identifying the costs and benefits that would make it possible to justify measures to strengthen water management at the basin level. This is a key aspect that organizations must address when putting forth water policies. In addition, in Latin America, basin water organizations rarely carry out cost/benefit studies to allow for a strengthened integrated management of basin resources (CEPAL 1998).

It is important to have an approximate cost of maintaining ecosystem services in order to estimate the contribution needed from all consumptive and nonconsumptive uses, and in what cases the state may need to provide subsidies. Thus, to help strengthen the ways of estimating the investments needed to maintain basin ecosystem services, the author developed a *focus group* where it was shown, in a very specific way, several criteria to identify these investment requirements.

To elaborate the following classification matrix, the available volume of water was a key aspect to determining basins' sufficiency or limitations that show there is a capacity to provide ecosystem services. So in Latin America basins with large volumes of water or more than 10,000 $m^3/s$ include the Amazon with 230,000 $m^3/s$ (Oliveros 2009), the Orinoco with 30,000 $m^3/s$, the Paraná with 25,700 $m^3/s$ (Biblioteca de investigaciones 2012), and La Plata with 25,000 $m^3/s$ (OAS 2006).

Basins with moderate volumes of water were defined as those having between 100 $m^3/s$ and 10,000 $m^3/s$, among which are the Guayas in Ecuador with 1,156.87 $m^3/s$ (Montaño and Sanfeliu 2008), the Canete in Peru with 244 $m^3/s$ (Andina 2012), and the Baudó in Colombia with 706 $m^3/s$ (Lobo-Guerrero 2008). Basins with a lower volume were defined as those with less than 100 $m^3/s$, and they include the Lurin with 6.7 $m^3/s$ (Emanuel and Escurra 2000) and Chili with 25 $m^3/s$ (Falcón 2009) in Peru and the Loa with 1.9 $m^3/s$ (MMA 2010) in Chile.

Additionally the extension of a basin was added as a relevant factor affecting the costs of maintaining it. This is because the size of a basin directly influences surface runoff, and when the size of a basin increases, the volume of water also increases (Comeca and Meléndez 2008). A basin's area is the most important geomorphological characteristic in project design. It is defined as the horizontal projection of the total drainage area of a runoff system outflowing to the same outflowing watercourse (Webdelprofesor 2002).

A classification of basins was also elaborated. Large basins were those with more than 25,000 $km^2$, medium basins those between 5,001 and 25,000 $km^2$, and small basins those with less than 5,000 $km^2$. Population ranges were also identified and classified in six groups as follows: less than 100 thousand inhabitants, between 100 thousand and 1 million, between 1 million and 3 million, between 3 and 10 million, between 10 and 30 million, and more than 30 million inhabitants, which represent different levels of population pressure on water resources and territories.

In general, basins with a low volume of water and reduced extension will have more issues with respect to providing water and face challenges when it comes to providing ecosystem services. Basins with large volumes of water and larger extensions have a broader range of ecosystem services, a situation that makes water collection for drinking purposes less costly. These costs rise when population and economic activity pressures also rise. Small basins with lower volumes of water and high population pressure may need extra water that will have to come from other basins, making human and economic development more costly and less efficient (Arana 2012b) (Box 5.7).

Following this approach, and to identify the contributors that would help to maintain basin ecosystem services, we must list the consumptive and nonconsumptive users and share proportionally the cost of maintaining ecosystem services. In Latin America, the agricultural sector is the largest consumer of water, followed by domestic and industrial uses. It is the benefit derived from marginal water use and vulnerable sectors that may need state subsidies in fair proportions and in an appropriate amount that does not create dependency (Fig. 5.12).

**Box 5.7** Scheme of a classification matrix to identify investment levels needed to maintain basins' ecosystem services by type of basin with different population and economic activity pressures

| Basin size by water volume | Extension of the basin | Population and economic activity pressure on basin (thousands of inhabitants) | | | | | |
|---|---|---|---|---|---|---|---|
| | | <100 | 100–1,000 | 1000–3000 | 3000–10,000 | 10,000–30,000 | 30,000–more |
| High volume | Large | Very low | Very low | Low | Low | Moderate | High |
| | Medium | Very low | Very low | Low | Moderate | High | High |
| | Small | Low | Low | Moderate | High | High | Very high |
| Moderate volume | Large | Very low | Very low | Low | Moderate | Moderate | High |
| | Medium | Low | Low | Moderate | Moderate | High | Very high |
| | Small | Low | Moderate | Moderate | High | High | Very high |
| Low volume | Large | Low | Low | Moderate | Moderate | High | Very high |
| | Medium | Low | Moderate | Moderate | High | High | Very high |
| | Small | Moderate | Moderate | High | High | Very high | Very high |

Very low, Low, Moderate, High, Very high

Source: Arana, Vladimir. 2012b. Focus group systematization to identify basins' investment requirements by type of basin, population pressure, and economic activity. Working paper. 3 April 2012. Lima, Peru

**Box 5.8** México: Cost of current water sources in the valley of the Mexico City Metropolitan Area (Hernandez and Morillón 2006)

| Number | Area | Volume ($m^3/s$) | Charge (m) | Distance (km) | Energy cost (USD/$m^3$) | Potabilization cost (USD/$m^3$) | Water source investment cost (USD/$m^3$) | Clean water transportation cost (USD/$m^3$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Cutzamala | 14.5 | 1100 | 127 | 2.1 | 0.16 | 3.885 | 6.145 |
| 2 | Lerma | 5.9 | 123 | 57.3 | 0.278 | 0.053 | – | – |
| 3 | Pozos | 43.4 | NA | NA | 0.495 | 0.053 | – | – |
| 4 | Surface | 1.2 | NA | NA | 0 | 0.16 | – | – |

| | | | | | | |
|---|---|---|---|---|---|---|
| Resources needed to maintain ecosystem services | = | Sufficient tariff by incremental volume of water used by consumptive and non-consumptive users | x | Marginal benefit by use of water factor | x | Level of vulnerability that may require State subsidies factor |

**Fig. 5.12** Resources needed to maintain ecosystems

## 12 Costs of Water Supplies and Sanitation in Latin America

In Latin America, the required investment changes depending on the country, population volume, geographical factors, and other factors described in this section.

### *12.1 Mexico: Investment Costs of Supplying Water*

In the case of the valley of the Mexico City Metropolitan Area, the demand for water has risen to 70 $m^3/s$, and it is recommended that external sources be specifically sought to prevent collapses in the city's territory. The city of Mexico as a territory is supported by the water underground. In general, the costs of energy to transport water and current and projected infrastructure costs are high. Potabilization costs are low compared to neighboring countries, and wastewater treatment costs are high.

Cost estimates were obtained through the Leveled Costs method, at a 12 % discount rate and a 30 years life at constant prices (Hernandez and Morillón, 2006). Several points of origin, future and current, were identified and show water sources and their costs to meet the 70 $m^3/s$ demand (Box 5.8): On the other hand, the National Water Commission (CONAGUA) has identified future potential sources from which the city of Mexico could obtain its water; the costs are by the cubic meter (Box 5.9).

A key aspect that is not commonly mentioned is the water source investment cost, which varies from USD 0.66/$m^3$ to USD 4.04/$m^3$; another factor is the clean water transportation cost, which ranges from USD 6.145/$m^3$ to USD 9.821/$m^3$. These numbers give us an important investment cost reference that could be applied in similar urban scenarios.

### *12.2 Ecuador: Rural Water Supply Costs*

In a water supply project in a oil concession, three rural areas were identified: (1) regional system 1, to provide water to communities and areas in the northern part of the Aguarico River (Cascales, Agrio Lake); (2) regional system 2, to provide

**Box 5.9** México: Cost of future water sources for the valley of the Mexico City Metropolitan Area (Hernandez and Morillón 2006)

| Number | Area | Volume ($m^3/s$) | Charge (m) | Distance (km) | Energy cost (USD/$m^3$) | Potabilization cost (USD/$m^3$) | Water source investment cost (USD/$m^3$) | Clean water transportation cost (USD/$m^3$) |
|---|---|---|---|---|---|---|---|---|
| 1 | Amacuzac | 13.5 | 1700 | 95 | 4.01 | 0.16 | 4.403 | 8.573 |
| 2 | Tecolutla I | 9.8 | 1266 | 143 | 4.74 | 0.16 | 3.597 | 8.497 |
| 3 | Temascaltepec | 5.0 | 1570 | 142 | 2.99 | 0.16 | 2.654 | 5.804 |
| 4 | Tezontepec | 7 | 323 | 61.5 | 0.71 | 1.12 | 0.66 | 2.49 |
| 5 | Wasterwater reuse | 7.4 | – | – | 0 | 8.87 | – | 9.821 |

water to communities located inside the area defined by the Aguarico River in the north, the Coca River in the west, and the Napo River in the south (Agrio Lake, Shushufindi, Sacha); and (3) regional system 3, to provide water to communities in the Orellana region.

Design and implementation criteria called comprehensive and covering were used that seek to ensure water sources were, in terms of quality and quantity, pollution free for the present and the future, as well as a physical and administrative structure that gave sustainability to the systems in terms of operation, maintenance, and financing. The cost of the three systems was USD 428,004.02. Per capita costs for regional systems 1, 2, and 3 were around USD 1,206, USD 1,237, and USD 1,917. These costs were calculated for the year 2027 population projection using a population growth rate of 4.4 %. The average cost for the three systems is USD 1,229. The inflation adjustment rate is 3 % for the year 2027, and it gives an average per capita cost of USD 1,342 (Scardina 2010).

## *12.3 Bolivia: Urban Water Supply Costs*

In southern Cochabamba, most families (95 % of districts 7, 8, and 14, and about 45 % in district 9) obtain water from private providers: water tank trucks or *aguateros*. This practice affects users directly who have to pay around USD 2.5 to USD 3.12 for each cubic meter, which is 25 times more expensive than the water paid through the city's water company, that is, between 0.12 and 0.36 by cubic meter. These populations are among the poorest of the city of Cochabamba and they are forced to consume as little as they can, which is around 20 L/inhabitant/day. This volume is the minimum that is distributed during humanitarian catastrophes. Water distributed to water tank trucks has the worst quality and the origin and the storage conditions are unknown (Achi and Kirchheimer 2006).

The cost of connecting these water committees is very expensive for these people, around USD 50 to USD 800, an average of USD 277.00. Forty-two percent of the built systems had costs below USD 210. This expensive connecting cost is discriminatory for many families that cannot afford this investment. Urban communities that have water pits obtain water at lower prices, but the water is not potable owing to underground pollutants. In addition, chlorine is not added so the water can be distributed more quickly (Achi and Kirchheimer 2006) (Box 5.10).

The Pro Habitat Foundation developed six water systems; the initial average connection cost per family was around USD 150.00, while the connection cost made by the Public Water Supply and Sanitation Company (SEMAPA) was around USD 210.00. In addition, the family repays USD 10 to USD 12 monthly over the course of a year. The result is that low-income families have access to water. However, the poorest families (whose income is USD 1 to USD 2 a day) are not connected to this service because USD 12 may mean food for 12 days, which they are not able to give up. A combined subsidy, solidarity, and market mechanism needs to be identified to eradicate economic exclusion.

**Box 5.10** Bolivia: Water supply connection costs by family in Cochabamba's Water Committees developed by the Pro Habitat Foundation

| Number | District | Project stage | Number of beneficiaries | Initial connection costs by family (USD) | Trench digging community works |
|---|---|---|---|---|---|
| 1 | María Auxiliadora | Since 2003 | 370 families | 65 (real cost 130) | Yes |
| 2 | Barrios Unidos | Since December 2004 | Start: 120 families; p resent: 142 families | 175 | No |
| 3 | Alto Pagador | Since September 2005 | Start: 405 families; present: 420 families | 149 | Yex |
| 4 | SPR | Since February 2005 | Start: 101 families; present: 120 families | 160 | Yes |
| 5 | Ticti Sud | Since November 2005 | Start: 123 families; present: 165 families | 166 | No |
| 6 | 21 de Septiembre | In implementation | 90 families | 164 | Yes |
| | | | Total: 1307 families, 6535 people. Average/committee: 218 families | Average: 149.5 | |

Source: Achi and Kirchheimer 2006.

## *12.4 Paraguay: Costs of Water Supplies and Sanitation in Rural Indigenous Areas*

In 2009, the InterAmerican Development Bank started a Water Supply and Sanitation in Rural Indigenous Areas Program. This program had a goal of providing water and sanitation to rural indigenous communities with less than 2000 inhabitants, aiming to improve their quality of life in the short term. Goals were set to extend water supply and sanitation coverage in rural and indigenous communities in a sustainable way, to develop a pilot solid water management program, and to strengthen SENASA's management capacity (BID 2009).

Under the program a new water supply and wastewater facilities were built in 400 rural communities, encompassing 32,000 families and 40 indigenous communities with 3200 indigenous people. The program had four main results: (1) increased investments in infrastructure, (2) project preparation and community development, (3) sold waste management pilot program, and (iv) institutional building for SENASA (BID 2009)

The estimated budget for this operation was USD 60 million, of which USD 40 million would be funded with the Water and Sanitation Fund for Latin America Spanish Fund, USD 12 million came from ordinary capital, and USD 8 million was a local contribution (BID, 2009). This program had an estimated cost per capita of around USD 1600.00, but if just water supply and sanitation costs were considered, the cost per capita would be USD 1190.00 (Box 5.11).

**Box 5.11** Paraguay: Costs and financing from the Rural Indigenous Water and Sanitation Program (BID 2009)

| Category and components | SFW | IADB | Local contribution | Total | % |
|---|---|---|---|---|---|
| I. Engineering and administration | 5.00 | 2.75 | 1.90 | 9.65 | 16 % |
| 1. Program administration | 1.50 | 0.00 | 1.50 | 3.00 | |
| 2. Civil works supervision | 2.50 | 1.25 | 0.25 | 4.00 | |
| 3. Studies and projects | 1.00 | 1.50 | 0.15 | 2.65 | |
| II. Direct costs | 35.00 | 8.75 | 4.60 | 48.35 | 81 % |
| 1. Water supply and sanitation systems | 32.00 | 7.25 | 3.60 | 42.85 | |
| (a) Rural communities | 28.00 | 6.25 | 3.60 | 37.85 | |
| (b) Indigenous communities | 4.00 | 1.00 | 0.00 | 5.00 | |
| 2. Solid waste pilot program | 0.00 | 1.50 | 0.50 | 2.00 | |
| 3. Institutional building | 3.00 | 0.00 | 0.50 | 3.50 | |
| III. Concurrent costs | 0.00 | 0.50 | 0.00 | 0.50 | 0.8 % |
| 1. Auditing, monitoring, and evaluation | 0.00 | 0.50 | 0.00 | 0.50 | |
| IV. Financial costs | 0.00 | 0.00 | 1.50 | 1.50 | 2.5 % |
| 1. Interests | 0.00 | 0.00 | 1.50 | 1.50 | |
| Total costs | 40.00 | 12.00 | 8.00 | 60.00 | 100 % |

### *12.5 Honduras: Urban Informal Water Costs*

In Tegucigalpa, the capital of Honduras, field research was conducted in three colonies, considered to be highly representative of high-, medium-, and low-income districts, respectively: Las Lomas del Guijarro, Miraflores Colony, and Nueva Suyapa Colony. Surveys, interviews, and visits were made in all three areas.

The three areas had very different average storage capacities: 25 $m^3$ in Las Lomas del Guijarro, 6 $m^3$ in Miraflores Colony, and 2 $m^3$ in Nueva Suyapa Colony. SANAA, the local public water supply company, had at the time 25 water tank trucks to distribute water in areas with difficult access. Another group, known as the *aguateros* (informal water providers), sells water barrels depending on supply and demand conditions. In some poor colonies, a barrel of salty water costs around 13 to 15 lempiras (USD 0.8 to USD 1). The poorest are forced to obtain water in this way because SANAA does not provide services. SANAA's table of water prices indicates that 20 $m^3$ of drinking water costs 25 lempiras (USD 1.51), while 60 $m^3$ costs 337 lempiras (around USD 20) (Revistazo 2002).

However, in the New Suyapa colony, families spend from 35 to 1600 lempiras to obtain the vital liquid. There a family's average income is around 2467 lempiras per month (USD 150), so around 60 % of the budget may go to obtaining drinking water. The lowest expense is for SANAA and the highest expense is for the water tank trucks (Revistazo 2002).

## 13 Private Investment in Latin America

The common factor during the water supply and sanitation reforms during the 1980s and 1990s in most Latin American countries was the private sector participation. In many cases, reforms were subordinated to the establishment of private sector control. Many of those that promoted this private sector participation in water supply management thought that it would generate a double benefit: on the one hand, it would bring in much needed funds and, on the other hand, management and technology, which would help resolve public sector deficiencies.

Also, in these decades, it was believed that macroeconomic countries' situation would improve (since the sale of loss-making public companies would help maintain the fiscal accounts balance and would send positive signals to investors) and attract the interest of large international investors. However, other private participants, such as national investors, local entrepreneurs, cooperatives, and small providers, were ignored. In addition, no incentives considered to increase public sector efficiency (CEPAL/GIZ 2010).

In Latin America, almost all counties have adopted policies to enhance private participation. As a result, private participation increased to 15 % of investments, higher than even the world average of 10 %. In most of half of the Latin American countries, we find several different kinds of public participation, like sales of stocks, concessions, BOT – Build, Operate and Transfer – management contracts, and others, on different scales, large, medium-sized, and small cities, tourist zones, and so forth, and with different productive forms (e.g., complete service, partial service, in some production cycles).

Private participation has been more the exception than the general rule, and two significant cases may show how it went. The first one was in Argentina, where private participation went from 13 % in urban coverage in the 1980s (mainly cooperatives) to 70 % in the 1990s and 30 % at the present time. The second one was in Chile, where private participation was 3 % in 1998 and went to 96 % at the present time, and where the remaining 4 % is provided by municipalities.

Between 1991 and 2008, in Latin America, more than 200 private water supply and sanitation projects were started, which is around 30 % of all private participation projects in developing countries. Of these projects, 75 % started between 1996 and 2004, with a fast rate of growth during 1991 and 1997, stable growth from 1997 to 2004, and a rapid fall after 2004 (CEPAL/GIZ, 2010).

It is estimated that private participation projects in water supply and sanitation had investment commitments of around USD 24 billion, which would be 40 % of all private investment in the same sector in developing countries. However, the calculation methodology tends to exaggerate private investment since theoretical commitments are made, not effective disbursements. In the region, the most important impacts were not on coverage expansion but on operating efficiency.

Coverage evolved in more or less the same way in areas with and without private participation. In general the initial goals were not fulfilled, which created conflicts and renegotiations that in some cases caused international operators to leave the country. In Latin America 75 % of private participation contracts in water supply and sanitation were renegotiated (CEPAL/GIZ 2010).

## 14 Investment Requirements in Latin America

Water is not only a complex resource to manage; it is also a key infrastructure sector in a country, essential for economic development, social progress, and poverty reduction. According to Global Water Intelligence (Global Water Intelligence 2009), the global financial presence of the water supply and sanitation sector was around USD 500 billion per year. In 2010, the water supply and sanitation sector in Latin America was a USD 25,000 million market per year, including USD 20,000 million in operational costs and USD 5,000 million in investments (CAF, 2011).

To close the infrastructure gap in the 2010–2030 period roughly USD 250,000 million in investment is needed, an amount equivalent to average annual investments of USD 12,500 million (CAF, 2011). This value represents 0.3 % of the regional aggregated GDP for 2010, which would be a reasonable amount of financial resources, considering the low national budgets and tariff revenue, at efficient rates, and equity criteria, to repay the investment. With this investment the Latin American region would have 100 % coverage in water supply, 94 % in sanitation networks, and

**Box 5.12** Latin America: Costs and proposed goals to reduce water supply and sanitation gap, 2010–2030

| Service | Billions of USD | Billions of USD average/year | Goals for 2030 |
|---|---|---|---|
| Water supply[a] | 45.4 | 2.27 | 100 % coverage |
| Sanitation[a] | 79.4 | 3.97 | 94 % coverage |
| Wastewater treatment[a] | 33.2 | 1.66 | 64 % depuration |
| Drainage[a] | 33.6 | 1.68 | 85 % in urban areas |
| New water sources | 27.1 | 1.35 | 100 % incremental demand |
| Formalizations of connections of water supply and sanitation | 30.5 | 1.52 | 50 % gap reduction (20 million of dwellings) |
| Total | 249.2 | 12.45 | |

[a]Expansion, rehabilitation, and renewal
Source: CAF 2011

85 % of urban areas would have pluvial drainage infrastructure. Complete water supply and sanitation coverage in the urban areas of the region could be reached in 20 years (CAF, 2012) (Box 5.12).

If the regional GDP grows at a 4.5 % rate, as estimated by the Economic Commission for Latin America and the Caribbean (ECLAC), with a regional investment of 0.3 % of GDP for 2030, the water supply and sanitation goals could be met by 2023. For this calculation an annual inflation rate of 2.5 % was assumed. On the other hand, if the aggregate GDP growth reaches 3 % and inflation continues at the same rate, the goals could be reached by 2027, or the average investment increase could be 14 %. In any case, GDP as projected by CEPAL, even in the most modest scenarios, shows a likelihood that the proposed water supply, sanitation, and drainage goals will be reached (CAF 2011).

## 15 Conclusions

Latin American countries need to include in their statistics indicators that may allow the measurement of water quality service in all its aspects, also including the correlations between quality levels and other vital impacts, such as per capita income, health, and education, to measure progress and to be able to compare each country's situation with others'.

Water supply and sanitation have a strong impact on diarrheal diseases, including deaths by diarrhea.

Latin American countries still have many deaths by diarrhea, which is an unimaginable situation in the twenty-first century, and even proportionally, the fact the rate of death by diarrhea is very low for some countries in which thousands of deaths occur every year despite high economic growth shows that economic development is still not connected to social policies. Of all the countries, Haiti requires special attention with respect to the development of both institutions and people. Haiti needs the solidarity of all Latin American nations.

Disinfection remains a challenge in some Latin American countries. There are plenty of south–south experiences to learn from, and work could be shared among countries to help those in need solve this compelling dysfunctionality.

Ecosystem services are a key aspect to ensuring sufficient water quality and quantity. Ecosystem services impact the water cycle and strengthen water purification capacities and enable the availability of quality drinking water.

Withdrawing more of a country's water resources does not necessarily ensure higher water supply levels. However, extracting more of a country's water may make the country richer, including by increasing consumption levels, but not by that much; the correlations are still low. On the other hand, extracting more water does not significantly reduce deaths by diarrhea because Latin American countries withdraw water resources mostly for agriculture.

In Latin America more water extraction does not significantly impact wealth, water-borne diseases, or quality of life. However, water depletion will make it impossible for these nations to create wealth, prevent diseases, and achieve a good quality of life.

Countries with more water availability, like those in the Andes and Amazon ecoregions, also have significant numbers of deaths by diarrhea, even more than Central American countries. So having more water does not assure the elimination of water-borne diseases.

A smaller water supply and lack of sanitation account for more deaths by diarrhea. The correlations are high in both cases, above 0.6. Lack of disinfection also strongly impacts the rate of death by diarrhea.

Latin American countries still need to break through the barriers that would allow a systematic and sustainable maintenance of ecosystem services. Some countries have timidly started some legislation to promote these services, but they have found strong opposition from productive sectors that will never want to pay.

Water supply and sanitation companies need to strengthen their knowledge on their vulnerability to increasingly more intensive climate change. This a key issue because a larger availability of renewable water resources is linked to higher water supply coverage. The "user pays" principle should be a regional policy with regional criteria, a Latin American policy, since their ecoregions are interconnected and since their cultural, social, and economic dimensions are very similar.

Latin American countries need clear, simple, and precise methods of identifying the investment needed to maintain the ecosystem services of a basin. Information and research about the costs and benefits of basin activities need to be collected and compared.

No information was found that might help determine the cost of maintaining a basin and its ecosystem services. A classification matrix to identify investment requirements to maintain basin ecosystem services by type of basin, with different pressures from population and economic activities, is provided in this book and may help researchers move forward in this regard.

It is important to determine the benefit of each activity in the basin and the demand for ecosystem services. In this way, estimations about level of contribution would be clear. Latin American countries need to strengthen their knowledge on integrated water resource management and about the ecosystem services approach, so that these aspects would become part of education and national policies.

Several countries have experience promoting ecosystem services and management. The lessons learned from this experience need to be systematized and shared among Latin American countries to enhance their policy performance. In Latin America, basin management and ecosystem services are not part of the cost structure of private companies, which prevents them from collaborating on and investing in activities that serve the common good. If this is never done, regions, basins, and cities will always subsidize polluters indefinitely.

Investment costs are higher in rural areas than in urban areas, and even higher in forest areas like the Amazon ecoregion. Costs in similar areas could be very different, and these differences are based on quality, components, accessibility, accompanying, methodology, scale, technology, management models, and political environment. Distance and scale factors increase transaction costs of providing drinking water and sanitation. However, the poorest are those who pay more for water, and even more for informal low-quality water.

In Latin America private investment is very important. However, privatization does not miraculously make profitable something that was never profitable. The national economy pays for water supply and sanitation services using tax revenue that go to paying for investments and paying back loans to multilateral organizations.

A level of investment of 0.3 % of regional GDP in water supply, sanitation, and drainage seems feasible. Closing the water supply and sanitation gap will help countries and their people to mitigate the dysfunctionalities that limit their access to wealth and happiness. Quality water supplies and sanitation can improve people's economic performance.

# Chapter 6
# Governance, Planning, Capacities, and Management Models

Recently the terms *governance* and *good governance* are being used with increasing frequency. In Latin America, bad governance is now considered one of the main reasons for society's failure. International financial organizations and donors are approving loans and donations considering more and more whether good governance reforms are taking place.

The governance concept is not new; it is as old as human civilization. Governance as a concept means the decision-making process and the process by which decisions are implemented or not, which implies that actors, formal and informal, as well as the institutional structures, formal or informal, should be considered in the implementation of decisions (UNESCAP 2006).

Good governance has eight main characteristics: (1) participation, (2) legitimacy, (3) transparency, (4) accountability, (5) consensus, (6) equity, (7) efficiency, and (8) effectiveness. Good governance ensures a minimum of corruption and consideration of minorities during decision-making processes (UNESCAP 2006).

## 1 Key Water Management Models Conceptual Framework

The importance of consolidating a water supply and sanitation management model, at the policy level as well as in service provision, is a key aspect because it could lead to the provision of a more efficient service and to resource conservation and productivity increases.

Water supply and sanitation management is a cycle of actions represented by an administrative process such as PMVA (planning, making, verifying, and acting). It is worth emphasizing that management is not just action but also impact, which is an issue that should always be borne in mind in the planning process.

Management control is an evaluation process that allows one to measure an organization's performance and, if necessary, adopt corrective measures. It is an instrument that allows one to monitor the efficiency and effectiveness of plans and goals



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and of all activities, including projects and administration, as well as the results achieved (Alcaldia de Puerto Nariño 2009).

In the case of governmental management, a map of four values for evaluating government's performance has been developed: (1) policy goals, which are items in a policy, including strategies and responsibility level; (2) program implementation, where efficiency and effectiveness are emphasized; (3) operational efficiency, where technology, financial administration, and field work take place; and (4) resource use efficiency, where human capital and assets are managed (Clemente and Rojas 2009).

In the case of water supply and sanitation management indicators, benchmarking is used that seeks to identify best practices in water supply systems management in order to implement practices that may elevate periodical performance. Management practices are important to water supply and sanitation companies and in the transference of management information. Data mining is also important for benchmarking (Garcia 2006).

The International Benchmarking Network for Water and Sanitation utilities – IBNET – appeared in the 1990s with World Bank support to provide access to comparative information to companies dedicated to operating or regulating urban water supply and sanitation systems; it was also where interested parties could obtain information to improve their performance. Trained personnel participation is also important for achieving management efficiency. Benchmarking techniques make it possible to identify areas needing improvement. David T. Kearns, a Xerox Corporation manager, stated in 1979 that "benchmarking is the continuous process of measuring products, services, and practices against the toughest competitors and those companies recognized as industry leaders" (Benavides 2007).

Another key aspect is public expenditure productivity (PEP), which considers government activities as production processes. Either provision activities or public goods production, the government spends resources on them, as well as on their administration. These public resources should be used in the most efficient way to fulfill their goals. In an analogous way to work or capital productivity, PEP is estimated by the goals achieved in relation to a specific amount or indicator of public expenditures, where PEP = production level/total expenditures. In this way, traditional public expenditure analysis, in terms of level, composition, and tendency, are important but not enough to assess policy alternatives. Increasing or reducing public expenditure recommendations should be sustained by PEP studies, to evaluate whether a public expenditure is really competitive in relation to similar programs in other countries. In this way, this difference could mean a better opportunity to a country, where the amount of money is not necessarily conclusive by itself (Mostajo 2000).

An important aspect of labor efficiency is education. Education affects productivity and growth through many different channels. An educated person absorbs information faster and applies new inputs more effectively. In Peru, for instance, farmers that had an additional year of education increased the probability that they would adopt new technology by 45 % (World Bank 1991). Professional abilities development is important to increase productivity. However, it is not enough to increase productivity or gross domestic product (GDP). Also, other factors and the policy environment are also applicable, in addition to professional abilities (OIT 2008). Good governance implies an appropriate management, definition of optimal goals, detailed results measurement, and a commitment from the supervisors of each of the government's projects, as well as from their recipients (Deloitte 2010).

## 2 Water Governance, Sector Planning, and Management Models in Latin America

Governance, a process to make sustainable decisions, uses sectoral planning as an instrument to justify and plan actions. These actions are found in many cases with weakened capacities that make action implementation inefficient since in many cases different management models are not based on results and in many cases they are not integrated. For example, in most Latin American countries, basin management is not integrated with water supply.

An approach that supports basin management is basin water and environmental social management (BWESM), defined as "the interaction of many users, organizations, and other actors involved in basin water and environmental use and management, to make accepted decisions and implement coherent actions in relation to the access to and distribution, multiple uses, and conservation of water and other resources, as well as a basin's shared spaces and infrastructure. In this interaction, actors' participation equity is sought, and respect and attention to new interests are given" (Bueno de Mezquita 2004). NGOs participate in promoting the basin approach widely, including those in Latin America and elsewhere, in addition to mainly European nonprofit organizations.

## 3 Case: Las Amunas de Huarochirí: Recharging the Aquifers in the Andes

The Amunas, of pre-Columbian origin, represent an artificial underground water recharge, carrying water to streams and collecting rainwater and glacier melt. This hydrogeological and sociocultural knowledge has as its goal to raise the volume of water in streams and rivers, and it has permanent communal participation, as an Incan heritage work system, where people share responsibilities and work for common purposes.

The BWESM approach was reflected in a project elaborated with the support of Inter-American Institute for Cooperation on Agriculture (IICA) that aimed to recover the Amunas' ancestral practices of reducing the water gap in the Andes (Apaza et al. 2006).

## 4 Case: The PDRS Project

The Rural Sustainable Development Program developed with the support of the German Agency for Development (GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) started in 2003 and worked for 12 years in several Andean territories and focused its activities on the development of new methodologies and actions to manage basins. This program combined rural development with natural resource conservation within a basin approach (PDRS 2011).

## 5 Water and Sanitation Value Chain

Every public sector organization in Latin America, and in the world in general, has a specific regulation of organization and functions that empowers or limits public institutions to do or not to do things. In other words, public institutions can act and, consequently, can assign a budget to activities and functions literally specified in the regulation of organization and functions, and it cannot assign human or financial resources to activities that are not specified in this regulation. The situation in Latin America is that most of the public organizations have had internal functioning regulations since the 1980s or before, where some concepts, tendencies, and approaches like climate change, value chain, or basin integrated management had not appeared, so they were not integrated into the regulations. Only a few Latin American public institutions have regulations that were passed in the last 5 years. Thus, it was found that Latin American institutions dedicated to or sharing certain responsibilities for water do not integrate the value chain of water. In addition, some Latin American countries do not have national legislation for integrating subnational water management demands and laws (Fig. 6.1).

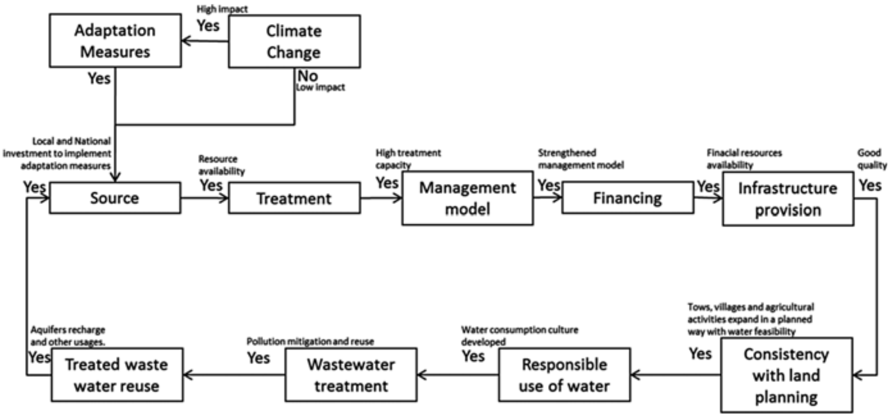


**Fig. 6.1** Positive water supply and sanitation value chain

There are also many actors in the political and administrative value chain of water management and sanitation in Latin America. In general, policymaking takes place at the highest government level, with some exceptions like federal Latin American governments, and service provision may remain at the lowest political level, like cooperatives, communal organizations, municipalities, or state-owned companies. The value chain of water is not considered in institutional internal regulations so these institutions "dedicated" to water cannot develop all the necessary projects or enact sectoral legislation in their sphere of responsibilities toward water.

Some Latin American countries have very fragmented value chain and in some cases policymaking is separated from regulation, from funding, from technical assistance, and from operational performance. So in this case the lessons learned, successes or failures, will never reach the policymaking level, and then the approaches, regulations or funding criteria do not change. This situation makes it more difficult and costly to align multiple water supply and sanitation operators with different sizes and that face particular geographical, environmental, and socioeconomic circumstances (Pública 2011).

In Latin America, urban and rural water supply and sanitation are separate, and the resources in these services are usually not integrated at all. Rural communities in Latin America are in general those under 2000 inhabitants. In Latin American cities, more than one and sometimes three or four different water supply and sanitation operators are found. In some cases there are three municipally owned companies, in other cases a cooperative and a municipal company or a communal organization and a municipally owned company. This phenomenon is due to progressive unplanned urbanization and to conurbation processes that unified dispersed urban and rural areas into one urbanized territory. Peripheral areas still unrecognized by local or national authorities have access to water through informal water providers, like water tank trucks, which sell water door to door at the highest price (Box 6.1).

According to the Water and Sanitation Program of the World Bank, small providers, supervised by the state, have successfully met an unsatisfied demand from the poorest sections of society. They have also demonstrated high performance and sustainability. A survey conducted in 14 Latin American areas in 2007 showed that 90 % of the people were happy with the volume of water they had access to, 80 % liked the quality of water, and almost half considered the price fair (MVCS 2007). However, the amount charged, around USD 0.15 to USD 0.25/$m^3$, is not enough for the maintenance of infrastructures and equipment (WSP 2005).

## 6 Water Supply and Sanitation Capacity Management

Water supply and sanitation efficiency and sustainability are provided by all actors participating in managing and operating those services. National planning instruments usually identify the following dysfunctional situations:

**Box 6.1** Latin America: typical public sector water and sanitation areas of work

| Area of work | Actor in charge |
|---|---|
| (a) Policy identification and approval | Congress, Parliament, President, Ministry of Infrastructure, Housing, Civil Works, Water, Agriculture, others |
| (b) Investment prioritization | President, Congress, Ministry of Finance, Economy, others |
| (c) Financial resource assignment | President, Congress, Ministry of Finance, Economy, others |
| (d) Regulation | Ministry of Economy, Water, Water infrastructure, Housing, independent subministerial water agency, others |
| (e) Approval and establishment of tariffs and fees | Ministry of Economy, Water, Water Infrastructure, Housing, independent subministerial water agency, others |
| (f) Specific regulation | Ministry of Economy, Water, Water infrastructure, Housing, independent subministerial water agency, others |
| (g) Project design and civil works | Ministry of Water Infrastructure, Housing, independent subministerial water agency, state or municipally owned company, municipalities, private companies, others |
| (h) Water supply and sanitation | Water supply and sanitation state or municipally owned company, private company, cooperative, committee, others |

- Insufficient coverage in water supply, sanitation, and sewage treatment;
- Bad-quality service and the risks it poses to people's health;
- Deficient system sustainability;
- Tariffs that do not cover service investments, operation, and maintenance costs (budget deficit);
- Market sizes that do not guarantee economies of scale or financial viability;
- Financial and institutional weaknesses;
- Too many workers who are unqualified and have high turnover in water supply and sanitation facilities.

However, planning in Latin America is usually disrespected due to political instability, economic crises, and social pressure, so plans are often discarded.

## 7 Human Resource Weaknesses

Water and sanitation services in Latin America are unsustainable, and tariffs levied to cover those services are not affordable for all citizens. In addition to infrastructure investments, there is a need for capacity development (CD) in the human resources sector. CD is defined as "an endogenous course of action that builds on existing capacities and assets, and the ability of people, institutions and societies to perform functions, solve problems and set and achieve objectives" (UNDP 1997; López and Theisohn 2003). Policies are required that consider a balance between knowledge and personal–institutional capacities with infrastructure investments for coverage expansion and quality improvement.

With this in mind, three levels of human resources sector CDs are defined: (1) individual level: developing abilities, knowledge bases, and attitudes that support increasing the professional level, improving institutional capacities needed for the development and sustainability of the sector; (2) institutional level: management capacity to include the requirements of staff CD in the policies, procedures, and frameworks of water and sanitation service providers (WSPs); (3) enabling environment: looking at the society as a whole, such that externalities and an enabling environment foster a system in which individuals and institutions accomplish their goals based on established standards and guidelines. Properly trained staff increase the social value and economic benefits of infrastructure investments. The strengthening of the WSPs fosters their efficiency and interactions with other involved institutions. Sector policies and reforms oriented toward sustainable development improve service management and prioritize establishing knowledge supported by a legal and political framework (GIZ 2015).

## 8 Investment Dysfunctions

According to a 2006 World Bank study, average water tariffs in Latin America are the highest of any region of the developing world. Tariffs are about four times higher than in South Asia, three times higher than in Eastern Europe and Central Asia, and almost twice as high as in East Asia. However, tariffs are less than half as high as in OECD countries. Based on a sample of 23 major cities in Latin America, the average residential water tariff for a monthly consumption of 15 $m^3$ was USD 0.41, equivalent to a monthly bill of only about USD 6.00 (Foster 2005).

The modalities of financing water and sanitation infrastructure differ substantially from country to country. Some countries that have reached higher levels of cost recovery, such as Chile and some utilities in Brazil and Mexico, rely on commercial credit financing. However, the vast majority of utilities rely on transfers from national governments. These can take various forms. In Colombia, municipalities are legally entitled to receive transfers calculated through a formula based on their costs and poverty levels; in Mexico, municipalities can apply for matching federal grants provided they fulfill certain conditions that vary by program; in Ecuador, municipalities receive transfers based on a formula that takes into account their choice of management model and improvements in cost recovery; and in other countries utilities simply receive transfers that can vary from one year to the next without any conditions. The level of transfers from national governments is highly variable and often far from sufficient to increase coverage and improve service quality. Some countries pass loans from international financial institutions on to utilities in the form of credits. However, these international loans only account for a relatively small share of water and sanitation financing in Latin America.

# 9 Regulation

At the level of national governments, responsibility for policies in water and sanitation is typically fragmented between various ministries, making the development of coherent policies in areas such as transfers to local service providers a challenging undertaking. The economic regulation of service providers is sometimes entrusted to ministries and sometimes to autonomous regulatory agencies. These agencies sometimes cover only water and sanitation or multiple infrastructure sectors; they can be either at the national (as in Chile, Colombia, and Peru) or at the state level (Argentina and some states of Mexico). Their functions vary and may include tariff approvals, monitoring of service quality, and handling of complaints. Environmental regulation is entrusted to environmental agencies and the regulation of drinking water quality to ministries of health. In some cases, independent state agencies are in charge of water prices and operators or providers of regulation and control.

# 10 Water Supply and Sanitation Management Models in Latin America

Several water supply and sanitation management models are in place in Latin America. They have different origins and founding legislation but still exist and constitute a variety of management models of water and sanitation.

## *10.1 Corporate State Model*

Many, especially urban, water supply and sanitation providers are mainly state-owned enterprises. They may obtain some resources from tariffs and central government transfers. Some of these companies have been given in concession to private companies, but the concession in large cities may not be successful (Schifini 2006). New water supply and sanitation schemes may be built with central government funds, and they may be transferred subsequently to municipalities or cooperatives for maintenance. Public-private partnerships have been common since the mid-1990s in Latin America. Tariffs may be paid directly by users or by the government itself.

## *10.2 Corporate Municipal Model*

Corporate municipalities are public companies owned by municipalities or local governments. Usually the municipality has the power to appoint or remove the managers of such companies, which is sometimes politicized, and managers of municipal companies are changed very often, represent a loss of experienced water supply and sanitation management officials. In some municipalities, following complex urban development processes, several kinds of providers may coexist in the same urban territory, such as cooperatives, rural committees, and water supply companies.

### *10.3 Rural Community Model*

Communal organizations or rural committees are put in charge of water supply and sanitation provision and maintenances. Low-income rural families pay a fixed monthly fee regardless of the volume of water consumed. The monthly fees can range from USD 0.20 to USD 4.5 per family and the resources are mainly oriented to the system's maintenance. Usually these rural committees are independent and no local or central government organizations monitor their development or quality of water provided.

### *10.4 Urban Community Model*

In some cases, cooperatives, urban communities, or neighborhood organizations start their own water supply and sanitation system without state participation, similar to rural committees in many cases. However, they hire specialized services that verify water quality and have specialized professionals working to operate and maintain the system.

### *10.5 Urban Informal Water Supply Provision*

This a service that is usually provided in illegal settlements that do not have access to services offered by the government. This lack of a state presence generates opportunities for informal water providers that in many cases may provide water to peripheral communities through water tank trucks (Box 6.2).

## 11 Basin, Water Supply, and Sanitation Governance in Latin America

Basin management has evolved, passing through different development stages and approaches. Initially, basin management was part of agriculture and hydrological studies. People's participation was not considered. It also was under the purview of

**Box 6.2** Latin America: water supply and sanitation management models and capacities

| Number | Type of management | National policy reference | National budget contribution | Intersectoral coordination mechanisms | Borrowing capacity |
|---|---|---|---|---|---|
| 1 | Corporate state model | Yes | Yes | No | Yes |
| 2 | Corporate municipal model | Incomplete | Selective | No | Very limited |
| 3 | Rural communal model | Yes | Selective | No | No |
| 4 | Urban community model | No | No | No | No |
| 5 | Informal urban water supply | No | No | No | No |

government forestry authorities. In a second stage, it became part of natural resource management, including the economic benefits thereof. At the present time it is oriented toward beneficiaries. Now it is has so-called participatory and integrated management, with the commitment of the local population (FAO 2007).

Besides integration, participation has been another key aspect in hydrographical basin management for 20 years. In 1983, FAO published a conservation guide related to community participation in highland management. Some of the aspects of this guide remain pertinent today: (1) natural resource management cannot be successful without the participation and support of natural resource users, (2) participants need to have the capacity to make decisions and assume responsibility, and (3) participation in basin management is a long-term process for which appropriate tools are needed. However, today it is clear that people and communities are not the only actors in participatory basin management. All actors have diverse and sometimes contrary interests, so nowadays basin management has shifted its focus from sensibilization and social mobility to negotiation and partnership creation (FAO 2007).

At the community organization level there are in Latin America more than 80,000 water and sanitation services community organizations, known as OCSAS in Spanish. Thus, according to the World Bank Water and Sanitation Program, these OCSAS give water to more than 40 million people in the region and have the capacity to provide water to an additional 18 million people. In Central American, Andean, and other countries, these community organizations produce around 30–40 % of the drinking water consumed for domestic purposes in a country. There are many kinds of OCSAS. Small OCSAS serve up to 500 families, medium-sized around 500–2000 families, and large OCSAS could serve thousands of users. Water supply is the main focus, though some OCSAS also work on wastewater treatment or solid waste management. Cost recovery has been focused on covering infrastructure maintenance, but it has not been oriented to ensure human resource sustainability, in other words, the investment in social capital that will guarantee an appropriate future administration.

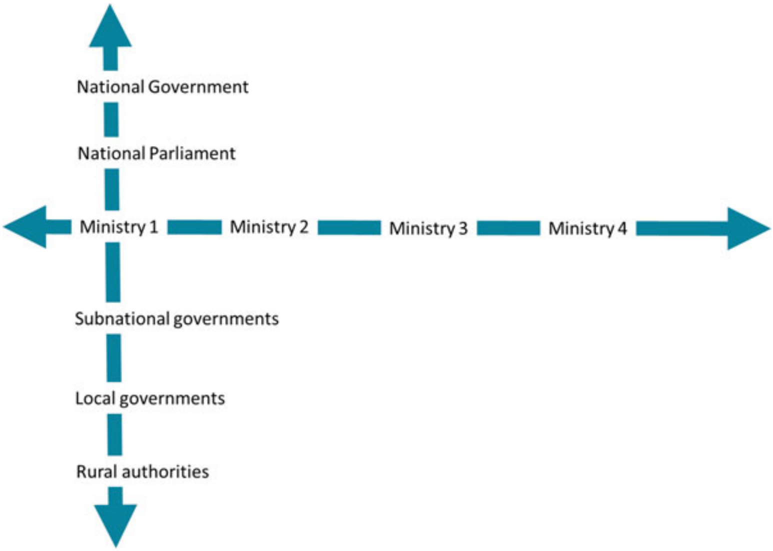


**Fig. 6.2** Latin America: opportunities for integrating public policy concerning water

This has created a situation where many systems become unsustainable. "Organizations like the Swiss Agency for Development and Cooperation (SDC), AECID (Spanish Cooperation Agency) and CARE and educational institutions have tried to cover these needs. However, the offer of these organizations oriented to OCSAS capacities is not uniform along the region and they have not reached sustainability" (Avina 2011).

There are no master plans that assign roles and tasks among ministries and other levels of government, since in many cases water management is in local hands. The challenge and need for a multiministry, local, subnational, and national coordination is increasing. Latin American countries need a holistic water institutional approach and design because water management is a complementary aspect at each level and sector of government (Fig. 6.2).

## 12 Water Governance and Legislative Framework in Latin America

The Organization of American States has made a valuable contribution to the governance and legislative situation of Latin American countries (OAS 2005) that has served as basis for up-to-date descriptions of these aspects.

Argentina uses a federal system of governance that places the responsibility for water resource management at the provincial level. Owing to this federal system and the country's geographic diversity, water issues vary across regions: an inadequate quantitative supply of water in Catamarca, for example, or problems with water quality (stemming from not only pollution but also natural quality and siltation issues) in Tucumán. In fact, this federal system may be the greatest water resource management issue for the nation as a whole. Citing inefficient and ineffective provincial legislation and interprovincial conflicts – which must be solved through interprovincial treaties – many critics believe that Argentina needs national water laws and national land-use laws to reform its current system. Other issues for the country as a whole are groundwater pollution and a need for increased transparency in the privatization process.

Some important pieces of water legislation include the Water Environmental Management Regime (Régimen de Gestión Ambiental de Aguas) Law 25688, adopted in 2002. This federal law established minimum environmental requirements at the national level. Much of Argentina's water legislation is decided at the provincial, not the federal, level, for example, the Código de Aguas (Buenos Aires), Law 12257, enacted in 1999. Other important environmental legislation includes the General Environment Law (Ley General del Ambiente) Law 25675, adopted in 2002.

In Bolivia, and according to the CONDESAN consortium, Bolivia's current legal framework for water management is outdated, fragmented, and occasionally contradictory. A newly amended (2000) Ley de Servicios de Agua Potable y Alcantarillado Sanitario is on the books and occasionally contradicts a smorgasbord of older and increasingly less relevant laws, such as the current Ley de Aguas (1906), the Codigo Civil, the Codigo de Mineria, and the Ley de Hidrocarburos. A more integrated legal framework could prove more appropriate in dealing with new water resource management issues, such as rising water demand and an ongoing battle over the privatization of water supplies.

Some important water legislation includes the Ley de Aguas that is still in force, enacted in 1906, a national law that regulates water ownership and use. Another example is the Ley de Servicios de Agua Potable y Alcantarillado Sanitario adopted in 1999 and amended in 2000. Also, Law 2878, adopted in 2004, is a national law that regulates the sustainable use of water resources in irrigation. Other important environmental legislation is the Ley 1333 del Medio Ambiente, promulgated in 1992.

Brazil is a large territory, and because of the size and geographic diversity of the Brazilian state, water issues vary significantly by region. For example, while as a whole Brazil has the largest supply of renewable freshwater in the world, the geographic distribution of this resource is uneven. Specifically, the scarcity of potable drinking water in much of the rural northeast has been described by the Brazilian government as a "social tragedy." In the south, however, water resource management issues often revolve around the excessive consumption and pollution of the large urban, industrialized areas. To better manage nationwide resources and update the legislative and institutional framework, the Brazilian government passed the National Water Resources Management Act in 1997 and created the National Water Agency in 2000. Among the principles of this new system are the pricing of water as an economic good and decentralized management with extensive community participation.

An important piece of water legislation is the Decreta o Código de Águas, enacted in 1934 and amended in 1975. This decree establishes the water code for public and private water use. It consists of 205 articles (in three books) defining waters affected by this decree and specifying conditions and requirements to be satisfied in order to perform the aforementioned activity (public and private water exploitation for various purposes, including hydropower generation). It regulates the issuance of water use concessions and authorization, which shall be under the competence of the Ministry of Agriculture. The authorization for waterfall exploitation for hydropower purposes is specified in the law. In addition, Law 9433, known as the National Water Resources Management Act, adopted in 1997 and amended in 2000, is a federal law that established the National Water Resource Policy and created the National Water Resource Management System. Moreover, Law 9984, enacted in 2000, is the most recent amendment to the National Water Resources Management Act (Law 9433 as described earlier) that created the National Water Agency. Other important environmental legislation is Law 6938, enacted in 1981, which established the Política Nacional do Meio Ambiente.

Chile has had the most free-market water laws and policies in the world since the passage of the 1981 Codigo de Aguas; which according to the economic think tank Resources for the Future, water in Chile is a fully marketable commodity and government regulatory powers are weak. While this system has been linked to increased private investment in water infrastructure – and may explain Chile's high 99 % drinking water coverage rate (WHO 2015), critics point to its impacts on social inequality and note that the weak institutional and legal framework negatively affects the government's ability with regards to "coordinating multiple water uses, managing river basins, resolving water conflicts, and protecting river ecosystems and in stream flows."

Important pieces of water legislation in Chile include the Codigo de Aguas, Decreto con fuerza de Ley No 1122, enacted (under a military government) in 1981 and amended in 1985; it regulates water use rights, administrative procedures, and the construction of water works. Also the Resolución 186, adopted in 1996, establishes norms regarding the exploration and exploitation of subterranean waters. Another piece of important environmental legislation is the Ley sobre Bases Generales del Medio Ambiente, Law 19300, adopted in 1994.

Colombia has a rich supply of hydrologic resources, including average annual rainfall levels more than three times greater than the global average and almost twice as great as the average for South America. However, according to the World Health Organization (WHO), the municipalities that control the water supply process suffer from weak management that has resulted in both high water loss rates during the distribution phase (due to, for example, leaking) and a progressive decline in water quality; this situation is aggravated by subsidized water rates that do not accurately represent real costs. Untreated effluents also present a problem. Like other countries in the region, Colombia has recently privatized its water supply in certain regions and the continued debate over water privatization will have a profound effect on Colombia's future with regard to water resource management.

As important water legislation there are environmental laws like Law 9 from 1979, amended in 1997, a national law that regulated environmental protection in general; water supply; workers' health; construction, food, and drug industry sanitary regulations; epidemics; natural hazards; handling of corpses; home use utensils; and health rights. In addition is Decreto 1594, adopted in 1984, which regulates Law 9 in the use of water and wastewater. The Proyecto de Ley del Agua was issued in 2005. Other important environmental legislation includes the Código Nacional de Recursos Naturales Renovables y de Protección al Medio Ambiente, Decreto 2811, enacted in 1974 and amended in 2004.

Costa Rica is naturally rich in hydrologic resources and has one of the highest rates of access to potable water in the Americas. The US Army Corps of Engineers (USACE) also praised Costa Rica's Instituto Costaricense de Acueductos y Alcantarillados, which oversees and regulates domestic use of water, for the central roles that it provides to local communities in the water management process. Increasing amounts of untreated waste and industrial effluent, however, do present problems. Other issues include erosion due to poor farming practices and the risk of natural hazards such as earthquakes and floods; according to the USACE, long-term planning to reduce the likelihood and mitigate the effects of floods will be critical to the continued prosperity of Costa Rica. Important water legislation are the Ley de Aguas, Law 2811, and the Ley Orgánica del Ambiente, Law 7554, adopted in 1995.

In the Dominican Republic, despite extensive water resources – 75 % of groundwater is still unexploited – an large sector of the population does not have access to drinking water. According to the UNEP, the three institutions that share responsibility for the country's water supply lack the capacity to integrate, either internally or externally, the financial, commercial, operational, and managerial aspects that successful water resource management efforts require. For example, due to poor registry practices, only 45 % of water consumers in Santa Domingo receive water bills. Pollution also presents a problem.

Important water legislation is the Ley del Domino de las Aguas Terrestres, Law 5852, enacted in 1962 and amended in 2000. This is a national law that governs water ownership, uses, titles, permits, public waterworks, irrigation districts and associations, and water police. The National Water Resources Institute (Instituto Nacional de Recursos Hidráulicos), an autonomous state agency under the Ministry of Agriculture (Secretaría de Estado de Agricultura), is responsible for administering, managing, planning, developing, and regulating water resources. A bill for a new water code (Proyecto de Código de Agua) is before the National Congress (Congreso Nacional). The National Water Resources Institute, the Ministry of Agriculture, and the Forestry Directorate (Dirección General Forestal) share responsibility for river basin management and conservation. Other important environmental legislation is the Ley General sobre Medio Ambiente y Recursos Naturales, adopted in 2000.

Ecuador has, according to the USACE, very serious problems with its water supply. Although the state owns abundant natural resources, the distribution of both water supply and population is very uneven. Furthermore, the country suffers from both desertification in the south and soil erosion and deforestation in the highland areas; these growing problems, coupled with increasing population, could compound Ecuador's water supply situation in the future. Much of the nation's groundwater resources remain unexploited and could be used to mitigate this supply shortage. Legal and institutional issues in Ecuador include the division of water resource management responsibilities across several different agencies and a debate about the role of the private sector in water resource management.

Important water legislation is the recent (2014) Ley Organica de Recursos Hidricos that regulates the use of marine, superficial, subterranean, and rain waters at the national level. Another important legislation is the Ley de Gestion Ambiental enacted in 2004.

El Salvador, like many countries in the Americas, is rich in hydrological resources, both in terms of surface and groundwater. Yet owing to extensive – 90 % – pollution of surface water in the form of untreated effluents, only groundwater is used for much of the nation's water supply. While groundwater supplies are plentiful, much of the resource remains untapped, and as a result, El Salvador has the lowest per capita water supply in Central America. Changing the water supply situation in El Salvador will require a change in the legal and institutional framework as well. For example, more than two dozen agencies share responsibility for overseeing the water supply situation in El Salvador, but, according to the USACE, no coordination mechanisms exist and thus efforts are often duplicated and resources used inefficiently. Furthermore, a pollution law regulating new industries has just been passed, but it remains the only law addressing industrial or domestic waste discharge and is not enough to adequately address the state's pollution problem.

Important pieces of water legislation are the Ley sobre Gestion Integrada de Recursos Hidricos, adopted in 1981, the Ley de Irrigation y Avenamiento (Law of Irrigation and Land Drainage), Law 153, enacted in 1970 and amended in 1999, which is a national law aimed at improving agricultural productivity and implementing the rational use of water. Usage of water for human consumption is given priority. Another important environmental legislation is the Ley de Medio Ambiente, Decree 233, adopted in 1998.

Guatemala is a country with rich hydrological resources, but as a result of a combination of unequal distribution of both hydrological resources and population and a lack of a comprehensive water management system, the nation's current available water resources are stressed and the nation suffers from high levels of surface water contamination. In fact, Guatemala does not have a national water law and no authority controls the water resources; instead, each of the 329 municipalities must manage their own system. To promote a more efficient and integrated system, the USACE's Water Resource Assessment Report recommends that Guatemala, among other things, create a national water commission and enact a national water law that includes provisions on the appropriate use of waterways (for example, regulations monitoring the discharge of effluents). Guatemala has no general law on water. An important piece of environmental legislation is the Ley de Protección y Mejoramiento del Medio Ambiente, enacted in 1986.

Haiti, geographically speaking, possesses an ample supply of water. Yet at the same time the lack of access to safe water in Haiti has reached critical levels, which the UNEP blames on unsustainable management, unequal distribution, and low supply levels. Furthermore, the combination of increasing population and widespread poverty in Haiti has severely compromised the environment's ability to provide for future generations of Haitians; this situation is further aggravated by the expansion of the population's need for safe water. Additionally, soil erosion and deforestation have caused the pollution and salinization of parts of the nation's water supply. Any water resource management plan in Haiti must be coupled with poverty relief efforts. Haiti has no general water law, just environmental protection embodied in its constitution.

Honduras is like many of the nations in Central America: the risk of natural disasters such as floods and hurricanes presents severe challenges to water resource management. Other issues in Honduras are the increasing effects of water contamination – 98 % of effluents remain untreated – and salinization. Water regulations in Honduras may be characterized as being dispersed (between various acts and laws) and weak. Recommendations of the Plataforma del Agua, a consortium of private and public agencies in Honduras working toward integrated water management, suggest that a more decentralized water management plan that would allow greater roles for both local governments and the private sector, as well as efforts toward a greater flow of information and greater coordination between the different agencies, would help improve water management in Honduras.

Some important pieces of water legislation are the Ley de Aprovechamiento de Aguas Nacionales, Decree 137/27, enacted in 1927 and amended in 1932, which is a national law that provides for water ownership and use. Also important is the Ley Marco del Sector Agua Potable y Saneamiento, Decree 118/03, created in 2003, a national law that established the rules applicable to potable water and sanitation services. Finally, there is the Ley General del Ambiente, Decree 104/93, adopted in 1993.

Mexico suffers from serious and growing water supply issues owing in part to an uneven distribution of water resources; 15 % of the country's aquifers serve 50 % of the population and suffer from overexploitation. Scarcity of water in the country's arid northern region has become a serious issue. Salinization is also becoming an increasingly salient concern. Finally, according to the CIA World Factbook, "prolonged drought, population growth, and outmoded practices and infrastructure in the border region strains water-sharing arrangements" between Mexico and the USA.

Important water legislation is the new Ley de Aguas, adopted in 2015, which has encountered powerful opposition from civil society organizations. The Ley General del Equilibrio Ecológico y la Protección al Ambiente was adopted in 1988 and amended in 2003 and 2015.

Nicaragua has rich hydrological resources, but unevenly dispersed resources and population mean that in certain regions, water demand outstrips supply. According to the Global Water Partnership, "the management of water resources in Nicaragua has traditionally been very fragmented among a number of State institutions, with mandates often unclear and overlapping"; this situation may have improved, however, since the recent passage of a national water law in 2004. Finally, water quality issues are growing in importance as a result of industrial pollution and poor agricultural practices.

Important pieces of water legislation are the Ley General de Aguas, adopted in 2010, and the Ley General del Medio Ambiente y los Recursos Naturales, Law 217, enacted in 1996.

In Panama, responsibility for water resources is vested in two institutions: Autoridad Nacional del Ambiente (National Environment Authority) and Autoridad del Canal de Panamá (Panama Canal Authority). The Panamanian Health Ministry is responsible for defining the water supply and sanitation sector's policy, whereas the Autoridad Nacional de los Servicios Públicos ASEP or National Authority for Public Services acts as regulatory agency.

Important water legislation is the Ley sobre el Uso de las Aguas, Decree–Law 35, enacted in 1966, amended in 1997. This is a national law that regulates the right to use national waters, creates a water authority, and establishes rules on water hygiene and safety. Another important environmental law is Law 41, adopted in 1998, which establishes the principles and basic standards of environmental protection and conservation and promotes the sustainable use of natural resources.

In Paraguay, responsibility for policy formulation is nominally vested in the Ministry of Public Works and Communications, and regulation is entrusted to an autonomous entity, the Regulatory Agency for Sanitation (ERSSAN). The institutional framework is codified in Law 1614/00 of 2000 establishing a regulatory and tariff framework for the sector. The law, which created ERSSAN, was drafted with the expectation that private sector participation in the sector would substantially increase, which did not occur. In practice, the Ministry of Public Works and Communications has not developed sector policies, leaving a vacuum in this important area. The regulatory agency, created for the purpose of regulating prospective private enterprises, has been ineffective at regulating the national public enterprise ESSAP. SENASA also faces many challenges since it does not have sufficient capacity to provide adequate support to the ever increasing number of juntas. Paraguay has no general law on water and no national law on environmental management.

In Peru, the distribution of surface water is very uneven, with 99 % of the resources located on the Atlantic slope of the Andes and 1 % on the Pacific slope, where 75 % of the country's population is located, and in the Lake Titicaca region. Water supply per capita in Peru's arid regions, home to much of the populace, is significantly lower than the global average despite the use of groundwater and strategic construction of dams and dam reservoirs. To reduce the inevitable conflicts that spring from water's extremely high economic value in Peru, the WHO stresses the importance of public–private partnerships – but not completely privatized management. Other issues include water pollution and flaws with current water management legislation, which does not contain provisions for participation by users (water management is run solely by the Ministry of Agriculture) and which privileges the management of supply among users and thus promotes inefficiency, specifically in the agricultural sector. Important pieces of legislation are the Ley de Recursos Hidricos, adopted in 2009, and the Ley General del Ambiente, enacted in 2005.

Of all of the states in Central and South America, Uruguay boasts the highest percentage of citizens with access to safe drinking water and treats the highest percentage of its effluents. However, the depreciation of capital over time has left many sewage treatment plants outdated, and the lack of a national hydrological plan or a national land-use plan has also been criticized. Other noteworthy developments are the increasing importance of groundwater as a source of water in Uruguay owing to recent episodes of acute surface water deficits and a referendum in October 2004, in which voters agreed that water and sanitation must be "exclusively and directly provided by state-run companies."

Important water legislation is the Codigo de Aguas, enacted in 1992, a national law that provides for water ownership, waterworks, uses, and the creation of a water resource inventory. Another important piece of environmental legislation is the Ley General de Protección Ambiental, Law 17283, adopted in 2000.

Venezuela has rich hydrological resources, but water pollution, specifically as a result of oil extraction practices, has damaged many of the nation's bodies of water. However, the wealth from this oil production has also allowed for large expenditures in water supply infrastructure, and as a result the country has maintained high levels of water and sewerage coverage despite recent financial crises. The WHO stresses that the decentralization and promotion of the active participation of civil society in the management of water resources would greatly improve the water management situation in Venezuela, specifically with regard to the inequality of access to water and sanitation services. It also recommends a system of tariffs and fiscal incentives that promote sustainability and the rational use of water. Important legislation pieces of are the Bolivarian Ley de Aguas, enacted in 2007, and the Ley Organica del Ambiente, adopted in 2006 (Box 6.3).

## 13 Water Management Roles in Latin America

In the last 30 years the water supply and sanitation sector in Latin America has experimented with several reforms. Most of the transformation processes have had common elements, for example, (1) decentralization, in many cases at the lowest governmental level, meaning municipality; (2) institutional separation of functions, like sector policies, regulation, and systems operation, including the creation of specialized service provision control; (3) private participation and, more recently, in many cases the departure of international private operators and return to public provision. Despite several reforms, the region still maintains important deficits. Many Latin American countries are far from universalizing drinking water and sanitation services and experience higher deficits in wastewater treatment and disposal. In many cases, the challenge is in providing quality services, clean water, and many hours of supply. Financial problems, and others that affect low-income populations, remain (Lentini 2011). However, Latin American reforms have not consolidated or strengthened performance, and institutional changes are still taking place (Schifini 2006).

**Box 6.3** Latin America governance indicators, 2015

| | Recent national water law (less than 20 years old) | Number of ministries with national water decision-making capacity | National water management institution is at ministry level | Strong rural presence of national water management institution | People/civil society organizations participate in decision-making processes |
|---|---|---|---|---|---|
| Argentina | Yes | 3 | No | No | No |
| Bolivia | Yes | 4 | Yes | No | No |
| Brazil | No | 5 | No | No | No |
| Chile | No | 4 | No | No | No |
| Colombia | No | 4 | No | No | No |
| Costa Rica | No | 4 | No | No | No |
| Dominican Republic | No | 5 | No | No | No |
| Ecuador | Yes | 4 | No | No | No |
| El Salvador | No | 5 | No | No | No |
| Guatemala | No | 5 | No | No | No |
| Haiti | No | 5 | No | No | No |
| Honduras | No | 4 | No | No | No |
| Mexico | Yes | 5 | No | No | No |
| Nicaragua | Yes | 3 | No | No | No |
| Panama | No | 4 | No | No | No |
| Paraguay | No | 4 | No | No | No |
| Peru | Yes | 5 | No | No | No |
| Uruguay | No | 4 | No | No | No |
| Venezuela, RB | No | 4 | No | No | No |

Chile made a transformation based on a legal framework that contemplated a Superintendence of Sanitary Service, regional companies (initially State owned property and then privatized), tariff regulation, and subsidies. The model was successfully applied and was the first step toward adequate funds to increase coverage and reach industrialized countries' indicators.

With a federal organization, Argentina has several actors. In one province (Entre Rios) services are in municipal hands, in another (Chubut) a cooperative of users is in charge, while in still other locations (San Luis, Santa Cruz, La Pampa, Chaco) municipal dependencies are in place. Since the 1990s main urban areas have been provided by private enterprises that own an operation concession. Three important failures are worth mentioning – in the Tucuman province, in the Buenos Aires province, and in the Santa Fe province. Only in 17 of 24 jurisdictions have regulatory entities been created to control and supervise private companies. These entities also supervise municipalities and cooperatives of user-providers.

In Bolivia in the 1990s, the model was adapted to the country's situation and a Sanitary Services Superintendence was created. The services in El Alto and La Paz were given in concession, with social conflicts erupting later on. In Cochabamba, the concession was a complete failure. In Santa Cruz de la Sierra, a cooperative of users totaling one million inhabitants is responsible for providing these services.

In Central America, central organizations (such as SANAA in Honduras, INAA in Nicaragua, IDAAN in Panama, AyA in Costa Rica, and ANDA in El Salvador) have historically been responsible for providing water and sanitation services, with few successes and many failures.

In Honduras, since 2003, the government has strengthened the sector and adopted a model creating, at the national level, an entity in charge of enacting policies and planning services (el Consejo Nacional de Agua y Saneamiento) and a regulatory body. San Pedro Sula, which always had an independent service, now has a private company responsible for services, and in recent years SANAA has been decentralizing its activities.

In Nicaragua in the 1990s, the government implemented a separation of roles. It created a Water Supply and Sanitation National Commission, with ministry participation, responsible for establishing policies and planning, it transformed the national operator into a regulatory body, and it created the National Enterprise of Aqueducts and Sanitation, with a national jurisdiction. However, the commission was not operative and so was shut down. In this way, in 2004, an adjustment process was put in place and the regulatory and planning function was centralized.

In Panama there is a public services regulatory entity and governing body, responsible for sectoral policies and planning and a Water Supply and Sanitation Office that depends on the Ministry of Health. This scheme has in practice a limited efficiency in relation to the operative capacity with respect to IDAAN. Costa Rica has a regulatory entity with limited efficiency in relation to the operational capacity of AyA. In addition, 28 important small and medium-sized localities have municipal providers that work independently. In Guatemala, the responsibility for providing water and sanitation services are municipal and there is no national governing or regulatory body.

In Colombia, there is a central regulatory body for each kind of public service and one supervisory body for all public enterprises. Water supply and sanitation services are in municipal hands, but planning remains the responsibility of the national government. Some important enterprises are the Empresa de Servicios Públicos of Medellín and the private operators of Cartagena and Barranquilla.

In Brazil there are state enterprises (from every state), established by the National Plan of Sanitation and with financial support during the 1970s, that provide efficient services in coordination with municipalities. There is no national regulatory body, and some states have regulatory entities. Private participation is limited, and there is strong opposition against this kind of solution.

In Uruguay, the Enterprise OSE provides services to most of the jurisdictions in rural and urban areas, and there is a regulatory entity that supervises its activities. The constitution establishes that only the state can provide these services, and OSE is taking over privatized services in the Municipality of Maldonado, which includes Punta del Este (Schifini 2006).

# 14 Conclusions

Water governance is used, and must be used, to promote democratic and sustainable decisions to properly obtain, utilize, and maintain water resource and ecosystem services, which need to be supported by sectoral and multisectoral planning to implement their actions.

Latin America needs to integrate basin management with water supply planning, among ministries and along local, subnational, and central government lines. This suggests the necessity of "reengineering" the regulation of organizations and functions of public entities linked to water management and that a national vision is needed on the use and conservation of water and its ecosystem services.

Cost recovery is weak in Latin America and nonexistent in rural areas. This suggests the need to rethink new mechanisms that would ensure systems' operation and maintenance. Rural areas have very dispersed communities that are not attractive to private investors and are not of a scale that would make it possible to maintain or reduce marginal costs for the state. However, putting more poor people together does not necessarily make an operation more profitable, and there is a risk of inefficiency and social conflict. Latin America demands new alternatives for efficiency in rural areas, where cost recovery may be increasingly linked to tariffs for extracting water and to the incremental benefits of water use.

Regulatory entities have an important role in water governance. However, few governments want them around. Regulatory entities help to reduce corruption and to establish open criteria to use and extract water, and these entities should also participate in basin management and ecosystem services compensation mechanisms.

There are important experiences in Latin America that may serve as examples in the same region to strengthen and make policies feasible. However, gaps in policies and actions are not visible and solutions require fast validation, scaling up, and consolidation. Local governments do not coordinate their regulations with subnational or national governments. In general, land management in Latin America does not incorporate water management or ecosystem services criteria. This situation is especially complicated in a region with quickly changing land-use patterns and with highly mobile rural-urban populations and resources.

OCSAS may have a more important role in government and management, but its tasks mainly relate to collecting money, operation, and maintenance. New collaborative approaches may develop, with the state and other private organizations, to strengthen their management and financial capacities in order to consolidate their activities.

Latin American countries are trying out different water and sanitation management policy reforms that have not been very effective. None of these transformational efforts have included the water and sanitation value chain, strengthening human resources, or multisector local or national integration. Decisions in Latin America still need to combine land management criteria with social needs and economic opportunities and potential.

# Chapter 7
# Experiences with Water Supply and Sanitation

Several programs, projects, initiatives, and social movements have combined their interventions to generate changes aimed at improving water supply and sanitation conditions in Latin America. This chapter discusses some successful and not-so-successful experiences that teach what aspects could be replicated or scaled up and what should not. These experiences are also a reference for future interventions and decisions in water management and sanitation policy issues.

## 1 Social Control of Public Policies in Argentina: The Case of the Matanza Riachuelo Basin

In 2006, the Supreme Court of Justice of the Nation (SCJN), in an unexpected and promising act, declared itself competent to understand and pass judgment on the issues linked to the prevention, rearrangement, and compensation for collective environmental damage in response to the court case known as the "Causa Mendoza" a complaint filed in 2004 by a group of neighbors (Fink 2014). This court demanded that the governments submit a sanitation plan for the basin and the sanitation companies to make public the information about their productive processes. In 2008 the SCJN delivered a historical verdict, by which the responsibility of the Federal Government, the Province of Buenos Aires, and the Autonomous City of Buenos Aires for the prevention, rearrangement, and compensation matters for the existing environmental damage in the basin was established.

This all changed in 2008, when the Supreme Court of Argentina decided the Mendoza case (Mendoza, Beatriz Silvia, and Others v. National Government and Others in Regard to Damage Suffered) in favor of the plaintiffs, holding the Federal Government, Buenos Aires Province, and Buenos Aires City (and 44 adjacent businesses) all equally responsible for the contamination of the river and its remediation. Specifically, the governments were charged with three duties by the court: to



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improve the quality of life for inhabitants within the basin, to conduct remediation of the basin's ecological components, and to prevent further contamination of the river basin (McKinney 2012).

Lacking an existing organization capable of administering this duty, the Argentine Senate created a new interjurisdictional body called, unusually, the Authority of the Basin Matanza Riachuelo (ACUMAR, by its Spanish acronym), by the extent of the M-R watershed. ACUMAR, or Autoridad de la Cuenca Matanza-Riachuelo, was created to permit basinwide governance, harmonizing data collection, regulation enactment, and enforcement, as well as to administer and distribute clean-up funds. Additionally, the creation of ACUMAR was backed by a number of international aid organizations, most prominently the World Bank, with its largest-ever loan, for a water remediation and sanitation project worth US$ 840 million (McKinney 2012).

The verdict set a compulsory compliance program, giving ACUMAR the means of enforcing it. In addition, it established the authority to impose fines if the program and the schedule were not complied with, fines that would fall on the president of ACUMAR and not on the institution (Avina 2011).

To guarantee the immediate fulfillment of the court's sentence and decisions and the effective jurisdictional control over its verdict, the court delegates the sentence's enforcement to the Federal Lower Court of Quilmes. Then, under the coordination of the ombudsman, a citizen's participation program was established to monitor compliance with the sentence through a Collegiate Body comprised of representatives of nongovernmental organizations that participated as third parties in the legal process. It was also established in the sentence that the funds and budgetary fulfillment would be carried out by the National Auditing Office. On the basis of the judgment of the Collegiate Body, the federal court establishes that in addition to sewage treatment and rain drainage, drinking water services must be provided throughout the entire Matanza Riachuelo Basin (Avina 2011).

## 2 Argentina: The Case of the Water Cooperatives

In Argentina, water and sanitation cooperatives emerged during the 1960s and 1970s as a strong sector, and they are presently responsible for services in most towns with less than 50,000 inhabitants. Today, 60 % of the urban sector is in the hands of private enterprise (mainly foreign companies), 20 % in municipal hands, and around 11 % (more than four million inhabitants) in the hands of cooperatives. The rest are various kinds of groups and neighborhood associations (Muñoz 2005).

Water cooperatives, as well as municipal enterprises, and communal and neighborhood associations hindered privatization policy measures, for two main reasons. The first reason has to do with the economies of scale that larger companies require to obtain a decent rate of return (usually higher in the countries of origin than in Latin American countries). The second reason is the strong resistance from people in smaller communities that helped build the infrastructure and services, who believed that this common effort, the infrastructure and services, belonged to them.

In October 2000, around 2000 water cooperatives from different parts of the province gathered in the city of Buenos Aires, and in March 2001 they founded the Buenos Aires Water Supply and Sanitation Cooperatives Federation (FEDECAP, by its acronym in Spanish). Soon afterward, the provincial government recovered control over the company that ran Azurix, a water supply and sanitation company that was a branch of the Enron Corporation.

These facts showed true progress in the recovery of socially controlled public spaces. Natural resources, including water, belong to the provinces and are regulated under the applicable legal framework of each jurisdiction. The break-up of water supply and sanitation companies in Argentina raised important challenges that, from the standpoint of sustainable and efficient water management, do not respect political boundaries, as the settlement of the legal conflicts in the water management privatization process, as well as the consolidation of different water quality standards for different jurisdictions (Muñoz 2005).

Cooperatives face important challenges related to water quality, such as arsenic contamination, which occur very often in the northern part of the city of Buenos Aires, eastern Cordoba, and southern Santa Fe. Another problem has to do with pollutants that originate from agricultural production in which pesticides and hard water are being used every more frequently. Also, financing for the construction of sewage collection and primary and secondary treatment plants are difficult for small cooperatives. Many cooperatives build reverse osmosis treatment plants and carry out water distribution with plastic tanks, which are used for feeding purposes, while the water that comes through the pipes is used for other purposes. The construction of aqueducts starting at the main sources is seen as the only feasible solution to this problem. However, cooperatives require public funding, and in recent years they have received support from the Inter-American Development Bank (IADB), first through the Rural Potable Water and Sanitation Provincial Services (SPAR, by its Spanish acronym) and then from the National Water Civil Works Entity (ENOHSA, by its Spanish acronym), which provides technical and financial assistance to the Sanitation Federal Council, to strengthen their governance and integrate people's participation in the form of cooperatives, which have proved their efficiency in towns with less than 50,000 inhabitants, with good quality services at lower prices. So far, they have been excluded from the big cities – and therein lies the challenge of the future (Muñoz 2005).

## 3 Argentina: Privatization of a Water Supply and Sanitation Enterprise

The privatization of the Nations Sanitary Civil Works (OSN, by its Spanish acronym) began in 1993 with the goals of promoting wide access to water and sanitation services and improving water quality. New infrastructure needed to be developed, and those already in place had to be rehabilitated and modernized. The state's alleged incapacity to carry out these functions was the main argument justifying privatization in the early 1990s in Argentina, which took place through an international competition.

The key factor in the international competition to obtain the rights to provide water and sanitation services was the lowest tariff for funding the services and a specific investment plan for the first 10 years of the concession, out of a total of 30 years. This tariff level could be modified in the investment plans after the first 10 years or, in case of extraordinary events, specifically identified in the contract. Despite the limits established in the concession regulatory framework, between May 1993 and January 2002, residential tariffs increased 88.22 % on average. Users subject to the minimum tariff experienced an increase of 177 %, while 10 % of users with the highest consumption levels saw a 44 % increase. In the same period the water supply coverage (an always controversial indicator showing the level of investment) increased by just 4 % since the beginning of the concession, while sanitation services decreased by 3 %, according to estimates by the National Institute of Statistics (INDEC). The concession performance worsened the regional hydrological imbalance, on the one hand since the concession developed a larger water network than sanitation network, because the return from water investments was much higher than that from sanitation investments, and on the other hand since there was no planning regarding the use of water resources. The greater difference between the high level of water supply service and low level of sanitation service caused the saturation of the sanitation infrastructure that literally caused flooding of sewage in the Buenos Aires conurbation (Azpiazu and Forcinito 2003).

At the end of 2002, under strong pressure from the World Bank and the International Monetary Fund on the National Executive Power to increase public service tariffs, the renegotiation process included a public consultation mechanism to debate the concessionary company proposal. The growing questions about the quality of service, monopoly abuse, environmental impact, and regulatory noncompliance prompted an important debate on whether or not the company should continue and whether the concession contract should be modified. Ultimately,the ombudsman and the Contracts Renegotiation Commission moved to revoke the contract (Azpiazu and Forcinito 2003).

## 4 Bolivia: Chronicle of Privatization Failure Foretold

It is a well-known fact that, as part of IMF loan conditions to Bolivia in 1998, the national authorities agreed to privatize all remaining public companies in the country, among which was the Water Supply and Sanitation Company of Cochabamba, known as the Potable Water Municipal Service, SEMAPA by its Spanish acronym (Barrera 2009).

A year later, in September–October 1999, and in the middle of closed-door negotiations, the Bolivian government auctioned off the city's potable water system operation. The auction had a single participant: the consortium Waters of Tunari, formed by two minor Bolivian partners and the International Water Co. (a British company owned by Bechtel Corporation), as a majoritarian stockholder. After the auction, the consortium signed up for USD 2.5 billion dollars and concession rights for 40 years to provide drinking water and sanitation to the city of Cochabamba.

Coincidentally, that same year the Bolivian Parliament approved a law (Law 2029), known as the "Law of Drinking Water and Sanitation," that forced residents to pay all the water costs and granted the consortium full rights over water resources, including the aquifer.

The consortium initiated operations in November 1999, and just a few weeks later appeared the first signals of social unrest. It had been agreed, with the government, that from the beginning of operations the water tariff would be increased by 35 %. However, this decision and other administrative actions implemented by the company produced a higher impact on family charges, which in some cases doubled and tripled the charges that they were paying, and increasing water bills up to 25 % of the average income of a Cochabamba's residents.

The local users joined forces with the *regantes* (irrigation users) and the urban committees, and in this way was formed the Water and Life Defense Coordination Committee, known as La Coordinadora. In January 2000, the first active, yet peaceful, demonstrations. A few weeks later, a general strike was declared and activists blocked many roads in the city with barricades. The city of Cochabamba was paralyzed for 4 days. These initial protests extended to other places in the country, involving both rural areas and important cities (Barrera 2009).

In March, La Coordinadora held an unofficial plebiscite, which resulted in a massive rejection of the privatization project (97 % of 50,000 votes). Nevertheless, the Bolivian government refused to hold any kind of dialog or negotiations. By early April, after a brief detention of the leader of La Coordinadora (when he was called in for negotiations), martial law was declared. The activists were detained without any constitutional guarantees and freedom of movement was suspended. During a protest rally in the main square of Cochabamba, a teenager was killed by a captain of the Bolivian army and dozens were injured by bullets (Barrera 2009). The social pressure was so strong that the government was forced to cancel the privatization contract and had to revise most of Law 2029.

Most careful analysts agree that the Cochabamba conflict was mainly the consequence of a poorly designed project and the result of a lack of transparency and social participation during the political process and contract assignment management. An additional factor was the asymmetric terms of the agreement that, in a context of political and economic uncertainty, exceeded the government's regulatory capabilities (Vargas and Nickson 2002). On the other hand, several researchers have highlighted the importance of the social context where this popular movement emerged and consolidated as a land organization that was capable of assembling interest groups that otherwise had maintained divergent attitudes and perspectives (Spronk 2006).

## 5 Bolivia: A Successful Cooperative Model

Santa Cruz de la Sierra is the capital of the Santa Cruz department, located in the eastern part of the country. It has a population of 1.4 million inhabitants occupying 39,000 ha. A diagnostic research study conducted by the Bolivian government in

2002 concluded that the water supply and sanitation quality improvement possibilities were seriously affected by three basic problems: (1) atomized services, which was infeasible due to the presence of small, dispersed, and low-capacity payment markets; (2) institutional and financial weaknesses of water supply and sanitation companies; and (3) extensive financial dependency on municipalities. In Santa Cruz, water supply services are mainly provided by eight cooperatives. The largest one is the Santa Cruz Public Services Cooperatives Ltd. (SAGUAPAC, by its Spanish acronym). Since it is a drinking water and sanitation provider, its activities fall under the legal framework established by the Ministry of Water, the oversight of the Basic Services Superintendence (SISAB, by its Spanish acronym), and coordination with the Prefecture and the Santa Cruz de la Sierra Autonomous Municipal Government.

SAGUAPAC provides water and sanitation to around 845,000 inhabitants through 135,000 water connections. In the case of sanitation, 450,000 inhabitants are served by 72,000 connections.

SAGUAPAC devotes special attention to highly impoverished areas. Around 30 % of the Santa Cruz population has their basic needs met, but 70 % lives below the poverty line. For this reason, SAGUAPAC gave families payment facilities to build connections from house networks to the main water supply infrastructure. It also established a social tariff (to help their most vulnerable customers cope with costs) of USD 3.10 for each 10 $m^3$/month/household, which is within the range recommended by the Pan American Health Organization, while at the same time maintaining a tariff not to exceed 3 % of household income or a worker's daily wage.

Analysis revealed that economically depressed areas consumed less than 10 $m^3$/month per household. This is a reasonable volume for a very low-income family to meet its basic drinking water needs. SAGUAPAC considers that the cooperative model is an important and valid alternative for water supply and sanitation services. This experience has been documented and publicized in case studies made by the World Bank and the Inter-American Development Bank. However, there is limited information regarding other cooperatives that provide services on the periphery of the city. It has been shown that certain features of the model could determine whether it succeeds or fails. The model should (1) create cooperatives that satisfy the demand for goods and services, (2) allow people to follow their own preferences for specific initiatives to satisfy their needs instead of waiting for the government's support, and (3) allow people to acquire greater social status by actively participating in these cooperatives (Banco Mundial 2008).

## 6 Brazil: The "One Million Rural Water Tanks" Program

The Articulation of the Brazilian Semi-Arid Region (ASA) has been working for the development of this region since 1999. In this region, public intervention had traditionally treated water issues by building larger infrastructures that benefited a minority, understood as those with more resources (Avina 2011). Water has been a currency used by politicians during election times and, as well as land, they were always concentrated in few hands. In 2003 the "One Million Rural Water Tanks" program (also known as the P1MC), proposed, launched, and managed by organized social groups, appeared. However, when the ASA put the program into operation, it did not replace the public sector in the implementation of strategies to access water because it was understood that access to water was a fundamental right guaranteed by the state (Avina 2011).

The water tanks of the P1MC were built with precast concrete plates. A simple method was used that allows the collection of rainwater through aluminum canals installed on the roofs of houses. Water circulates through the pipes to the water tank and is then extracted for family consumption using a hand pump simple enough for any family member to use. The total cost of the construction is around R$ 2000.00, which is approximately USD 1100 per family. This amount includes the cost of the entire process of mobilizing and training the beneficiaries and building the cistern, as well as administrative costs. The materials used for the construction are cement, steel wire, pebbles, lime, sand, rain gutters, pumps, and concrete plates. Building a water tank takes around 3 to 5 days and is usually done by local masons who are members of beneficiary communities.

The P1MC has a goal of building one million water tanks in the Brazilian semiarid region, where low flow periods could occur 8 months out of the year. The water tank was selected by ASA to store rainwater because of its low construction costs, ease of use, and amenability to word-of-mouth advertising. With one million water tanks distributed in the entire semiarid region of Brazil, it will be possible to store 16,000 million liters of water in a decentralized way. Along with the "One Million Rural Water Tanks" program, ASA also promotes training and mobilization of beneficiary families. Community members with water tanks participate in all program stages, from the selection of beneficiary families to water resource management (WRM) courses, as well as additional activities to ensure the sustainability of the interventions, good community governance, citizenship, and protection of rights. In this way, ASA has become a cornerstone for families' mobilization and social development with respect to basic rights, access to drinking water, education, and health (Avina 2011).

## 7 Colombia: Social Programs for Water Supply Services

In Medellin, the municipality is responsible for providing public services, and the Public Enterprises of Medellin (EPM, by its Spanish acronym) manages electricity, gas, water and sanitation, and telecommunication services.

In the water sector, there are no alternative water and sanitation providers. Water supply coverage is 98 and sanitation coverage is 94 %. The service is of good quality and without interruption. However, this coverage does not include illegal settlements. It is in these areas where the poorest population of Medellin is located. The existence of these neighborhoods is being gradually acknowledged, and thanks to infrastructure improvements and plot requalification, these spaces have made their way into the EPM coverage area, which authorizes them to demand water supply and sanitation services.

Neighborhoods without a formal connection to the EPM network obtain water in three different ways: (1) by building an illegal connection to the EPM network, (2) by obtaining the authorization to use the water of a community that gets its water from a local source, or (3) by obtaining a community connection from the EPM and directly managing the distribution in a nonsecured way. In this last case, the EPM charges users with a fixed tariff that subsequently, when the water supply service is formalized, will be accepted as a contribution to connection costs.

One of the aspects of interest of the program project cycle is the social contract that makes it possible to hire community businesses to create jobs when expansion or maintenance infrastructure activities are developed by the EPM. A social contract involves participation and community organization from project conception to fostering a strong sense of belonging and strengthening relationships between communities and the EPM (World Bank 2008).

## 8 Ecuador: Successful Privatization of Drinking Water Services

Since August 2001, the private Consortium Interagua obtained a 30 year concession to provide water and sanitation services to the city of Guayaquil, Ecuador's largest city. Before the concession started, there were around 242,000 houses with drinking water connections, which represented 63 % of total demand, but just half of this demand had sanitation connections; a similar percentage of the population had no continual service and noncommercialized water reached 80 %.

Five years later, the percentage of users being served reached 77 %, even when the demand increased slightly less than 13 %. Interagua projections showed that in 2011, 83 % of users would have access to its services.

In urban areas, sewage treatment service coverage has undergone a more gradual evolution. Through the use of collecting networks, pumping stations, water drivelines and treatment, coverage went from 50 % in 2001 to 58 % in 2006. Projections were that in 2011, 70 % would have access to piped sanitation. At the end of 2006, Interagua was providing 24 h water supply delivery service to 90 % of the population of Guayaquil (World Bank 2008).

One of the aspects that allowed the attainment of these indicators is the approach of the company to the communities. To promote community-based management services, a map of the slum area leaders was developed to invite them to monthly meetings in which in the first 5 years more than 7000 persons have participated. In addition, the program "We are Water" trained 280 people in hygiene and proper water use habits. Other strategic alliances have been developed with the municipality of Guayaquil, the Pan American Health Organization, the Ministry of Health, the European Union, and several other foundations and organizations (World Bank 2008).

## 9 Guatemala: Water Supply and Sanitation with a Basin Approach

Water of the People (ADP, by its Spanish acronym) operates in rural indigenous agricultural communities that trace their heritage back to the Maya, where families live in extreme poverty, lacking most public services. The project developed under a comprehensive approach, which considered, in addition to the water supply system, other complementary aspects such as the construction of latrines, sinks, training for families, training for local workers, and soil conservation through reforestation, on the understanding that drinking water management is part of the basin's water management.

The construction of latrines, as a complement to the water system, also contributes to reducing impacts on the aquifer and other water bodies located around the communities. Sink systems collect the sewage that flows on the surface carrying all kinds of substances, like detergents, soaps, oil, and others that flow to water bodies. The soil conservation practice in irrigation systems has a positive environmental impact, for instance, infiltration pits exist in the natural environment by nurturing the underground water that ultimately, once filtered, contributes to water availability (GWP/AA 2010).

ADP operates in several communities of Sololá, Momostenango, Aguacatan, and Totonicapan that have 25–35 years' experience managing local water supply systems and that have demonstrated their technical, social, organizational, and environmental capabilities. This has brought about a state of affairs that can be characterized as follows: (1) communities manage the water systems in accordance with their own vision, (2) the organized community culture is applied in managing the water system, (3) local human resources are capable of maintaining and adapting the system to suit local needs, (4) the water committees and the community development councils apply their own cultural principles, (5) community organization through water transcends other organization levels, (6) the organizational capacity and community knowledge function efficiently in emergency situations, (7) the water project management community model could be a cornerstone for public policies with grassroots participation (GWP/AA 2010).

This community work is complemented by that of the Association of Communities for Water, the Environment, and the Comprehensive Development of the Naranjo River Basin (CADISNA, by its Spanish acronym), which works on behalf of socially vulnerable populations, prioritizing children, women, and the elderly and aims to increase access to water, with respect to both quantity and quality, in the region (GWP/AA 2010).

## 10 Mexico: Water Governance at the Local Level: A Case Study of the Municipality of Zapotitlan de Vadillo, Jalisco

The municipality of Zapotitlan de Vadillo belongs to the Ayuqila-Armeria River Basin, and it has a complex environment due to altitude variations and a rough terrain. The municipality is located in the low part of the basin, it has a high level of social exclusion and half of its population lives in rural areas. In the social arena, there is social unrest caused by the unfair distribution of water, which is also wasted, and water management is limited to administrative and political aspects. In the economic arena, a high number of users do not pay for water service (23 %), the municipal budget is low, and the infrastructure is obsolete (pipes are more than 40 years old), which has resulted in a large number of leaks and breakdowns (Salcido et al. 2010). The Water Management Municipal Act, currently under development, is a vital instrument for creating a more sustainable approach to water use, and its absence does not allow for the kinds of relationships that should exist between federal, state, and municipal levels and that could lead to better management of water resources at the local level.

Society feels this dysfunctional situation and important events have marked the municipality's governance. On 21 January 2003, an earthquake hit the area and damaged more than 1300 houses. This event mobilized the municipal government, the church, and the army to help those affected. Another process was the creation of the water committee in the headwater municipality's territory, which took place when the people disagreed with the idea of running a water pipe from this source to the municipality of Toliman because it would create more water scarcity for the municipality of Zapotitlan de Vadillo. The local population organized themselves through open meetings in which local water management officials also participated, and by 2012 all parties agreed to create a joint committee to make decisions on water use and management. Even though this committee is not active at the present time, it is an important actor that makes decisions at this level (Salcido et al. 2010).

This experience shows the capacity of local organizations to organize themselves and to develop the capacity to block other communities' access to water, legitimizing their actions by including the local water committee and a broad-based local-population consensus. On the other hand, it demonstrates the use of resources can be organized without state involvement in a way that benefits all affected parties, including neighboring communities.

This case study shows that several public policies have not attained their goals at the local level since the range of problems in the municipality of Zapotitlan de Vadillo, still requires a more influential organization to participate in decision making and a government that allows public involvement and supports and promotes citizens' participation. It is important to note that the local government is, at least until the time of this research, unprepared to properly involve itself in these governance processes that aim to resolve the problems around water management, even though this public institution has as its mission to promote and strengthen social welfare, health, and the environment and to invite people's participation as the means to making democratic decisions (Salcido et al. 2010).

## 11 Peru: The "Water for All" Program

The "Water for All" program (PAPT, by its Spanish acronym), now rechristened the Rural Sanitation National Program, was designed and launched as a political initiative during the 2006 presidential campaign by candidate Alan Garcia, who was in fact elected president at that time. Though it might be too early to see the impact of this program, the PAPT was not simply an infrastructure program to provide water and sanitation services but an example of what could be called a "cost approach" in the fight against poverty and indigence.

Following a debate about indigence or poverty as a key aspect, state intervention was identified as the only possible way to overcome it. In addition to what is known as conditioned cash transferences ("demand approach"), there is the concept of interventions to reduce what labor theory calls unavoidable costs and to liberate family cash flow to increase discretionary income for the satisfaction of basic needs and to reach a standard of living that would allow these families to participate in the market (Garrido-Lecca 2010). The PAPT achieved important results in water supply and sanitation coverage, especially in urban areas. Thus, even though the local and regional governments were not prepared or trained to manage or contract large water supply and sanitation projects, the Ministry of Housing, Water Supply, and Sanitation allocated funds directly to the municipalities and regional governments to avoid giving the money back to the Ministry of Economy because of low levels of budgetary implementation.

This situation resulted in a revision of human resources and administrative procedures because local and regional governments did not want to lose the resources allocated by the Ministry of Housing, Water Supply, and Sanitation because there were time limits to spend the budgets. In this way, the decentralized capacity to implement water supply and sanitation projects was literally pushed forward "by force" and speeded up the project's design and implementation timelines, which would be called a kind of accelerated "trickle down" effect.

## 12 Peru: Water Supply and Sanitation in the Andes

The Basic Sanitation on the South project (known in Spanish as Sanbasur), which designed and validated the Basic Environmental Sanitation Sustainable Management Integrated Model (SABA in Spanish), was implemented with the technical and financial support of the Swiss Agency for Cooperation and Development.

This model has contributed to strengthening the sectoral investment sustainability and the fight against poverty through water and sanitation. This model, at the micro level, understood as the community level, considers infrastructure together with the social component, which includes the project promotion, training, and sanitation education, which are important factors in participatory and sustainable sanitation management by the JASS, the community water supply and sanitation management committee. In addition, this committee works with the local government to improve people's behavior with respect to personal and environmental hygiene. The interventions' premise was to make local and regional governments partially responsible for the project, in accordance with current legislation on basic environmental sanitation, and require the health and education sectors to develop technical support actions, closely coordinating with local governments and organizations involved in sanitation projects. In this way, this project contributed to changing the paradigm of basic service provision by only considering infrastructure without community participation, that is, by including users directly (GRC 2011). However, these interventions had many weaknesses, summarized in the "Social Actions during the Construction Workshop" report published by the regional government of Cusco as "the absence of the resident engineer during construction, the lack of coordination with the field team, the lack of communication with users, the participation of inexperienced master builders and without knowledge of project methodology, ignorance about quality construction materials, the disregard of social promotion, and a political means of hiring master builders and trainers by the municipality" (GRC 2009).

In addition, "the institutional promoters were not identified with the work, they did not work with the social plan, and there was no coordination with the institutions involved in the basic sanitation methodology." The same report mentions the "lack of implementation of the basic sanitation offices, the weak communication with distant communities, and the overloaded capacity of the municipal basic sanitation project manager. Also, supervisors did not comply with deadlines, did not know the Quechua language, and had weak communication with the resident engineer." The situation was apparently even worse in distant Quechua and Aymara communities: "The educational institutes that were involved did not work in a coordinated way. The teachers did not have an idea of the basic sanitation methodology and did not use the local plans. The health sector employees did not comply with the agreements due to a lack of human resources and the great distance between communities" (GRC 2009).

## 13 Peru: Saving Urban Water Under Market Conditions

As part of the environmental initiatives of the Ministry of Housing, Water Supply and Sanitation, the Office of the Environment explored during the year 2007, with local banks, the idea of providing low-interest-rate loans to families interested in buying products and water-saving devices to save money on their monthly water bills. After making a market and credit assessment and evaluating banking conditions, the Office of the Environment started negotiations to facilitate this essentially private service to families (Arana 2012c).

To spur interest among families in low-interest-rate credit to buy products, it had to be demonstrated that: (1) families would be able to pay the loans back with the money saved by reducing their monthly water consumption and, consequently, reducing their water bills; and (2) houses should have no leaks that would create additional nonmeasurable costs increasing the water consumption (Arana 2012c).

In addition, it was very important to have a well-distributed number of hardware stores that could provide these water-saving devices at a competitive price.

The ministry called all the local banks, since by law it could not give preference to a specific bank, but in the end only the Nation's Bank and Scotiabank signed agreements with the ministry and with SEDAPAL, the Water Supply and Sanitation Company of Lima and Callao (the capital of Peru). To put the agreement on wheels, it was necessary to identify: (1) trained technicians who could conduct a serious evaluation of the sanitation infrastructure in every house to prevent leaks and save water and (2) providers certified by Sedapal who could offer devices for families to buy (Arana 2012c).

In most cases, families saved money and water, and the savings were enough to cover the monthly payment for buying the water-saving devices. Scotiabank offered the product to all its cardholders at a 12 % interest rate, at the time almost the same rate as the country's annual rate of inflation, and in 24 months the bank made around 25,000 loans. In the case of this particular bank, 80 % of the families paid back their loans in full – with the savings they made by reducing water consumption – after a year or one and a half years maximum. The Nation's Bank introduced its financial product at an interest rate of 14 % and allowed automatic approval to people whose paychecks were deposited in accounts at the bank (Arana 2012c).

This water-saving initiative could be implemented by facilitating market dynamics with users, for instance, by promoting the participation of water-saving sanitation device providers and technicians, who would spur wider competition to the benefit of consumers.

The beneficiary families reduced the leaks in their homes and their unnecessary consumption and cut their monthly water bills. Around 40,000 families opted into this initiative, and as an average, water consumption was reduced in 30 %–40 % during the first two years of the implementation of the Program, which meant increased water availability – or greater water consumption – for around 16,000 to 20,000 additional families. However, the low cost of drinking water serves as an incentive to waste it or consume without thinking. The water-saving initiative could be implemented in other countries to optimize the use of water resources.

## 14 Peru: The Water Group

The Water Group, or El Grupo Agua in Spanish, is the committee formed by bilateral and multilateral development and financial agencies that seek to support mainly water supply and sanitation development. It was formed in 2004 by development agencies and is chaired by a representative of the Ministry of Housing, Water Supply and Sanitation, usually the vice-minister or , infrequently, the minister. Even though the name of the committee contains the word *water*, other agencies, like the National Water Authority, the Ministry of the Environment, Health and Agriculture, do not participate in the committee's activities, though the group says that they do. The Water Group is not a legally established entity – there are no bylaws or a formal constitution – and it exists simply because of the good will of the water and sanitation sector and the development agencies.

The main development agencies that form this committee are the Japan International Cooperation Agency (JICA), the Japan Bank for International Cooperation (JBIC), the Spanish Agency for International Development Cooperation (AECID), the United States Agency for International Development (USAID), the Inter-American Development Bank (IADB), the Latin American Development Bank (CAF), the Pan-American Health Organization (PAHO), the Swiss Agency for Development and Cooperation (SDC), the Swiss State Secretariat for Economic Affairs (SECO), the Fund of the Americas (FONDAM), the German Agency for Cooperation for Development (GIZ), the German Bank for International Development (KfW), and the Water and Sanitation Program (WSP) of the World Bank.

This way to put the multilateral and bilateral agencies and the main public investor in water together, has some advantages because it allows a closer coordination between policy development and project implementation with the capacity to fund these initiatives. Bilateral and multilateral organizations are always interested in showing or presenting to water and sanitation authorities new approaches, experiences, or ideas for assisting the government in its decisions or strengthening its initiatives and providing the resources it may need, either in the way of a small, nonreimbursable pooled funds or in the way of larger loans. At this level, negotiations are not conducted by the committee; they require the participation of the Ministry of Economy, which by law must authorize international indebtedness. The existence of this committee avoids feelings of territoriality among development agencies and forces them to act in a more coordinated way. The winners in all this are the government and the people, who expect a more coherent and efficient public investment. This experience could be replicated in other countries in the region with very positive impacts.

## 15 Peru: Rural water supply and sanitation with basins approach

In general in Peru, and in Latin America, rural water supply and sanitation is administered by small community organizations or committees without funding or technical capacity. These organizations work independently from water management public institutions, or from rural agricultural committees which consume water just to obtain economic benefits.

In 2014, the International Secretariat for Water in partnership with the Canadian foundation Wings of Hope, the Seine-Normandie Water Agency and the Dieppe Nord Syndicate, started a rural water supply and sanitation with basins approach infrastructure project, that strengthened rural water supply and sanitation administration with water resources management on the indigenous community of Cuchoquesera that is located on the headwaters of the Cachi river at more than 4000 meters of altitude in the Ayacucho Region. This community had given their land to the government (to allow the construction of a 80 MCUM reservoir) because in exchange they would receive water supply and sanitation services that in fact never arrived. Also, this community is being threatened by mining activities that are «climbing» to the headwaters area.

The strategy was to implement a sustainable rural water supply and sanitation infrastructure project combined with a participatory headwaters land management and water and environmental conservation activities. The project also promotes the creation of a new rural community organization strengthening the rural water supply and sanitation committee (JASS) with new functions to manage water resources, conserve the headwaters territory and to establish a land management communal policy.

This communal institutional strengthening is a key aspect of the project because it covers an important absence of the State since public organizations do not go often to rural communities that are far or located in very high altitude areas. This new community organization is also important because the community is located on a headwaters territory where water sources are originated and then distributed along the basin. This experience could be replicated in many other Latin American countries and specially to contribute to participatory headwater territories management and to protect water towers of the region.

## 16 Conclusions

Several experiences, successful and unsuccessful, show us *sui generis* water management aspects that impart to us important lessons that could help policymakers rethink their actions or the policies they propose.

In Argentina, people's organization around a Supreme Court verdict that forces the government to repair and compensate for environmental damage is a nonprecedent experience that creates jurisprudence in the region. Equally, in Argentina, cooperatives provide a lesson in highly efficient water management, where they show how to be very efficient in communities with less than 50,000 inhabitants, in a country where 11 % of the urban water supply is in the hands of cooperatives. In addition, in Argentina, the lessons from the Nation's Water and Sanitation Company, where a contract renegotiation to increase water tariffs called for a public consultation mechanism, proposed the existence of strong public opinion regarding common goods management.

In Cochabamba, Bolivia, the failure of privatization in societies traditionally developed under cooperative and community mechanisms is a lesson that demands that these initiatives have social legitimacy, consider the economic conditions of the societies they work with, respect the law, and be transparent at all levels. Other experiences show that enterprises and communities can work together to the benefit of all. Also in Bolivia, in Santa Cruz de la Sierra, as well as in Argentina, the cooperative experiences with administering water supply and sanitation services among less than 50,000 inhabitants have shown a remarkable level of efficiency, in many cases as a response to the absence of the state. However, when the cost of infrastructure exceeds the revenues of these cooperatives, new management and association strategies will be needed.

In Brazil, the "One Million Rural Water Tanks" project demonstrates that to achieve economies of scale, it is not necessary to be concentrated or agglomerated, and a one-million-water-tanks initiative in the Amazon generates a decentralized scale and reduces the marginal cost of building inputs while at the same time using local manpower.

In Medellin, Colombia, the incorporation of social programs in water supply services, on a specific scale and in specific issues, shows how community contractors can work well with a public utility company under a clear methodology. The Guatemalan case of "Water of the People" is a replicable project where rural water supply and sanitation get together with the rural basin management approach to provide a valuable lesson. In Ecuador, the lessons from the private consortium Interagua, which provides water and sanitation to the city of Guayaquil, demonstrates that it is possible and positive that private infrastructure companies work together with grassroots organizations and local communities.

In Mexico, the experience of the municipality and the people's opposition, specifically organized over conflicts having to do with the water supply, shows the necessity of holding negotiations and dialog with the community.

In Peru, the "Water for All" program showed that it is possible to drastically increase coverage if there is firm and continued political will to modify and reformulate local procedures and attitudes to the rapid implementation of investment projects. Also in Peru, the Sanbasur project, using the SABA approach, shows us that interventions in water supply and sanitation are a good thing, as long as they incorporate comprehensive investment with local governments and health and education agencies, but they could be even better if they could consider the basin approach, waste water recycling, and if they could consider local cultural conditions even more carefully. Also in Peru, the water-saving initiative promoted by the government and implemented by the private sector demonstrates that water can be saved, while families save money at the same time, facilitating markets dynamics. Too, the International Secretariat for Water shows that it is necessary and possible that community organizations strengthen their responsability to administrate, possibly under the delegation of the central government, headwaters territories protection. Finally, the Water Group shows that coordinated development agencies' participation can enhance the sectoral water supply and sanitation agenda.

Market dynamics can be used to promote savings and better services to users. However, the fact that not all social groups will react in the same way to the same market incentives must be taken into consideration, so any scaling up of a proposal should include the social, economic, and cultural conditions specific to the location where a proposed project is to be developed.

In general, all these experiences show that Latin America keeps innovating, and these validations, with relevant adaptations, could form part of new policies to revitalize civil society and local and national government intervention schemes.

# Chapter 8
# Policy Recommendations and Project Proposals

Latin America is made up of several countries that have very similar cultures, languages, economies, and organization, mainly inherited from colonial institutions, as well as environmental conditions, societies, and problems. Dysfunctional water management and sanitation situations are basically the same, with some variation, and the opportunities seem to be similar in each country. However, Latin American countries still have not developed the capacity to work out water management and sanitation strategies in an integrated way.

Some Latin American countries have shown in the past decade important economic growth that has not been necessarily reflected in more social equity, beginning with basic services like water supply and sanitation. The fact that there are similar cultures or languages does not necessarily justify the need for integrated policies, but when water resources are shared with countries that occupy the same ecoregion, as demonstrated in this chapter, then it is simply illogical to manage them separately because all the countries depend on the same resource and the same biophysical dynamics at the ecoregional scale.

At the same time, this chapter shows that some conditions that are in a positive state, such as the availability of water resources, investments in water and sanitation, and ecosystem services, have a strong impact on people's income and wealth. However, the effective improvement in these conditions depends on multinational interventions. Thus, if Latin American countries are interested in creating wealth for their people, they need to work closely and in a more integrated way to conserve water resources, providing efficient and sustainable drinking water and sanitation infrastructure, and to maintain ecosystem services.



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# 1 A Policy Framework Proposal for Latin American Countries

There are several approaches to identifying a policy framework to ensure water and land security in Latin America. One of them is strictly oriented to water and environmental countries' interdependency or key environmental conditions that create wealth. In the case of Latin American countries, these conditions are grouped into ecoregions and not current political divisions. In this region, political boundaries were historically established during colonial times where the main goal was to extract natural resources and take them abroad, to the metropolis, Spain, and Portugal. This colonization process did not necessarily consider environmental conditions, so current boundaries do not integrate these geographical conditions; as a result, it is very common to see headwaters originating in one country and terminating in another one or traversing many countries.

Another approach to coming up with a Latin American policy framework is by sectoral division, mainly characterized by the regulations that defined the facilities and capacities of the countries' ministries. However, as shown in this book, Latin American ministries manage water in a dispersed way; for instance, agricultural policies are set by one minister, environmental policies by another, and the same for land management and water and sanitation.

Another approach identifies the dimensions that constitute development and that are more commonly used for academic purposes, such as social, economic, physical, ecological, political, and managerial dimensions. However, all the sectors of development or ministries in a government can use these dimensions. Translating the development dimensions into political decisions is another challenge.

Another approach focuses on urban and rural spaces and the different income groups that coexist in these territories. In this way, there are four main social-territorial sectors: low- and lower medium-income families that live in urban and rural areas; and upper-medium and high-income families that also live in urban and rural areas. Each sector may require a separate analysis and interpretations and differentiated policies and strategies.

# 2 Ensuring the Quality and Quantity of Water Sources

Latin American countries can enhance the conditions that determine quality water source availability in a variety of ways.

## *2.1 Political Aspects*

1. A Latin American water resources authority could establish criteria to protect water resources and ecosystem services in the region. This might require a focal point at the national level in every country, along the lines of a national water

agency that exists in some countries. This regional authority would establish criteria to work among sectors or ministries and among countries, especially transboundary basins, international headwaters, or ecoregions.
2. Open information to water management could strengthen citizen participation and transparency among countries. The regional water authority, in coordination with country representatives, would establish the criteria and the kind of information that would be available.
3. Establishing guidelines regarding the water cycle, ecosystem services, and climate change adaptation in the regulations of ministry functions might allow different sectoral authorities concerned with water to participate and intervene in their particular sector to protect water resources from their sources throughout the entire water cycle.
4. Establishing water management criteria at the subnational, municipal, and communal levels might allow local authorities and communities to intervene in water conservation and protection activities at the local and basin levels.

## 2.2 Organizational Aspects

1. Strengthening the water conservation capacities of human resources dedicated to water supply and sanitation management might include personnel from water supply and sanitation companies, cooperatives, and rural committees, so that water use and conservation links may become better integrated.
2. Empowering subnational and municipal authorities, as well as community leaders, in basin management and ecosystem services would help management capacities in the field, to protect resources, design projects, and implement and monitor them.
3. Redesigning internal managerial structures in subnational and local governments to respond to water conservation needs would help make it easier to address more directly and efficiently local demands, issues, and project opportunities to conserve water resources and ecosystem services.
4. Establishing interacting management spaces would allow for coordination and cooperation, for instance, between cooperatives and community organizations, with water supply and sanitation enterprises in a basin.
5. Applying common assessment and project design criteria among water supply and sanitation organizations, basin organizations, or water supply committees that belong to different countries, especially in transboundary basins or in the same ecoregion, would allow for a more concerted, integrated, and uniform approach to water resource management.

## 2.3 Physical Aspects

1. Policies regarding the construction of reservoirs, infiltration channels, and water harvesting infrastructure at the national and international levels to ensure the biophysical functions and ecosystem services of basins.

2. Equipment for water monitoring and management should be provided at the local and community levels; equipment like water monitoring tools, water management instruments, and vehicles are key to allowing good professional performance.
3. Projects for maintaining headwaters could be launched; this might include, for example, "respiration" pits, infiltration canals, lakes with low percolation rates, artificial fractures to channel water to underground streams, forestry of specific areas, and water attraction plants.
4. Headwater territories could be zoned in certain ways with people's participation. In Latin America headwaters need to be conserved to ensure water for the basins; at the same time headwater territories affect poor rural Latin American communities, so zoning is important to ensure sustainable land use. People's participation might help mitigate the fact of imposing restrictive uses that would impact rural household economies.
5. Construction materials and construction methods that respect headwater fragility should be identified. To promote the conservation of headwater territories, it is important to determine common construction criteria that might be useful in Latin American ecoregions.
6. Provisions for urban and rural water supply and sanitation infrastructure should be enhanced. In this way, the fight against poverty would be more effective and conditions for sustainable wealth and growth may be put in place.

## *2.4 Environmental Aspects*

1. Criteria, guidelines, and legislation should be established in Latin American countries to promote water use efficiency in all consumptive uses in urban and rural areas. This measure would enhance regional action on water use efficiency to promote equity.
2. National environmental surveillance and enforcement should be strengthened. This would help to establish regulations in Latin America that would force all countries equally responsible and not avoid allowing polluting countries to enjoy the benefits of water conservation and ecosystem services.
3. Laws requiring restitution for environmental damage should be passed and strictly enforced to make polluters pay for damage they do to the environment.
4. Municipal environmental and water quality monitoring should be implemented to reduce environmental vulnerability through local institutions that have a faster disaster response capacity.
5. Monitoring and early warning systems should be developed in headwater areas through communal organizations. In this way communal organizations would once again make a stronger contribution to sustainable water management.
6. There should be criteria and reward mechanisms established in Latin American countries for ecosystem service conservation so ecoregions and headwaters would be equally protected throughout the region.

7. Criteria, guidelines, and regulation governing urban and rural sustainable land management in Latin America should be strengthened to avoid disparities in different countries' land occupation patterns that might affect ecosystem and ecoregion performance.

## 2.5 Economic Aspects

1. Confunding mechanisms should be established to finance water conservation and infrastructure at the local, regional and national levels: In order to support investment projects with bilateral and multilateral funding, complement the national budget and to cofund decentralized financial mechanisms.
2. Incentives should be put in place for cofinancing community infrastructure in water supply and sanitation, for example, tax reduction, intermunicipality funding, and ecosystem service conservation awards, to match private social responsibility and cooperation funding.
3. The economic contribution of other consumptive uses to ecosystem services should be recognized. Industrial and, especially, agricultural users are important consumers of water and so should also contribute to the maintenance of ecosystem services, and national governments should develop legislation to promote this.
4. Low-interest-rate loans should be offered for the installation of water-saving devices. In this way people would reduce their monthly water bills and with the savings pay back the loan they took out to buy the saving devices.
5. The costs of basin maintenance need to be identified. This is very important because little is known about the costs of maintaining a basin, which makes it impossible for governments to calculate how much each user should pay. In some cases basins will have to be managed by several governments.
6. Tariffs on water consumption should be imposed in such a way that how much one pays for water is directly tied to how much one uses.
7. Promoting financial insurance mechanisms to give a compensation to basins' that may be affected by natural disasters or radical climate changes phenomena; in this way basins, ecosystem services and their families could easily and fast obtain resources to rebuild and to reestablish basin's biophysical conditions.
8. Polluters should have to pay restitution for the damage they do. Precautionary principles need to be put into action to prioritize water conservation. Water polluters should pay damages and restoration and recovery costs. A legal framework would be necessary for determining damages.

## 2.6 Social Aspects

1. Criteria for regulating water use in Latin America should be set up to unify efforts to protect a common resource, establish common tariffs, and formulate efficiency indicators for water and sanitation operators at the regional and

national levels. These criteria should include rural and urban users and operators.
2. Urban and rural organizations and independent citizens should be made part of the decision-making process when it comes to water use and sanitation services. This should apply to drinking water and basin management as well.
3. A method for assessing the efficiency of organizations located in basins. This could include urban and rural civil society organizations and public institutions. Operational and management aspects would be included in such assessments.
4. Social tariffs should be imposed on behalf of vulnerable families. This would help protect vulnerable families and help them develop their household economies.

## 3 Providing Urban and Rural Drinking Water Supplies and Sanitation in a Fast and Sustainable Way

The water supply and sanitation sector in Latin America has important weaknesses and an expectant economic projection due to the current economic growth of some countries. So far, the inhabitants of Latin American countries have been concentrating in urban areas, and mostly in coastal areas. Urban areas are the main centers responsible for the countries' GDP, while rural areas, especially mountains, which are of ecological importance for human survival, are shedding their populations. The most abandoned rural areas are where water sources are located. The alignment of these phenomena is causing the loss of water resources and, hence, leading to decreased availability for drinking purposes.

Latin American countries are experiencing important water supply and sanitation deficits in urban and rural areas, and rural areas are the most affected by poor management capacities.

Water management needs to be strengthened at different levels of government and by authorities who hold different responsibilities for water management and do not coordinate activities among each other. Public-sector management of water is weak in most Latin American countries, and their work is not integrated into small committees, cooperatives, or communities that manage rural water supply and sanitation services. In urban areas, informal urbanization demands large amounts of water, which is delivered in organized ways directly to private providers, generally informal, with low quality and at high prices. On the other hand, rural people have organized themselves to build and maintain services, in many cases without ensuring water quality, while sewage may go directly to water bodies without treatment. Rural communities are distant from one another, and providing services to these populations may be three to five times more expensive than in intermediate centers.

Water supply and sanitation sector goals are not ambitious in Latin American countries. One of the myths surrounding this sector is that greater levels of investment in infrastructure projects would cause more money to circulate in the system, spurring demand and creating inflation, so infrastructure investment should be done slowly. However, investing in basic infrastructure would not create inflation because recipients will not see the cash directly in circulation. They will have water and sanitation services that will reduce diseases, giving them more time to be productive, be with their families, or study. In other words, they will have more economic – noncash – economic benefits.

Another myth promoted by some governments is that ramping up investment in water and sanitation too quickly would lead to low-quality infrastructure that would soon break down or stop working properly because of the low-quality technical capabilities in the country. This situation could be easily resolved if calls for proposals or bids were open to other organizations and enterprises in other countries, not just construction companies but also cooperatives, committees, or private corporate providers. However, even though international bids are allowed in all Latin American countries, many governments insist on selecting local friendly companies to build infrastructure projects. In general, regulatory organizations focus on large companies, ignoring small cooperatives or rural committees that in most Latin American countries do not enter into the regulatory picture.

Latin American countries that have not met 100 % of service demand in urban and rural areas have very modest short-term goals. A sectoral plan to reduce the gap to zero in the short term would be revolutionary, not only because it would lead to the elimination of externalities, costs, and diseases associated with a lack of water and sanitation, but it would also boost the construction sector. Sectoral planning would need clear management models and simple construction methods, from project planning to postmortem evaluations.

Many experiences in this area may be considered. However, it is important to highlight alternative and efficient options like cooperative and community models that work well in communities under 50,000 inhabitants, which could be a response to privatization failures that have generated conflicts and unfulfilled contracts. In addition, water tank trucks have, with community involvement and low-intensity work, succeeded at providing drinking water in mainly urban areas.

On the other hand, what may work well in urban areas may fail in rural areas. Each approach and management model would imply a different scenario requiring its own specific assessment so that beneficial social and economic processes would not be undermined (Fig. 8.1).

The characteristics of urban and rural water supply and sanitation change depending on the capacity of families' savings capacity. Rural families with low savings capabilities (low-income groups) are widely dispersed, have workers with few to no skills, and attract little interest from private companies. For these reasons, such areas require a significant level of subsidies, accompanied by land management measures that would help create the needed infrastructure in a more efficient way and train potential workers so they are prepared to take on construction responsibilities.

Rural families with higher incomes or higher levels of savings (high-income group) show moderate population dispersion, living mainly in small rural villages or close to intermediate cities, have the capacity to take on large amounts of debt, and may have access to water supply and sanitation services from community or cooperative providers.

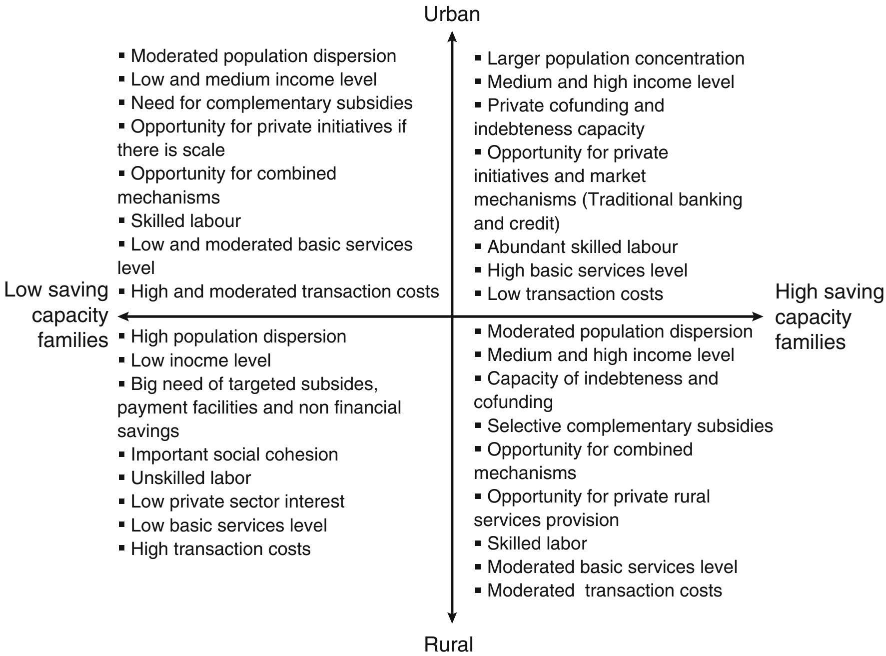


**Fig. 8.1** Latin America: characteristics of water supply and sanitation for urban and rural families by saving capacity levels

In urban areas the situation is different. Families with low income levels (low-income urban group) have more skilled labor to offer, though they may have little opportunity to save money, with the exception of population under the extreme poverty line. There is, however, an opportunity to water supply and sanitation private providers, especially if there are economies of scale and high density, so in this way transaction costs are reduced. On the other hand, urban families with higher incomes (high-income urban group) have higher levels of indebtedness capacity and higher water consumption. They are also a target group for private investors.

The analysis of these four groups allows us to identify differentiated policy measures to provide what is needed in particular circumstances. In general, public policies in Latin America do not take into consideration differences in local circumstances in rural or urban areas, or whether social groups have more or less capacity to function independently (Fig. 8.2).

Low-income rural families are the most vulnerable, so governments may need to denote special attention to such policy measures as subsidies in construction materials and technical assistance, inclusion of local labor in infrastructure construction and maintenance, the establishment of municipal and specialized nonprofit organizations

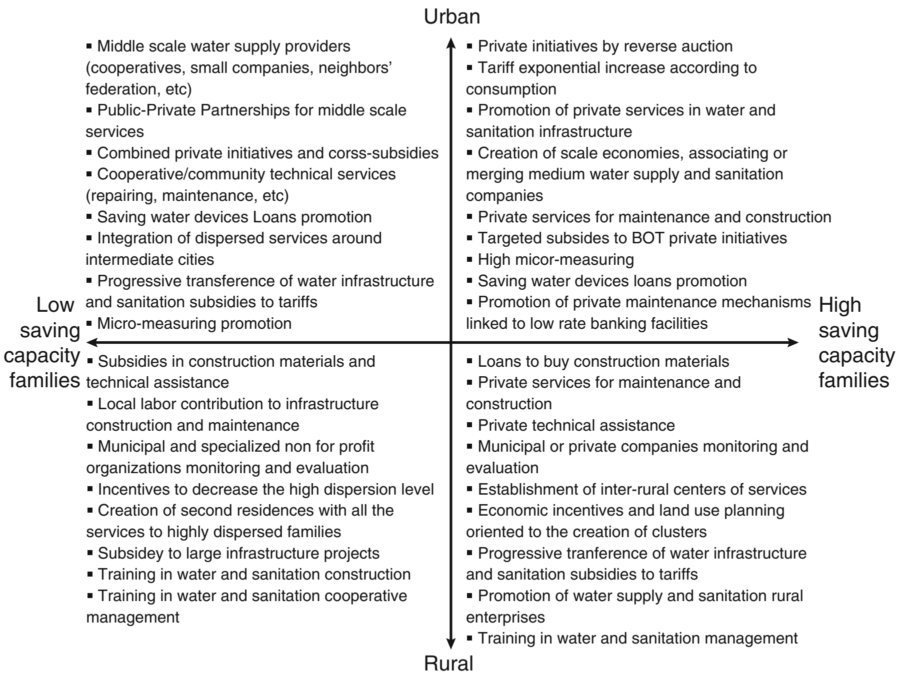


**Fig. 8.2** Latin America: policy options in water supply and sanitation for urban and rural families by saving capacity levels

to monitor and evaluate water supply and sanitation projects, incentives to decrease the high rate of population dispersion, the creation of second residences with all services to highly dispersed families, subsidies for large infrastructure projects, training in water and sanitation construction, and training in water and sanitation cooperative management for rural residents.

In the case of low-income urban families, it will be important to consider such policy measures as incentives to promote medium-scale water supply providers (e.g., cooperatives, small companies, neighborhood federations), public–private partnerships for medium-scale services, combined private initiatives and cross subsidies, cooperative/community technical services for doing repairs or maintenance, loans for purchasing water-saving devices, the integration of dispersed services around intermediate cities, a gradual transition from providing water infrastructure and sanitation subsidies to imposing tariffs and water metering.

For high-income rural families the following policy measures could be considered: loans to buy construction materials, private services for maintenance and construction, private technical assistance, municipal or private company monitoring and evaluation, the establishment of interrural centers of services, economic incentives, and land-use planning geared toward the creation of clusters, progressive transition from providing water infrastructure and sanitation subsidies to imposing tariffs, the promotion of water supply and sanitation rural enterprises, and training in water and sanitation management.

High-income urban families have greater economic resources and capabilities for adapting, and in their case the following policy measures are among those that could be proposed: the establishment of private initiatives by reverse auction for infrastructure projects, the establishment of tariff increases according to consumption, the promotion of private services in water and sanitation infrastructure, the creation of economies of scale, the promotion of associating or merging medium-size water supply and sanitation companies, the promotion of private services for maintenance and construction, the establishment of targeted subsidies to Build-Operate-Transfer (BOT) private initiatives, the establishment of permanent water metering, facilitating loans for the purchase of water-saving devices, and the promotion of private maintenance mechanisms linked to low-rate banking facilities. These proposals are part of specific scenarios but also need complementary political, managerial, physical, environmental, social, and economic measures to ensure sustainable water supplies and sanitation for all.

Providing urban and rural water and sanitation is important, and it is equally important to provide it in a fast way, because by reducing the implementation time, some transaction costs, costs generated by the presence of diarrheal and skin diseases, cost of time, transportation costs, and costs to obtain water, could be as well reduced. Also, the existence of formal water supply systems would lead to significant reductions in water prices. Furthermore, it is important to provide water and sanitation, but to do so expeditiously.

## *3.1 Political Aspects*

1. Firm political decisions and strong follow-up: this is a key aspect that must start at the highest governmental level. No other level is capable of maintaining such an important flow of investment and decisions that need to be made to ensure water supply, sanitation, and sewage treatment. The highest level of government must follow up on the evolution of investments, results, and impacts.
2. Strengthening water supply and sanitation sector leadership: this could include concentrating investment efforts in only one sector and establishing automatic mechanisms to transfer resources or to transfer construction and other responsibilities for bidding processes to subnational and local authorities. This is important because one sector by itself will not have the capacity to design and build all the needed water supply and sanitation projects at once.
3. Promoting local water supply and sanitation leadership: this will be important to ensure the political and social defense of infrastructure projects that could encounter opposition in neighboring communities but that also need leadership to ensure the sustainability of construction and maintenance processes.

4. Strengthening water supply and sanitation companies, cooperatives, and associations: it is very important to allow for good management and good governance. These organizations will need to have a minimum of responsibilities and facilities to bill clients, build infrastructure, improve management, and identify new kinds of problems and provide proper and fast solutions.
5. Strengthening urban planning and land management in a way that is consistent with water sources, water supply, and sanitation infrastructure development: this is a key issue because, generally, informal urban growth leads to the establishment of settlements in areas that are vulnerable to natural disasters, which increases the costs of water and sanitation services. Latin America has few municipalities that practice sustainable urban planning and that have developed urban expansion plans; often urban centers grow faster than planning capacities, so better land management would improve water and sanitation infrastructure and resource conservation.

## *3.2 Organizational Aspects*

1. Administrative reengineering and institutional building to speed water supply and sanitation access: while not all cases are the same, in general Latin American institutions need changes at the operational and policymaking levels to improve their performance. These institutions need to reduce the number of administrative procedures for granting construction permits, selecting contractors and service providers, and paying these contractors and providers.
2. Establishing horizontal coordination between urban and rural water supply and sanitation organizations: this would allow, for instance, construction material to be bought at cheaper prices since the scale increment would likely reduce marginal prices, or technical assistance to be shared, or decisions to be made in a coordinated way, especially at the basin level.
3. Strengthening ecosystem service approaches in water supply and sanitation organizations: this is important because these organizations need to understand and act to conserve the water resources on which they depend.
4. Selecting water supply and sanitation managers and officials in open competitions: in Latin America, as in many other countries, important management positions are given to friends or partners of government officials. Independent bodies, like international organizations or neutral organizations, should be put in charge of implementing selection processes.
5. Permanently assessing water supply and sanitation organizational performance: this is very important for ensuring positive changes and permanent improvement. Clear indicators should be developed to measure performance. Results should also be published periodically.

### 3.3 Physical Aspects

1. Strengthening fast construction processes: this is important because the construction materials needed could be known in advance, which make it possible to provide preconstructed parts, for example, water tanks, pressure-break boxes, water distribution boxes, and micromeasurement boxes. This would lead to reductions in construction times, saving important resources.
2. Creating disincentives for population dispersion: this will be very important to avoid unfeasible land occupation that may make infrastructure provision more costly.
3. Introducing sustainable energy technologies: such technologies would facilitate the use of pumping systems, tanks, and treatment machines to harness renewable energy. It would help create some energy independence in places where electricity remains unavailable. It would also reduce the environmental footprint and emissions generated by diesel generators, which are commonly used in rural areas.
4. Using easy-to-obtain spare parts: this is very important to avoid stoppages in water supply, sanitation, and treatment systems, but also to promote economies of scale in infrastructure spare parts.

### 3.4 Environmental Aspects

1. Promoting community water-quality-monitoring systems: this would allow the presence of some control over water quality in places that cannot be reached by authorities.
2. Strengthening national and sectoral authorities in water quality: in general water quality needs a strong legal framework and institutions need clear and strong capacities to establish punitive sanctions for water pollution.
3. Integrating environmental approaches in water supply operations: this could include the integration of ecosystem services in water supply and sanitation management plans, as well as pollution- and emission-reduction policies.
4. Incorporating strategic environmental assessment in zoning and land-use changes: this would help to reduce the negative impacts of urbanization on water resources and at the same time help strengthen the feasibility of population-density increases in relation to water supply and sanitation capacities.

### 3.5 Economic Aspects

1. Sustainable and continuous budgeting: in some cases national budgets are approved a year in advance, which might not leave time to include new and urgent items. To ensure an effective continuity of investments, one choice is to

create a national water and sanitation fund (that would include water management and water supply and sanitation) or to commit financially to identified projects that might not yet have technical dossiers. Funding in Latin America is widely available, especially from multilateral organizations or development agencies, with both types lending money at low rates; the difference between them is how quickly they can put the necessary resources in place.

2. Identification of viable opportunities for enterprises, cooperatives, committees, and other bodies: since water (including water management and water supply) and sanitation management organizations may not have access to specialized data on population, income, water and sanitation, investments, deficits, infrastructure, costs, and performance, it is important, on the one hand, to allow organizations and the general public to access this information so they can conduct their own analyses and make their own decisions, but on the other hand, some investment and performance analysis may be prepared and published to create interest in putting forth private initiatives.
3. Incremental marginal tariffs on higher consumption: water wastage should be avoided and prevented. One important disincentive could be the price of water, which would rise exponentially after basic household consumption needs are met. In most Latin American countries that have significant water supply deficits, high-income families that have in-ground swimming pools pay less for each cubic meter of drinking water than low-income families that live in dirt-floor slums with no formal water supply and sanitation services.
4. Permanent water accounting: water efficiency and pricing would work if there were permanent water accounting. This would also allow governments to measure and compare water production with water consumption, so they could estimate water losses that occurred during distribution.
5. Loss reduction: there are four main methods of reducing water supply losses: (1) infrastructure management, (2) quality and speed of repairs, (3) effective leak control, and (4) pressure management. These methods imply the elaboration of plans that require funding, so water supply and sanitation administrators should have the resources to implement policies that would reduce water losses.
6. Water-conservancy mechanisms: policies related to saving water could be implemented through private actors with help from the public sector, where sanitation devices that save water could be introduced to the market and once installed would force users to save water and money.

## *3.6 Social Aspects*

1. Legal inclusion of nontraditional water and sanitation management organizations (e.g., consortiums, private enterprises, mixed enterprises, community organizations, cooperatives): in some Latin American countries many water supply and sanitation organizations work without legal registration or outside the law. However, the lives of people lie in their hands. Without a legal existence organi-

zations cannot be officially recognized to receive benefits or subsidies. Thus, it is also important that procedures to register water supply and sanitation organizations be simple and fast.

2. Legal inclusion of cooperatives, neighbors, and committees organizations in construction activities: some community organizations have the capacity to build their own infrastructure, but in some cases they might not be allowed to because of national legislation that gives exclusive rights to engineering professionals. With some training community members might be able to take on simple projects and build or water supply and sanitation infrastructure or provide related services.
3. Strengthening water and sanitation consumer associations: it is important that civil society organizations be able to monitor and verify water and sanitation management and performance and that their rights as consumers be respected. Consumer associations could be the voice of thousands of users affected by service provision.
4. Strengthening regulators' authority by including rural and urban operators: regulators should not only be able to establish tariffs in accordance with certain criteria but also to enhance the performance and sustainability of water management and supply, sanitation, and treatment. Urban and rural operators and providers are part of the same basin, so the consequence of weak management will impact them equally. Urban and rural operators should be included in the debate and in some decision-making processes, which would allow sustainable conservation of water resources and sewage disposal (Box 8.1).

## 4 Project Options for Latin American Countries

Latin America is a region where collaborative projects may be developed in a south–south orientation, especially because of the shared water resources and similar economic and social contexts and patterns that characterize this territory and its populations. The same phenomena are affect most Latin American countries, and for every country to deal with these issues independently appears to be a daunting challenge.

Latin America has seen many pilot experiences and projects implemented by various organizations using development agency financial resources. Each project had a different context, and the level of the interventions did not allow for easy scaling up. These experiences, failures and successes alike, are part of a regional or ecoregional validation process to facilitate collaboration in expanding water resource availability, as explained earlier in this book. The implementation of regional policies and projects will demand multinational coordination efforts through international mechanisms and agreements that are not yet in place. Latin American countries need a common vision with respect to water resources, including drinking water and sanitation, to make them sustainable for the long term and to ensure high standards of living for their people.

**Box 8.1** Latin America: policy options to strengthen water and sanitation management

| Goal | Political | Organizational | Physical | Environmental | Economic | Social |
|---|---|---|---|---|---|---|
| Ensure quantity and quality of water sources | (1) A Latin American Water Resources Authority that may institutionalize criteria to protect water resources and ecosystem services in the region. | (1) Strengthening water conservation capacities of human resources dedicated to water supply and sanitation management. | (1) Construction of reservoirs, infiltration channels, and water harvesting infrastructure at the national and international levels. | (1) Establishing Latin American criteria, handbooks, and legislation to promote water use efficiency in all consumptives uses in urban and rural areas. | (1) Establishing water conservation and infrastructure cofunding mechanisms at the regional level. | (1) Latin American criteria for water regulation. |
| | (2) Open information on water management. | (2) Strengthening subnational and municipal officials, as well as community leaders in basin management and ecosystem services. | (2) Provision of equipment for water monitoring and management at the local and community levels. | (2) Strengthening national environmental surveillance and enforcement. | (2) Incentives to cofinance communal infrastructure in water supply and sanitation. | (2) Incorporating urban and rural organizations and independent citizens in water and sanitation decision-making processes. |
| | (3) Establishing the water cycle, ecosystem services, and climate change adaptation in the regulations of ministerial functions . | (3) Redesigning internal management structure in subnational and local governments in response to water-conservation needs. | (3) Construction of headwater maintenance projects. | (3) Enhancing environmental damage restitution legislation. | (3) Economic contribution of other consumptive uses to ecosystem services. | (3) Continual measuring of basin organization efficiency. |

(continued)

**Box 8.1** (continued)

| Function | Political | Organizational | Physical | Environmental | Economic | Social |
|---|---|---|---|---|---|---|
| | (4) Establishing water management criteria at subnational, municipal, and communal levels. | (4) Establishing interacting management spaces. | (4) Specific and differentiated zoning in headwater territories with people's participation. | (4) Establishing municipal environmental and water-quality monitoring. | (4) Offering low-interest-rate loans to install water-saving devices. | (4) Identifying social tariffs for vulnerable families. |
| | | (5) Common assessment and project design criteria. | (5) Identification of construction materials and construction methods that respect headwater fragility. | (5) Developing monitoring and early warning systems in headwater areas through communit organizations. | (5) Identifying the costs of basin maintenance. | |
| | | | (6) Enhancing urban and rural water supply and sanitation infrastructure. | (6) Establishing Latin American criteria and reward mechanisms for ecosystem service conservation. | (6) Establishing tariffs as a function of water consumption. | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | (7) Strengthening Latin American urban and rural sustainable land management criteria. | (7) Promoting financial insurance mechanisms to compensate people for basins affected by natural disasters or radical climate change phenomena. | |
| | | | | | (8) Establishing financial restitution from water polluters. | |
| Provide urban and rural drinking water supply and sanitation in a fast and sustainable way | (1) A firm political decision and strong follow-up. | (1) Administrative reengineering and institutional building to speed water supply and sanitation access. | (1) Strengthening fast construction processes | (1) Promoting community water-quality monitoring systems. | (1) Sustainable and continuous budgeting. | (1) Legal inclusion of nontraditional water and sanitation management organizations (e.g., consortiums, private enterprises, mixed enterprises, community organizations, cooperatives) |
| | (2) Strengthening water supply and sanitation sector leadership. | (2) Establishing horizontal coordination between urban and rural water supply and sanitation organizations. | (2) Creating disincentives for population dispersion. | (2) Strengthening national and sectoral authorities in water quality. | (2) Identification of viable opportunities for enterprises, cooperative, and committees. | (2) Legal inclusion of cooperative, neighborhood, and committee organizations in construction activities. |

(continued)

**Box 8.1** (continued)

| Function | Political | Organizational | Physical | Environmental | Economic | Social |
|---|---|---|---|---|---|---|
| | (3) Promoting local water supply and sanitation leadership. | (3) Strengthening ecosystem service approaches in water supply and sanitation organizations. | (3) Introducing sustainable energy technologies. | (3) Integrating environmental approaches in water supply operation. | (3) Incremental marginal tariff for higher consumption. | (3) Strengthening water and sanitation consumers associations. |
| | (4) Strengthening water supply and sanitation companies, cooperatives. and associations. | (4) Selecting water supply and sanitation managers and responsibles in open competitions. | (4) Using easy-to-obtain spare parts. | (4) Incorporating strategic environmental assessment in zoning and land-use changes. | (4) Permanent water accounting. | (4) Strengthening regulators' authority by including rural and urban operators. |
| | (5) Strengthening urban planning and land management consistency with water sources, water supply, and sanitation infrastructure development. | (5) Continually assessing water supply and sanitation organizational performance. | | | (5) Loss reduction control. | |
| | | | | | (6) Saving water mechanisms | |

Multinational policies and projects will need to be ratified at the central governmental level and with the participation of subnational and local governments and organizations. Such a collaborative effort will require important resources and specialized management, which might imply a parallel process to strengthen capacities at different levels. Countries that share water resources also need to eliminate perverse incentives created by the low value of water, weak regulation, or weak environmental management policies.

Several projects and policy proposals are presented as follows; this does not represent an exhaustive list of projects needed at the national and regional levels; they are simply proposals that may serve as s source of inspiration to policy and decision makers in Latin America.

1. Creation of Latin American Water and Sanitation Commission

   Summary: Latin America has many shared resources, and joint efforts will lead to more efficiency in water use and management. Water has become the most sensitive resource of the region and now its conservation goes beyond national boundaries. The Latin American Water and Sanitation Commission (LAWSAC or CASAL in Spanish) could be the multilateral space for discussion and approval of different issues, including, but not limited to, water management, drinking water, sanitation, ecosystem services, and climate change adaptation joint regional policies and funding strategies. This commission will have representatives from different countries who, at the same time, may have their own technical support teams. The commission should be an independent body specifically created by the governments, through a regional agreement, to adopt sustainable common policies, projects, and funding. This organization should not be part of the United Nations or the Organization of American States.

   Goals: (1) identify common water conservation and use policies and strategies; (2) establishing ecoregional quality standards and ecoregional maximum allowable limits; (3) promote synergy through the implementation of common initiatives.

   Results: Short term: establishment of the Latin American Water and Sanitation Commission. Medium term: identification and approval of Latin American water and sanitation policies and project designs.

   Estimated budget: In the short term, it is estimated that a budget of USD 50 million will be needed.

   Potential funders: national governments, Latin American Development Bank (CAF), Inter-American Development Bank (IADB), World Bank, international development agencies like the US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

2. Ecoregional water source conservation planning

   Summary: Water resource sustainability depends on the biophysical performance of each ecoregion. Not all ecoregions work in the same way, and not all respond in the same manner. It is clear, though, that specific research and planning at the ecoregional level must be done to conserve water resources, including basin management, which will benefit the ecoregions' countries. It will also allow for the identification of common measures, policies, and projects for countries that share an ecoregion.

   Goals: Identify the measures and projects needed to maintain the biophysical conditions of each ecoregion and their basins.

   Results: A consensual planning document by ecoregion, with policy recommendations and project identification at the prefeasibility and profile level.

   Estimated budget: The estimated budget for each ecoregion would be between USD 15 million and USD 20 million.

   Potential funders: National governments, CAF, IADB, World Bank, international development agencies like US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

3. Establishment and recognition of communal headwater protection authorities

   Summary: Latin American countries are experiencing depopulation of their headwater territories, and the state does not have the capacity to maintain a presence in these areas. The most capable social agents that could have a presence in these territories are rural communities, which in the case of Latin America are mostly indigenous or autochthonous communities that at the same time are inheritors and holders of important traditional knowledge that could be shared among Latin American communities and combined with other formal technical knowledge. However, it will be important to institutionalize the creation of communal authorities, recognized by governments, that could be responsible for protecting headwater territories. These communal authorities must be properly trained to respond to headwater management demands.

   Goals: (1) Establish headwater conservation as a priority across all countries; (2) develop legal and institutional frameworks so that communal headwater authorities are recognized by governments; (3) strengthen the capacities of these communal authorities in sustainable land and water management.

   Results: (1) Established and strengthened headwater conservation communal authorities in every basin and (2) a headwater conservation working plan in every basin.

   Estimated budget: The estimated budget for each headwater is between USD 0.1 and USD 1 million.

   Potential funders: National governments, ecosystem service conservation reward mechanisms, multilateral cooperation.

4. Establishment of Latin American Ecosystem Service Conservation Reward Mechanism

Summary: Rewarding ecosystem service conservation is a voluntary mechanism whereby organizations that contribute to the protection of ecosystem services and that benefit all inhabitants of a basin may receive economic rewards provided by water users of the basin.

Goals: (1) Establish national and local complementary financial mechanisms for headwater conservation; (2) establish effective distribution mechanisms for water management and ecosystem service conservation priorities.

Results: (1) National regulation to establish a ecosystem services conservation reward mechanism; (2) establishment of ongoing mechanisms to develop conservation actions that benefit ecosystem services and that reward involved basins' conservation organizations.

Estimated budget: A consultant to prepare the national regulation proposal may cost from USD 20 thousand to USD 50 thousand. The establishment of each reward mechanism may cost from USD 20 thousand to USD 50 thousand by basin.

Potential funders: National governments, CAF, IADB, World Bank, international development agencies like US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

5. Identification of Latin American desalination opportunities

Summary: The population concentration in coastal zones is creating important costly demands for drinking water. However, cities, or countries, do not embark easily on desalination plant projects because they are expensive or because the marginal price is acceptable only if such services are needed on a large enough scale or because the technology is still unknown and maintenance would be even more complicated. For these reasons, desalination initiatives could be an alternative if binational or multinational interests come together; in this way a significant scale could be reached and marginal prices could decrease. A unique technical management mechanism could be established between participating governments and tariffs could be equally charged by the cubic meter; however, it would be the responsibility of each participating country to establish subsidies or payment facilities for its nationals.

Goals: (1) Identify national and multinational feasible desalination project opportunities and (2) identify multinational negotiation and management mechanisms for multinational desalination projects.

Results: (1) Prefeasibility documents and plans of potential desalination project opportunities and (2) consensual multinational tariff and agreement documents.

Estimated budget: It is estimated that each prefeasibility study could cost around USD 1 million to USD 5 million.

Potential funders: National governments, private investors, CAF, IADB, World Bank, international development agencies like US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

6. Establishment of a Latin American regulatory framework to identify regional maximum allowable pollution limits to water bodies and nondomestic pollution levels in the sanitation infrastructure, as well as the corresponding tariff and restitution rates.

Summary: Latin American countries share the same ecosystems, so their habitats and ecoregions are interdependent. Water is a common regional good. If one country pollutes more than other countries, it affects other countries and itself in an equally negative way. This is why it is necessary to establish regional pollution limits that could be equally respected and complied with in all Latin American countries. On the other hand, establishing pollution limits requires extended monitoring and restitution mechanisms. At the same time, sewage treatment plants, mainly designed for domestic wastewater, also receive nondomestic, mainly industrial, sewage. It is more costly to treat industrial sewage because it has more pollutants. However, all treatments would be paid for equally by all taxpayers in Latin America. So it is perfectly logical that nondomestic waste disposal in the sanitation infrastructure and treatment costs would be covered directly by polluters. It align perfectly with the "polluter pays" principle.

Goals: Establish consensual regional pollution limits in water bodies and the sanitation infrastructure, as well as a common regional regulatory framework.

Results: A consensual regional legislation proposal establishing pollution limits in water bodies and in the sanitation infrastructure regulations.

Estimated budget: It is estimated that around USD 0.5 million to USD 3 million will be needed for this initiative.

Potential funders: National governments, private investors, CAF, IADB, World Bank, international development agencies like the US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

7. Establishment of Latin American land-use and urbanization criteria compatible with water resource conservation

Summary: Latin American land-use and population dynamics are creating urbanization patterns that are negatively affecting water sources. Land management and urban planning are very weak in Latin American countries. Local governments do not give priority to land management, and urban planning has been systematically abandoned. This has promoted illegal urbanization processes that occupy vulnerable areas or water-sensitive territories, disrupting ecosystem services and biophysical dynamics. Also, Latin American countries should consider a unique conurbation management, in other words, a single local government and administration for fused urban areas. A regional land-use policy would also optimize distances, reducing transportation costs and greenhouse gas emissions. At the same time, people are abandoning headwater territories and are occupying middle lands and intermediate and main urban centers without concern for the environment or water.

Goals: Establish Latin American land-use and urbanization criteria to promote more efficient and sustainable mobilization of people, land occupation, and governance.

Results: A consensual document establishing sustainable land occupation and urbanization criteria, national regulation proposals, local and basin land-use policy proposals, and training plans.

Estimated budget: An estimated budget for this important task could be between USD 5 million and USD 20 million

Potential funders: National governments, CAF, IADB, World Bank, international development agencies like US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

8. Ecoregional water supply and sanitation companies, cooperatives, and committees, emission reduction ,and adaptation to climate change.

Summary: Most emissions in water supply and sanitation operations are due to the untreated sludge that comes out as an output of treatment processes and due to the use of diesel-based electric generators. On the other hand, water and sanitation operators, especially in Latin America, need to be adjusted to climate change effects like the displacement of water sources, deglaciation, landslides, or erosion created by climate phenomena. Latin America will be one of the regions hardest hit by climate change.

Goals: Reduce emissions and the vulnerability of water supply and sanitation operators to climate change

Results: Prepared and strengthened water supply and sanitation operators who are able to reduce emissions and adapt to climate change.

Estimated budget: The World Bank (2010a, b) estimates annual adaptation costs for the region to be USD 16.8 billion to USD 21.5 billion by 2050 for all purposes, while Agrawala et al. (2010) estimate annual adaptation costs to be approximately USD 28 million by 2105. However, even though the approaches are very different, many factors influence the estimation of costs of adapting to climate change. Thus, in the present research, to estimate the adaptation costs, several factors were considered; on the one hand, the type of water supply and sanitation operator was taken into account, such as large water supply and sanitation companies, which operate mostly in capital cities; medium-size operators in medium-size cities and intermediate urban centers; and rural water supply and sanitation committees. These different types of operators may require different types of infrastructure, for example, water-transfer tunnels, reservoirs, water harvesting initiatives, and water distribution optimization. Other criteria include accessibility, population concentration, and environmental and ecosystem conditions. Thus, considering all these factors it was possible to arrive an an annual per capita water sector adaptation cost range for a 5-year period of between USD 80,000 and USD 120,000.

Potential funders: National governments, CAF, IADB, World Bank, international development agencies like US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

9. Water-conservancy policy

Summary: Saving water is something that could be developed entirely by private actors but that needs to be facilitated by national governments. Under this mechanism, families, especially urban families, would receive low-rate loans to change their water supply devices, like faucets, showers, and toilet tanks and repair leaking pipes to reduce water consumption. The loan would be paid with the money saved by conserving water and in addition water would be saved for others who do not have access to it. Certified sanitation device providers and certified inspectors would be needed to invigorate the market and to avoid inappropriate and unnecessary investments.

Goal: Reduce the average urban water consumption.

Results: At least 20 % of urban water consumption has been reduced through water-saving mechanisms.

Estimated budget: There is no need for public investment. Private investors like hardware stores and banks will invest depending on market needs.

Potential funders: Private investors, local banks.

10. National Sustainable Urban and Rural Water Supply and Sanitation Programs

Summary: Latin American countries still have important water supply and sanitation deficits that require major investments to resolve. A lack of water, and especially a lack of sanitation, is the strongest indicator of poverty in the region. Poor populations will not rise out of poverty without water supply and sanitation. In addition, some factors, such as diseases, the costs of obtaining water, and time consumption, keep poor people in poverty.

Goals: Attain universal and sustainable access to water supply and sanitation throughout the Latin American region.

Results: 100 % of the population has access to permanent and a sustainable water supply and sanitation services.

Estimated budget: The CAF estimates that to close the infrastructure gap in the 2010–2030 period roughly USD 250 billion in investments are needed, a sum equivalent to annual average investments of USD 12.5 billion (CAF 2011). This value represents 0.3 % of the regional aggregated GDP for 2010, which would be a reasonable amount of money, considering low national budgets and the contribution of tariffs, at efficient rates, and equity criteria, to the repayment of the investment. With this investment, the Latin American region would have 100 % water supply coverage and 94 % sanitation network coverage, and 85 % of urban areas would have access to pluvial drainage infrastructure. The universalization of water supply and sanitation in the urban areas of the region could be reached in 20 years (CAF 2012). However, the situation is different in every country. Also, this amount does not account for additional adaptation costs to ensure water supply and sanitation services.

Potential funders: National governments, private investors, CAF, IADB, World Bank, international development agencies like US Agency for International Development, European Commission, Japan International Cooperation Agency, Spanish International Cooperation and Development Agency, and others.

# Annexes

 
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Latin America: Population projections 1990–2020

| Ecoregion, country and area | | | 1990 | 1995 | 2000 | 2004 | 2008 | 2012 | 2016 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Andean ecoregion | Ecuador | Urban | 5,649,600 | 6,609,880 | 7,383,600 | 8,084,800 | 9,243,000 | 10,250,000 | 11,276,800 | 12,359,400 |
| | | Rural | 4,622,400 | 4,786,320 | 4,922,400 | 4,955,200 | 4,800,000 | 4,649,000 | 4,498,000 | 4,347,000 |
| | Colombia | Urban | 24,129,300 | 27,750,240 | 31,590,000 | 34,584,550 | 37,579,100 | 39,573,650 | 43,568,200 | 46,562,750 |
| | | Rural | 10,840,700 | 10,791,760 | 10,530,000 | 10,330,450 | 10,130,900 | 9,931,350 | 9,731,800 | 9,532,250 |
| | Venezuela | Urban | 16,577,400 | 18,994,820 | 21,243,660 | 23,128,160 | 25,461,290 | 27,651,402 | 29,841,514 | 32,031,626 |
| | | Rural | 3,157,600 | 3,092,180 | 3,174,340 | 3,153,840 | 3,133,340 | 3,112,840 | 3,092,340 | 3,071,840 |
| | Bolivia | Urban | 3,734,640 | 4,414,380 | 5,156,540 | 5,765,760 | 6,374,980 | 6,984,200 | 7,593,420 | 8,202,640 |
| | | Rural | 2,934,360 | 3,067,620 | 3,160,460 | 3,243,240 | 3,356,290 | 3,458,238 | 3,560,186 | 3,662,134 |
| | Chile | Urban | 10,938,570 | 12,091,800 | 13,254,320 | 14,027,880 | 14,801,440 | 15,575,000 | 16,348,560 | 17,122,120 |
| | | Rural | 2,240,430 | 2,303,200 | 2,157,680 | 2,096,120 | 2,034,560 | 1,973,000 | 1,911,440 | 1,849,880 |
| | Perú | Urban | 15,009,570 | 16,924,270 | 18,944,960 | 20,395,880 | 20,699,095 | 21,910,795 | 23,122,495 | 24,387,978 |
| | | Rural | 6,743,430 | 6,912,730 | 7,007,040 | 7,166,120 | 7,079,881 | 7,047,170 | 7,014,459 | 6,942,130 |
| Amazon ecoregion | Brazil | Urban | 112,045,500 | 125,873,280 | 140,824,980 | 154,486,920 | 168,148,860 | 181,810,800 | 195,472,740 | 209,134,680 |
| | | Rural | 37,348,500 | 35,502,720 | 33,033,020 | 29,426,080 | 25,819,140 | 22,212,200 | 18,605,260 | 14,998,320 |
| Chaco ecoregion | Paraguay | Urban | 2,067,310 | 2,511,080 | 3,008,500 | 3,489,060 | 3,969,620 | 4,450,180 | 4,930,740 | 5,411,300 |
| | | Rural | 2,151,690 | 2,317,920 | 2,461,500 | 2,527,140 | 2,592,780 | 2,658,420 | 2,724,060 | 2,789,700 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Central American Cordillera ecoregion | Costa Rica | Urban | 1,661,040 | 1,946,000 | 2,318,110 | 2,594,330 | 2,870,550 | 3,146,770 | 3,422,990 | 3,699,210 |
| | | Rural | 1,414,960 | 1,529,000 | 1,610,890 | 1,658,670 | 1,706,450 | 1,754,230 | 1,802,010 | 1,849,790 |
| | El Salvador | Urban | 2,503,900 | 3,061,260 | 3,642,400 | 4,057,200 | 4,472,000 | 4,886,800 | 5,301,600 | 5,716,400 |
| | | Rural | 2,606,100 | 2,607,740 | 2,637,600 | 2,704,800 | 2,772,000 | 2,839,200 | 2,906,400 | 2,973,600 |
| | Guatemala | Urban | 3,646,540 | 4,287,100 | 5,024,700 | 5,778,650 | 6,532,600 | 7,286,550 | 8,040,500 | 8,794,450 |
| | | Rural | 5,247,460 | 5,682,900 | 6,141,300 | 6,516,350 | 6,946,967 | 7,363,692 | 7,780,417 | 8,197,142 |
| | Honduras | Urban | 1,946,800 | 2,362,500 | 2,826,560 | 3,242,080 | 3,657,600 | 4,073,120 | 4,488,640 | 4,904,160 |
| | | Rural | 2,920,200 | 3,262,500 | 3,597,440 | 3,805,920 | 4,014,400 | 4,222,880 | 4,431,360 | 4,639,840 |
| | Nicaragua | Urban | 2,098,800 | 2,417,580 | 2,777,040 | 3,118,080 | 3,459,120 | 3,800,160 | 4,141,200 | 4,482,240 |
| | | Rural | 1,861,200 | 2,059,420 | 2,181,960 | 2,257,920 | 2,333,880 | 2,409,840 | 2,485,800 | 2,561,760 |
| | Panama | Urban | 1,301,940 | 1,468,500 | 1,652,000 | 1,809,750 | 1,967,500 | 2,125,250 | 2,283,000 | 2,440,750 |
| | | Rural | 1,109,060 | 1,201,500 | 1,298,000 | 1,365,250 | 1,432,500 | 1,499,750 | 1,567,000 | 1,634,250 |
| Mexican Plateau ecoregion | Mexico | Urban | 60,693,120 | 67,541,790 | 75,066,000 | 80,331,240 | 85,596,480 | 90,861,720 | 96,126,960 | 101,392,200 |
| | | Rural | 23,602,880 | 24,981,210 | 25,022,000 | 25,367,760 | 25,713,520 | 26,059,280 | 26,405,040 | 26,750,800 |

*Source*: PAHO (2004) Water supply and sanitation coverage basic data for the Americas. www.bvsde.paho.org/AyS2004/paises.html. Accessed 30 Sept 2015

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