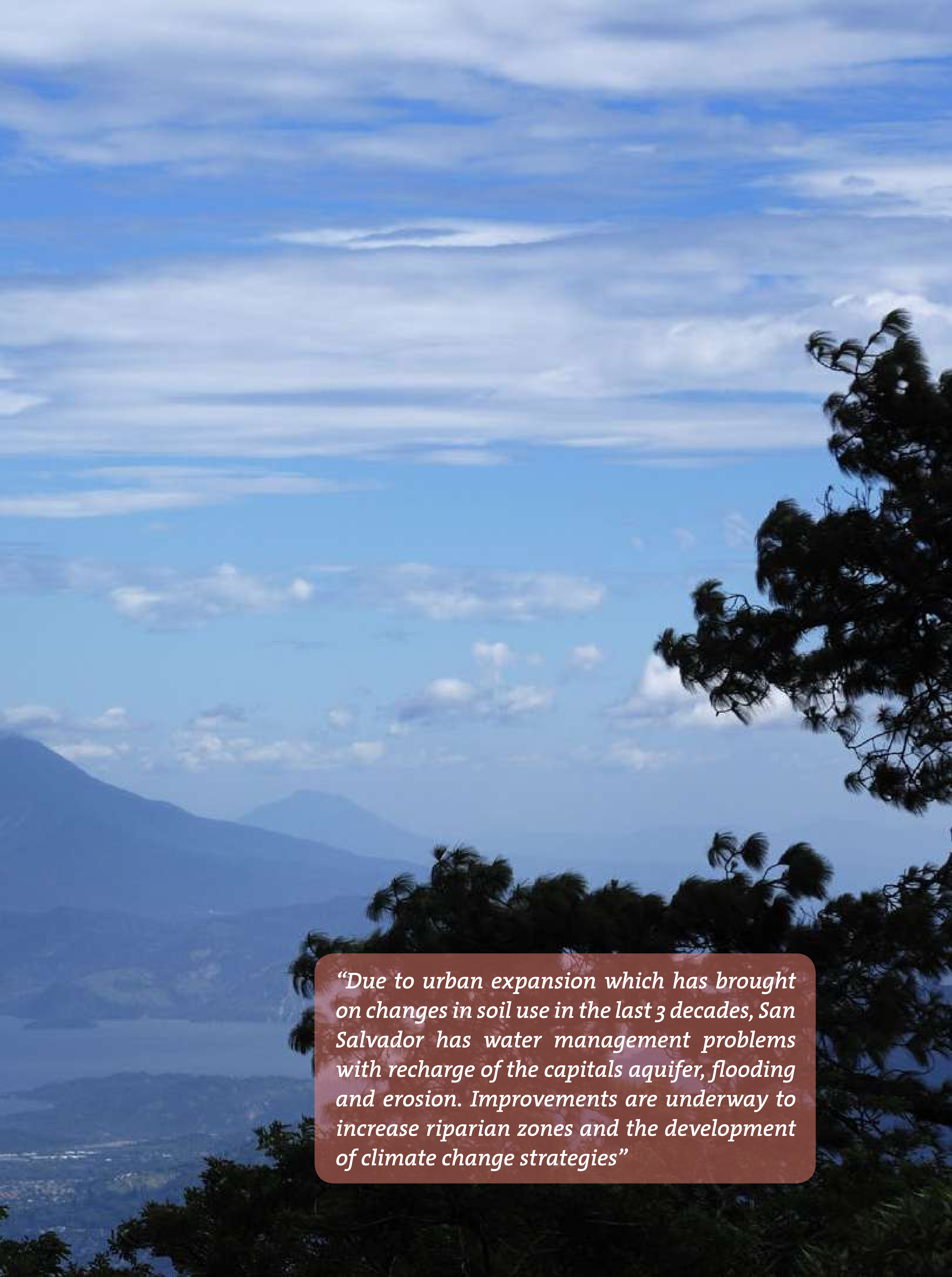
El Salvador

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



"Due to urban expansion which has brought on changes in soil use in the last 3 decades, San Salvador has water management problems with recharge of the capitals aquifer, flooding and erosion. Improvements are underway to increase riparian zones and the development of climate change strategies"

The Perspective of Urban Waters in El Salvador*

Julio César Quiñonez Basagoitia

Summary

In this chapter on *Urban Waters in El Salvador*, we discuss San Salvador's Metropolitan Area (SSMA) as the primary region for analysis. San Salvador's Metropolitan Area is divided into fourteen municipalities and includes the nation's capital of the same name. One of the first considerations to note is the gradual variation in land use occurring over the last three decades. This variation is primarily the result of urban sprawl into wide areas of forest lands –lands which are essential for the hydrologic recharging of the capital's aquifers. These forested areas also act as buffers and inhibit surface runoff during extreme environmental events. On many occasions, these extreme events have resulted in loss of life; high-risk zones have emerged, principally in low areas of the capital. Extensive investments have been made in riparian zones to regulate water flow, widen and confine drainage canals, avoid erosion and reduce the likelihood of flooding.

Another noteworthy consideration is the current status of aquifers and surface water, as well as their strategic importance for supplying water to the population. A multitude of factors must be taken into account in this regard, such as the current extent of potable water delivery, problems related to water production and level of investment during the last few years. Losses throughout the delivery system, primarily due to leaks, in addition to fraudulent connections, could be contributing to artificial recharging of San Salvador's aquifers.

One aspect of great importance within the *Urban Waters* dynamic covered in this chapter is sanitation and concomitant issues such as human waste disposal; water quality; recycled water; extent of wastewater treatment services for the population; and the regulatory and legal framework in relation to international parameters. The topic of sanitation is vitally important due to its close relationship

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to population concerns such as contamination and health problems. This chapter covers current levels and statistics for principal illnesses related to water and sanitary conditions reported by the Ministry of Health (MINSAL). We also cover current issues and problems, efforts being carried out through the national public health care system and budgetary aspects. Budgetary aspects include, to a large extent, state spending on health problems resulting from the vulnerable socio-environmental situation of a large sector of the population.

We conclude the chapter with the impacts of climate change on water resources; on subterranean and surface water; on water availability; and projections for the future based on various studies which have been carried out. We also report on national climate change strategy measures and the adaptation plan currently in place.

1. Introduction

The perspective of *Urban Waters in El Salvador* has gained greater importance and priority in dealing with a variety of related dynamics, challenges, risks and problems, primarily during the last two decades, with special emphasis around the time of the 1992 peace accords. Following the end of armed conflict, El Salvador entered a new stage - one of stability leading to an economic boom, primarily among the financial, real estate, commercial, importation and logistics sectors. This boom was expressed to a large degree in greater economic development and modernization in urban processes, i.e., those processes operating within the metropolitan arena. The productive agricultural and economic processes of the 1970s and earlier, taking place primarily in rural areas, with an agriculture-based economy which played an important role in determining the country's social and cultural dynamics in terms of livelihoods for broad sectors of the rural populations, did not share in the post-conflict economic boom to the same degree.

The socio-political crisis in the 1970s, prior to the period of armed conflict (1980-1992), and the turnaround in the socio-productive model within a relatively short period of time (the decade of the 1990s), generated a profound level of migration from the countryside to the city. San Salvador Metropolitan Area (SSMA) became the urban zone with the highest population growth in the country. According to the National Center for Statistics and Census Data (DIGESTYC), the department of San Salvador where the SSMA is located grew from 733,455 inhabitants in 1971 to 1,512,125 inhabitants in 1992, i.e., a population increase of more than 100%. According to a study carried out by Lotti & Associates in 2001, unplanned urban expansion in the metropolitan area grew by 21% between 1994 and 2002.

At the same time, seismic events in 1965, 1986 and 2001 resulted not only in loss of life but in significant damage and extensive destruction to social infrastructure in areas with scant economic resources. This situation contributed in later years to a gradual increase in urban and peri-urban squatters' settlements, many of them illegal and without land titles. These settlements occupied riparian and buffer zones in close proximity to gullies, rivers and natural drainage systems which gave rise to situations of vulnerability during storms and extraordinary meteorological events.

In addition, urban sprawl has extended into the higher and mid-level slopes of the Metropolitan Area basins, primarily during the past fifteen years and in the southwestern sector of the capital in particular. This sprawl has combined with frequently occurring flooding to create a new pattern of runoff which has resulted in considerable damage and loss of life in the lower elevations. In this regard, it is fitting to mention the memorable event of July 3, 2008 which produced colossal flooding in one of San Salvador's lower elevation sectors (*La Málaga* neighborhood); the river overflowed its banks and swept away a bus carrying passengers, resulting in tragic loss of life.

According to an analysis based on hydrologic modeling of changes in land use in SSMA (Erazo, A. MARN-2009), the flow rates occurring at the site of the tragedy were 22% higher than the flow rates generated by the same meteorological conditions in 1992. What's more, forest cover is currently 12.7% less than forest cover in 1992, and the peak flow rate during the 2008 flood occurred 25 minutes before the peak flow rates would have occurred in 1992. In other words, between 1992 and 2009, the watershed basin has lost its lamination capacity or ability to reduce or restrict high flow rates due to an increase in the magnitude and rapidity of the flows. Since this tragic event, there have been other instances of waterways overflowing their banks in different sites within the capital due to low pressure meteorological events associated with Hurricane Ida (11/7/2009), Tropical Storm Agatha (29-30/05/2010 and Tropical Depression 12E (10-20/10/2011). All three events resulted in loss of life and significant material damage.

On the basis of the aforementioned damage and loss, substantial investments in protection and mitigation have been made over the last few years including rehabilitation of some sections of the rivers along with the formulation of a watershed management plan; construction of peripheral walls and drainage canal confinement; and storm drain rehabilitation and enlargement.

These efforts have contributed significantly to reducing critical flood points, high-risk zones and riverbank overflows in various sectors of the capital.

There are a number of other issues of concern in addition to the previously mentioned problems. The challenges presented by the sanitation process, sources of water and water distribution are important in the analysis of *Urban Waters*. So are water quality monitoring and water contamination, and their impact on public health. The SSMA currently represents 43% of the country's urban population. It is also the geographical area subject to the greatest study, discussions, analyses and actions related to Salvadoran *Urban Waters* dynamics.

2. Urban Zone Water Sources and Impacts Caused by Urbanization

2.1 Changes in Land Use in the San Salvador Metropolitan Area (SSMA)

El Salvador has a total area of 21,040.80 km² divided into fourteen departments. The largest department is San Salvador in which the SSMA is located. The SSMA, in turn, is home to the nation's capital, San Salvador, and thirteen neighboring municipalities.

In 2011, the nation's total population was 6,213,730 inhabitants (Multi-Purpose and Household Survey 2011 – EHPM-2011). The EHPM reports that 62.5% of the population (3,871,332 inhabitants) lives

Figure 1. Map of El Salvador's local and regional governmental divisions

in the urban area, while 37.7% (2,342,398) lives in rural areas. San Salvador currently has 1,683,726 inhabitants. El Salvador is located on the Pacific coast of Central America, bordering Guatemala to the west, Honduras to the east and Nicaragua to the southeast. The Gulf of Fonseca separates El Salvador from Honduras and El Salvador. Figure 1 reflects the country's local and regional governmental divisions; the continuous red line corresponding to the SSMA.

The Metropolitan Area lies within the central western zone of the volcanic chain that crosses El Salvador from east to west, bordering the San Salvador volcano, extending out broadly from the foothills to the east, northeast and southwest. The city occupies a great portion of the volcano's slopes – 15% to 18%, which possess great capacity for generating rapid water flows, principally in zones with scarce vegetation and greater impermeability. These slopes descend until they reach zones with inclines measuring less than 3% which are considered to be the low zones with the greatest susceptibility for accumulating flows and experiencing flooding.

The geological formations surrounding the SSMA, along the interface between the city and the peri-urban region, are volcanic in nature, consisting of pyroclastic rock, Quaternary lava with lava produced during recent volcanic activity (less than ten thousand years) and volcanic fragments or rubble. These materials allow for a high degree of permeability.

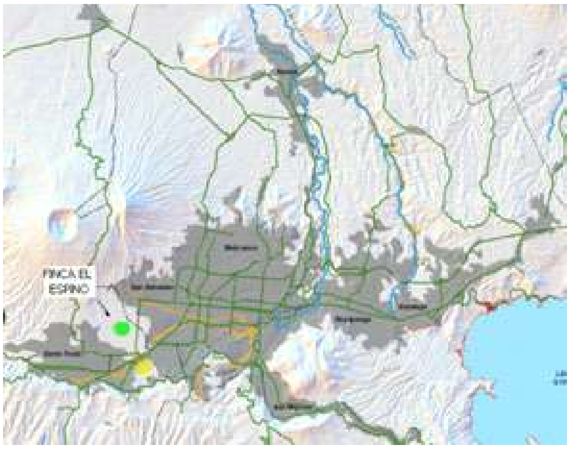
The predominant soil in the SSMA comes from volcanic ash known as Andisol (40-50 cm depth) which possesses a loamy (loamy-sandy) texture and a granular structure. These soils have a high degree of water retention and very good water infiltration, principally in areas where the slopes are moderate or low (<8%), with ample forest cover. These factors help restrict surface runoff and prolong humidity retention which benefits water infiltration and subterranean percolation toward the capital's aquifer. The aquifers exploited by San Salvador are located in the city's mid and low altitude zones.

There has been a slow process of degradation in these essential water recharge and natural surface runoff restriction zones during the last few decades. The extreme manner in which this is evidenced can be seen in the intervention and progressive destruction of the *Finca El Espino* as a consequence of urban sprawl. The *Finca El Espino* is the most important hydrographic area for recharging the waters of San Salvador's aquifer, as well as the urban area's rain water buffer zone, which contributes significantly to reducing the risk of flooding downstream. This hydrographic area is located to the southwest of the capital as shown in the map of SSMA in Figure 3.

Figure 2. Panoramic view of San Salvador's southwest zone

Source: http://ht-i2012-773-sansalvador-sanmiguel.blogspot.mx/2012/05

Figure 3. Map and location of SSMA



As shown in the Dada Architects Report -2010, the Finca El Espino had a total area of 798.1 ha at the end of the 1970s. During the conflict years in the 1980s, 31.1 ha became the property of a military academy. During the 1990s, a 12.45 ha portion became the site of university campuses and private educational institutions. Later, between 2002 and 2005, another 27.7 ha were turned into commercial centers and parking, which were accompanied by the construction of preferential axis roads and highways consisting of an estimated 33.2 ha. Finally, in addition to completing the road building projects planned since the 1990's, the most important alteration to the *Finca El Espino* took place between 2010 and 2013. This consisted in the gradual formulation and implementation of luxury residential and housing projects which now occupy 110.8 ha in one of the most important hydrological areas of the country, not only because of the type of soil found there but because of the native vegetation and modest slope.

It is noteworthy that the *Finca El Espino* possesses not only the most favorable soil types and geological characteristics mentioned previously but as a completely forested plain with broad vegetative cover and modest slopes, it is an area of high laminate runoff retention and presents one of the highest levels of water recharge on the national level, determined to be between 450 mm and 500 mm (Balance Hídrico, SNET-2005, and Junker. M. Método RAS-2005). This level of recharge is equivalent to sub-surface and subterranean water storage greater than 3.6 million m annually.

At the same time, due to its vegetative cover including original forests, coffee plantations and secondary forests, this territory plays an essential role in the preservation of biodiversity close to the capital; in oxygen generation, in carbon fixing, as a regulator of atmospheric contaminants; and as a landscape filled with natural beauty within the city's borders.

Economic interests have played an important role in contributing to worsening problems associated with changes in land use and the impacts of urbanization in the SSMA. During the 1990s a legislative decree approved urbanization in these essential zones while evading or ignoring guidelines established in the 80s and 90s, and even prior, regarding the characterization of the territory and environmental management.

The METROPLAN-80 initiative, formulated in 1969, held that urban planning for the coming decades was to have focused on reaching social and economic goals, requiring strengthening in the areas of institutionalism, and the legal framework for sustainable administration, within the spatial and environmental policies for urban territory. In line with this approach, the Forestry Law was approved in 1973 which contained the first declarations on Protection Zones for the San Salvador volcano. In the 1980s, the PLAMDARH-1982 established the importance of wide sectors of the San Salvador volcano foothills. The foothills in Hydrographic Region A, Sub-region San Salvador fulfilled strategic functions in terms of recharging the San Salvador aquifer. The hydrogeological characteristics of this region included high water infiltration (within the C=0.4 – 0.6 range), and high percolation towards deep strata, characterized by the study as "zones of maximum potential for infiltration and minimal runoff". As a result, the report established their protection as a priority; even more so when the same study found that the aquifer was already over-exploited by that time, with an annual decrease of 1.0 m.

The report findings were based on observations of fluctuating levels in nine wells between 1967 and 1971 within the framework of a project by ANDA – PNUD (National Association of Aqueducts and Sewers, and the United Nations Development Program). Later, through the PLAMDARH study, a digital model of the San Salvador aquifer was prepared, which determined a reduction in the phreatic surface level of 0.6 m/year.

Taking this history and experiences into account, a Urban Development Master Plan was created in the 1990s (PLAMADUR-1996) which defined land use categories which established protection and development zones from an environmental planning perspective. In a way, this planning effort protected and categorized the *Finca El Espino* as a "maximum protection zone", that is, not for urbanization, along with other zones essential to the southwestern sector of the SSMA.

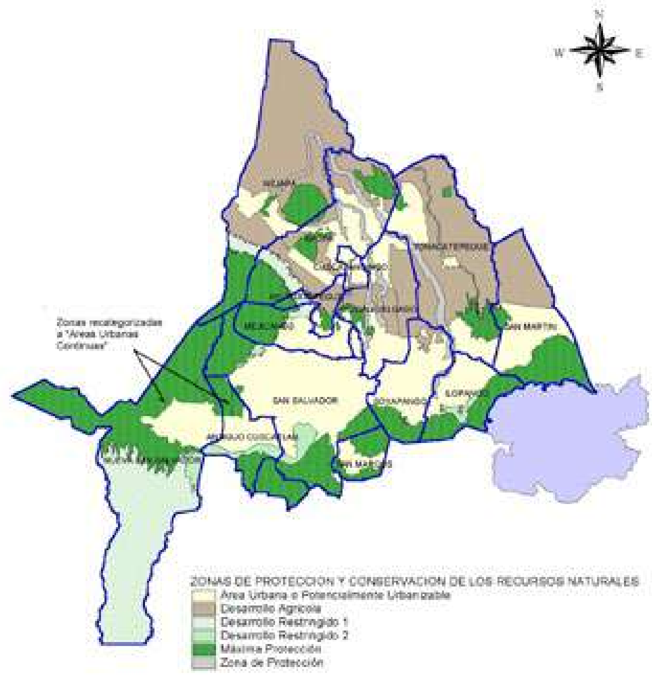
Nevertheless, given that PLAMADUR came about under the protection of the SSMA Development and Territorial Administration Law, approved in 1993, it was open to modifications and amendments according to municipal plans or those coming from private or legal entities and individuals that might consider that "their special plan could provide greater benefits or make better use of the site in question", or that the site of interest and its "initial use guidelines had been overturned due to the evolution of territorial development". Under this reasoning, all previous hydro-geological, socio-environmental, downstream risk reduction and water resources preservation guidelines became relative and could be easily over-ruled.

In the mid 1990's, Inspector Mario Lungo, Director of the SSMA Planning Office (OPAMSS) considered that the market for urban land in San Salvador (PRISMA-1996) was primarily in the southwestern sector of the capital. This land market came about with newly established land values and gradually included the old coffee farms which belonged to a reduced number of owners, who, although reduced in number, still had the capacity to drive the urban development dynamic outside the realm of a true socio-environmental planning scheme created by the State, and, more importantly, outside of a regulatory framework promoting equity and the preservation of resources. In Inspector Lungo's view of the perspective of the urban land market, not only is the vision of sustainable development lost due to accelerated environmental degradation, but social and spatial segregation and exclusion in the cities are intensified as well. The great majority of the population with low income is without access to that new urban elite sector into which, paradoxically, the State must invest great quantities of resources to facilitate and provide transportation infrastructure, lighting, services, security, etc.

In recent years, a significant reformulation in terms of the re-categorization of land use is presented in various municipal reports and guidelines for Environmental Zoning and Land Use, established by the Ministry of the Environment and Natural Resources (MARN-2013). These same reports and guidelines referring to the southwestern zone of the capital present significant sections of land, previously considered in the PLAMADUR-96 to be under "maximum protection", today are presented in a reformulated manner as "continuous urban area" zones, which demonstrates the adaptation and adjustment of the current environmental administration plans to follow the logic of urbanization. In Figure 4 we show the zoning proposed by PLAMADUR-96 in which the color green signifies maximum protection zone.

Currently, more than 110.8 ha have been re-categorized in the zones indicated as "continuous urban zone" and "rehabilitation areas".

Figure 4. PLAMADUR - 96



From this perspective the recurrent and progressive changes in land use aggravate two fundamental problems in the analysis of the *Urban Waters* dynamic. The first problem entails the continuous reduction of forest cover in the San Salvador aquifer's water recharge zone and the impacts this has on the aquifer. The second entails the increase in surface runoff and peak water flows, intensifying risk zones in the capital's low elevation zones.

2.2 Reduction of Forest Cover

Reduction of forest cover in the water recharge zone and impacts on the dynamics of the San Salvador aquifer, taking into account recharge activity stemming from water leaks.

The reduction in water recharge and fluctuations in static water levels in the San Salvador aquifer is a topic which has been undergoing analysis since the 1970s. As was mentioned previously, the PNUD-ANDA studies in 1972 and the PLAMDARH in 1982 established a reduction in static water levels of 1.0 m and 0.60 m respectively. In recent times, new studies

Figure 5. Location of the Acelhuate River urban basin

Source: Barrera, M. "Caracterización Hidrogeoquimica…", Sept. 2010.

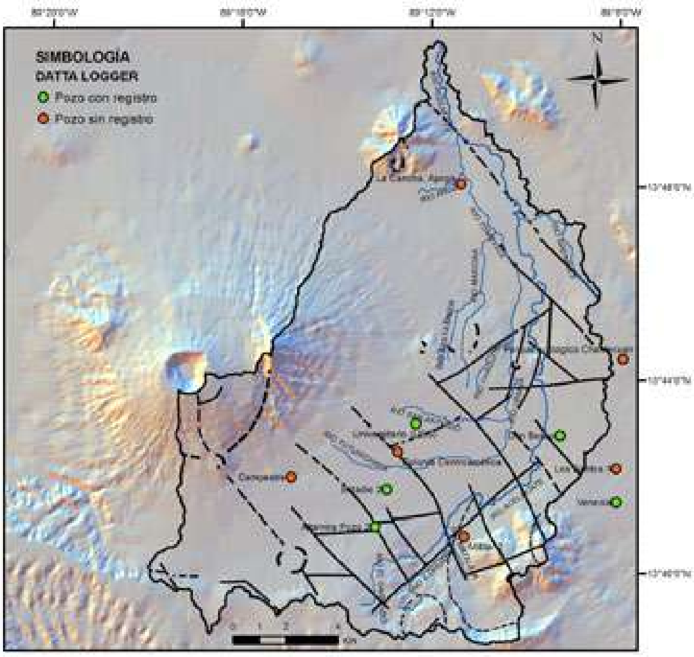
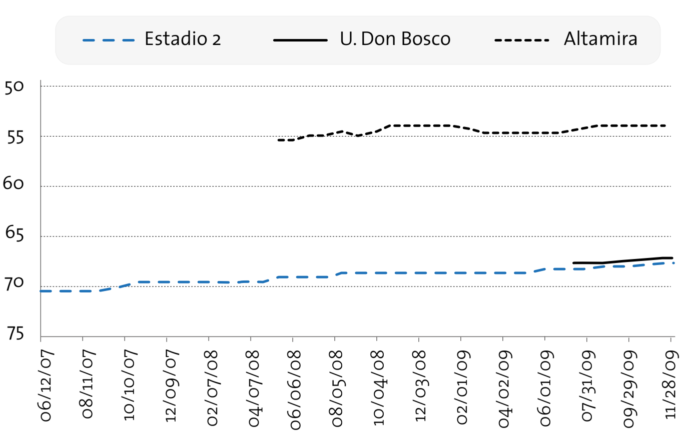


Figure 6. Temporal variation in well water levels

Source: Barrera, M. "Caracterización Hidrogeoquímica…", 2010



and analyses have been carried out which reflect the same tendency, determined principally from phreatic levels in wells situated in low elevation zones.

Two important university studies are cited and reproduced within the framework of hydro-geochemical characterization studies of the San Salvador aquifer (Barrera, M., 2010), which highlight the decrease in the phreatic water level by approximately 1 m per year (Coto, UCA-1994), discovered in analyses carried out in 1994, as well as through more recent analyses in 2005, which estimated decreases of 2.47 m per year for San Salvador and 1.47 m per year for Soyapango (Arévalo y Vásquez, UCA-2005).

The analysis of fluctuations in the static water levels of wells and of the possible recharging of the aquifer as a result of water leaks from San Salvador's potable water and sewage systems, is the central objective of research carried out by Marcia Barrera in 2010 using hydro-geochemical characterization of the waters that recharge the aquifer.

At that time, the report states, monitoring was carried out on the level of five wells using a data logger device, with records covering the period of 2007-2009. Two wells are located in the water basins high elevation zone and three are in the intermediate zone. Figure 5 presents the placement of these wells in green, immersed in the hydrographic basin of the *Acelhuate* River which is where San Salvador's aquifer is located.

One of the wells in the basin's intermediate zone had an increase in water level on the order of 0.60 m (*Don Bosco* well), yet there is only one record of five months during the 2009 rainy season. A second well in the same zone did not present any variations within the short period recorded, however, there was a decrease of 4.79 m in relation to the initial 2007 record.

One of the wells monitored in the higher altitude zone (*Altamira* well) generally maintained a fluctuation corresponding to the annual rain cycle, in other words, from May to October, considered to be the rainy season, and from November to April, considered to be the dry season, presenting a reduction in a certain period and then an increase in another period of the year, with a relative increase of 0.16 m.

Nevertheless, one of the particular aspects of this well is that it is located precisely within the corridor of geological faults coming from the high zones of water recharge, one of which extends in the direction of the San Salvador volcanic crater, contributing significantly to its maintenance as it is within the preferential flows circulation zone and would not be very representative of other sectors of the aquifer.

The other well situated in the high zone (*Estadio* well) lacks this cyclical-seasonal fluctuation; its behavior reflects a continual tendency toward increase regardless of the annual periods of recharge and discharge.

This condition could lead to the assumption of an "artificial recharge", stemming precisely from leaks in the potable water, rain drainage and sewage systems, as well as a reduction in water exploitation in the zone from disuse of some of the wells, and also of the well under analysis as the latter was not functioning during the period being recorded. Figure 6 reflects the behavior described in the wells analyzed between 2007 and 2009. The left hand column reflects the depth of the wells' phreatic levels in meters.

One of the aspects of the research which stands out is the decrease in the potentiometric lines, or lines that establish the water levels in the aquifer, principally in the intermediate low elevation of the water basin. This is reflected in low productivity or disuse of some important wells situated in popular sectors in the Soyapango and San Marcos municipalities.

Given the configuration of the geological structure, the wells situated on or near fault lines heading towards the recharge zones, which are primarily located in the intermediate and higher elevation levels of the water basin, conserve their yearly recharge pattern, and some of them experience a certain increase in their phreatic levels. However, those wells found in the lower zones, formed hydro-geologically by a porous and sedimentary aquifer formation of greater consolidation and intermediate permeability, experience a gradual decline and even disuse due to low productivity and the high costs of keeping them functioning.

Although the amount of water for consumption is not quantified in the hydro-geochemical characterization study - water that could be recharging the aquifer in the form of water leaks – the study does establish qualitatively the significant contribution that this volume of water can be providing to the San Salvador aquifer.

To do so, taking into account the analysis of some physical-chemical parameters (pH, temperature, electric conductivity), a concentrations analysis (mg/l) was performed on the ions of some hydro-geochemical elements of San Salvador's water sources and supplied water, principally calcium (Ca), Sodium (Na2) and Magnesium (Mg2), which were comparatively correlated with samples obtained from SSMA wells. The results obtained presented a correlation between the characteristics and concentrations found in some sectors of the aquifer and those coming from the two principle external sources of water supply that feed the capital's water distribution system. In this regard it is important to note that SSMA water is supplied through the use of three systems, their corresponding contributions for 2013 being: 1. *Las Pavas* (38.5%); 2. *Zona Norte* (north zone) (20.9%); and 3. *Systema Traditional* (traditional system) (40.6%). The first two are external systems of water supply for SSMA while the third is a system of internal wells that extract water from the San Salvador aquifer.

Through an analysis of the environmental isotopes Oxygen 18 and Deuterio, which are related to altitude and inversely related to temperature, it was determined that subterranean recharge from rain occurs primarily in the intermediate and high elevation zones of the water basins and in the corridors of the structural geology of fault lines located in these zones, which are characterized by lesser urban population density. At the same time, the subterranean water sample which was analyzed from within the water basin presented isotopic compositions similar to the two systems of water supply coming from the basins outside of the capital, those being "Las Pavas" and "Zona Norte".

Finally, the analysis revealed that a significant contribution comes from the city's human waste sewage system, due to the presence of high concentrations of nutrients and other reference elements such as nitrate ions (NO3), chlorides (Cl) and sodium (Na) which are present to a greater degree in the central and intermediate zones of the basin where sectors with fragile and outdated sewage pipes (over fifty years) are located.

According to the ANDA-2013 annual report, water production for SSMA totaled 183.3 million m^3, representing 518% of water produced on a national level by the institution, the national total being just under 3.354 million m^3. Other operators produced 9.1 million m^3 nationally.

Total water consumption (billed for) in SSMA was 113.8 million m^3, while 69.5 million m^3 constitute losses due to leaks in the networks from outdated pipes and unbilled water consumption. Unbilled water consumption consists of water extracted from hydrants and from illegal water connections, as well as the existence of a small group of users who have not yet had a water meter installed, the percentage of the latter group according to ANDA being 9.8%, and another group of users with non-functioning meters (3.5%). The bill for these two last groups is fixed and estimated.

According to ANDA, loss due to illegal connections and permanent theft of water has been reduced considerably during the last few years. This has been made possible thanks to a series of administrative and technical measures, including:

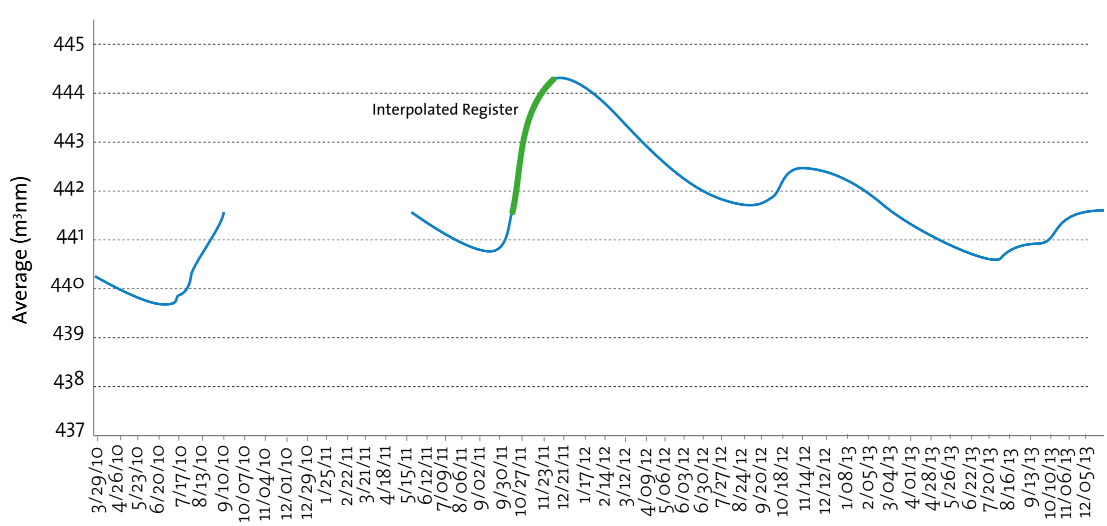
- Systematic monitoring and inspections of distribution networks and water connection points, having legalized a significant quantity of illegal connections.
- Modernization of the customer enquiry, service and participation through implementing 24 hour communications centers for reporting fraud, water leaks, problems with service and billing problems, etc.
- Implementation of hand held or portable mini-computer devices to read meters, control the amount of water supplied, photography for the control and verification of water connection points, problem reporting, historical record of water usage, etc.
- Installation of meters in the pumping stations with devices for controlling flow in order to be able to establish a balance between water produced in the circuits and networks, distribution and billing. This improvement provided the ability to localize, trace and identify problems of fraudulent connections, among other things.
- Modernization of land registry and computerized maps of users which contributes to better control of grey water.
- Opening of kiosks and branches for better client attention.

With the above in mind, losses from illegal water consumption have been significantly controlled and thus their contribution to non-billed water consumption is low. If we consider that they still represent 10% of current losses, the losses for unbilled consumption represent 23.3%, making the losses from water leaks responsible for 53.3 million m^3 of water, a large portion of which will directly recharge the aquifer and a lesser portion could be contributing to sub-surface baseflows of some of the springs in the intermediate and low zones of the city.

To this artificial recharging of water must be added the recharging resulting from leaks in pipes and black water tanks which can be assumed to provide considerable quantitative contributions to

Figure 7. Record of phreatic levels Nejapa Well No. 6

Source: Subterranean Water Monitoring Network records, Environmental Hydrology Observatory Administration-MARN 2013



the aquifer yet which has substantial detrimental repercussions on the quality of the water later extracted, as was discovered in the study previous mentioned.

It is important to point out that the International Water Association (IWA) considers losses within the potable water system to be on an intermediate level when the percentage of losses oscillates between 8% and 15% (Gerlingen, D., 2001, cited by Barrera, M., Characterization Hydro-geochemical...2010).

In general, although the San Salvador aquifer maintains its dynamic equilibrium in the intermediate-high zones of the basin, according to the analysis of the records of the five wells, this situation is not reproduced in the low zones where the wells reflect a reduction, as was reported in the study on hydro-geochemical characterization.

However, this equilibrium in the intermediate-high zones does not correspond to natural recharge but to an acute problem of leaks which signifies high operational costs for ANDA, not only due to economic losses which can reach several million dollars in surplus production to satisfy the demand for water supply, but also for the growing need for purification of the extracted waters.

From this perspective, the water recharge zones possess not only an essential function in the conservation of the aquifers, but also in contributing to the dilution capacity and the preservation of subterranean water quality.

Interrelated to the San Salvador aquifer, the Nejapa population aquifer is located within the SSMA, but formed by its own hydrographic region –the San Antonio River basin, which in turn forms part of the second most important external source of water supplied to the capital, known as *Proyecto Zona Norte*, the North Zone Project.

The Nejapa aquifer, although much smaller than that of San Salvador, acquires strategic importance due to its close proximity to the capital, and provides good quality water which requires much less treatment, and thus investment, than water coming from other sectors. This is due to its water recharge zone being well preserved with ample forest cover and free from sources of direct urban contamination. As a result, and due to its low level of urbanization, the Nejapa aquifer is not influenced by artificial recharging but instead depends primarily on the yearly rain cycle.

Nevertheless, during that last few years, given the problems which have affected the San Salvador aquifer such as environmental deterioration, increasing contamination of subterranean waters and a reduction in phreatic levels in the low altitude zones, all of which results in the need to increase production costs for well water, diverse industries including water and beverage bottlers have transferred or expanded their operations in the Nejapa aquifer.

This displacement phenomenon in various industries and economic projects has generated a condition of greater pressure upon the aquifer which has already experienced a reduction in phreatic levels, revealed in different studies analyzing hydro-geological balances and monitoring of one of its representative wells (ANDA Well No. 6).

Figure 7 presents the monitoring of Nejapa Well No. 6 during the period from March 29, 2010 to December 5, 2013, revealing that during the period of continuous recording, maximum recharging of the aquifer occurred between December 2011 and December 2013, reaching elevations of 444.25 meters and 441.5 meters above sea level respectively, which means a decrease of 2.75 meters in two years.

From the perspective of surface water, changes in land use and urban sprawl generate a second problem in the cities –an increase in surface runoff and peak water flows during extreme meteorological events and an increase in risk zones, principally in the low altitude zones.

2.3 Increase in surface runoff and generation of peak water flows during extreme meteorological events in San Salvador's low altitude zones

The effect of an increase in peak water flows related to changes in land use which began in the high recharge zones began to be studied following extreme hydro-meteorological events in recent years (208-2011) which lamentably resulted in loss of life and material damage. One of the most memorable and tragic events occurred in the neighborhood of *La Málaga* on July 3, 2008, as was mentioned earlier. Following that dramatic event, new flooding occurred in the same neighborhood and in other sectors of the city as a result of low pressure associated with Hurricane Ida (November 7, 2009), Agatha (May of 2010), Tropical Depression 12E

Figure 8. *Arenal Montserrat* micro-basin analysis

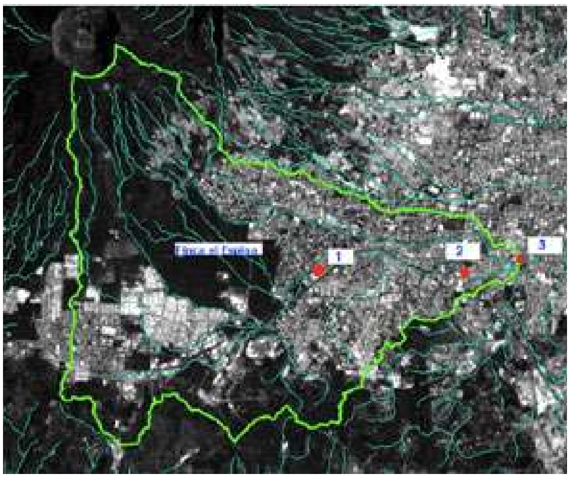
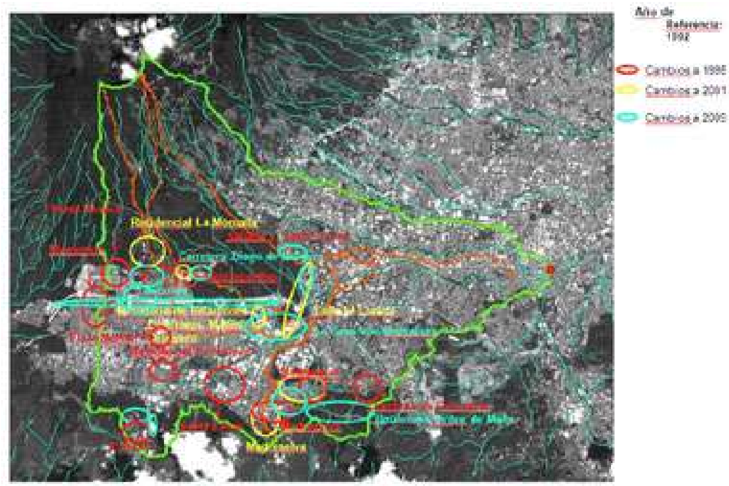


Figure 9. Changes in land use in the Arenal Montserrat micro-basin



(October of 2011). Of these three events, the one with the greatest magnitude and consequences occurred in 2009 which again caused flooding and volumes of water greater than the event of 2008.

In 2010, the National Territorial Studies Service (SNET), now known as the MARN Environmental Observatory, carried out an analysis using hydrological analysis on the maximum flood levels registered in the 2008 and 2009 events, using the *Avenida Revolución* (Avenue of the Revolution) (1), *La Málaga* neighborhood (2) and *Puente Belloso* (Belloso Bridge) (3) as control points as shown in Figure 8. Also shown is the micro-basin of SSMA, known as *Arenal Montserrat*, whose high zones are located in the San Salvador volcano while its low zones are in the central sector of the capital, where the *La Málaga* neighborhood is located. The study consisted of comparing hydrograms of water flows generated by these events with water flows generated through hydrological modeling for the same meteorological conditions, with based on 1992 land use data.

Figure 9 reflects the gradual changes in land use which came about beginning in 1992 and continuing until 2009, with zones modified in 1998 circled in red, zones modified in 2001 circled in yellow and zones modified in 2009 circled in blue. Overall, between 1998 and 2009 a total of 5.53 square kilometers of permanent forest cover were urbanized.

Figures 10, 11 and 12 present the results obtained from the three control points. The figures reflect the times at which peak flow rates occur and a notable increase in these rates under current conditions of reduced vegetative cover.

Figure 10 reflects the calculated flow rate with current land use as 14.8 m^3 per second vs. the simulated flow rate considering 1992 land use patterns, of 10.78 m^3 per second.

This control point has experienced the urbanization of 13.68% (3.73 km^2) of this point's basin area (27.3 km^2) and an increase of 4.1 m^3 per second, equivalent to 38% of the peak water flow rate.

Figure 11 shows the flow rates calculated for the point at which the 2008 tragedy occurred. At that point, the basin area for this point is 40.95 km^2, 5.20 km^2 (12.70%) of which were urbanized. Flow rates increased by 10.5 m^3 per second, representing an increase of 74% in the peak flow rate, with a 30 % reduction in time.

Lastly, Figure 12 presents the flow rates calculated for the *Puente Belloso* station. The basin area for this control point covers 53.47 km^2, with 5.52 km^2 (10.33%) of urbanization. Flow rates increased by 16 m^3 per second (98% of the peak flow rate) and a 40% reduction in arrival time.

2.4 Evaluation, location and use in urban zones of the principal surface and subterranean water sources on the national level

Water is supplied to urban zones or greater population density sectors through the capture of surface water in rivers and springs, and through extraction from wells situated in the country's principal aquifer zones. Figure 13 represents the updated MARN-SNET 2002 hydro-geological map of the country, although this map was original based on PNUD-ANDA 1972 and PLANDARH 1982 studies. The interior aquifers in the area of the central volcanic chain are represented in blue. These aquifers were formed by pyroclastic materials and are of moderate to high productivity. Aquifers shown in violet are formed by alluvial deposits located along the coastal strip and in riverine areas, reservoirs and wetlands. Water recharge zones are shown in orange, located especially in the volcanic foothills.

Aquifers in the area of the volcanic chain have a strategic function because of their close proximity to the country's principal cities (SSMA, Santa Ana and San Miguel). Nevertheless, their vulnerability has increased during the last few decades due to greater pressure on water resources and the effects of contamination from urban areas. Aquifers situated along the coastal plain have been better exploited historically for supplying urban zones, although they also play an important role in supplying water to the local rural population and cultivation zones using irrigation methods. However, one problem affecting these aquifers is the presence of trace contaminants originating from the intensive use of agro-chemicals, principally in the large agricultural plantations of cotton and sugar cane beginning in the 1950s. At the same time, focal points of marine water intrusion have appeared which results in less water availability in terms of quality. One of the most strategically important aquifers in the coastal zone is "*El Jocotal*" and "*Olomega*", located in the extreme southeastern portion of the country. This zone, unlike the other coastal areas, is confined in the south by the "*Jucuarán-Intipucá-Conchagua*" cordillera or mountain range, which isolates it from interaction with marine dynamics, and facilitates its conservation as completely fresh water. It has not been very exposed to direct contamination by pesticides and agro-chemicals in the past, being located as it is in a protected nature zone, Ramsar sites and species conservation zones, formed by the *Olomega* and *Jocotal* lakes. However, it is still vulnerable to contaminated effluent from the *Rio Grande de San Miguel* River, which interacts directly with that aquifer zone.

Figure 10

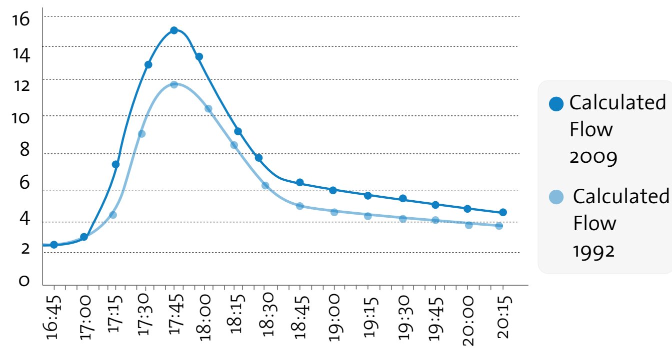


Figure 11

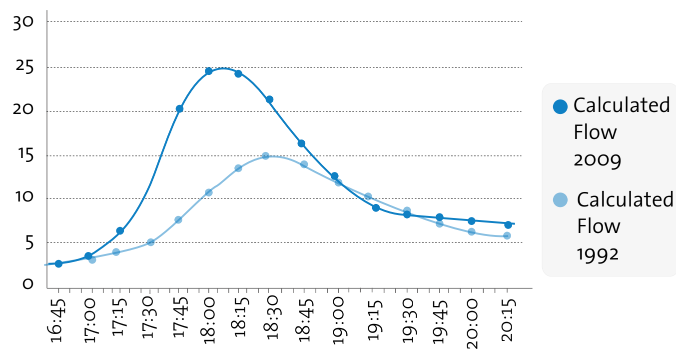


Figure 12

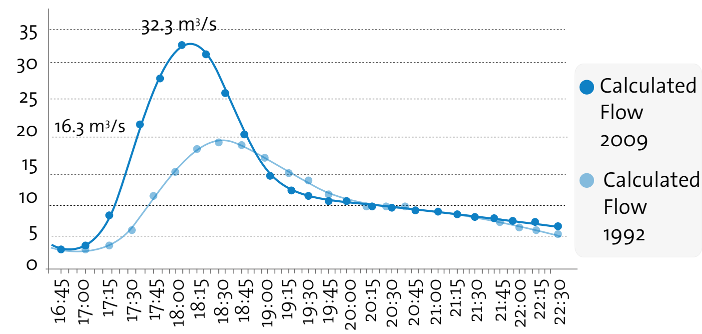
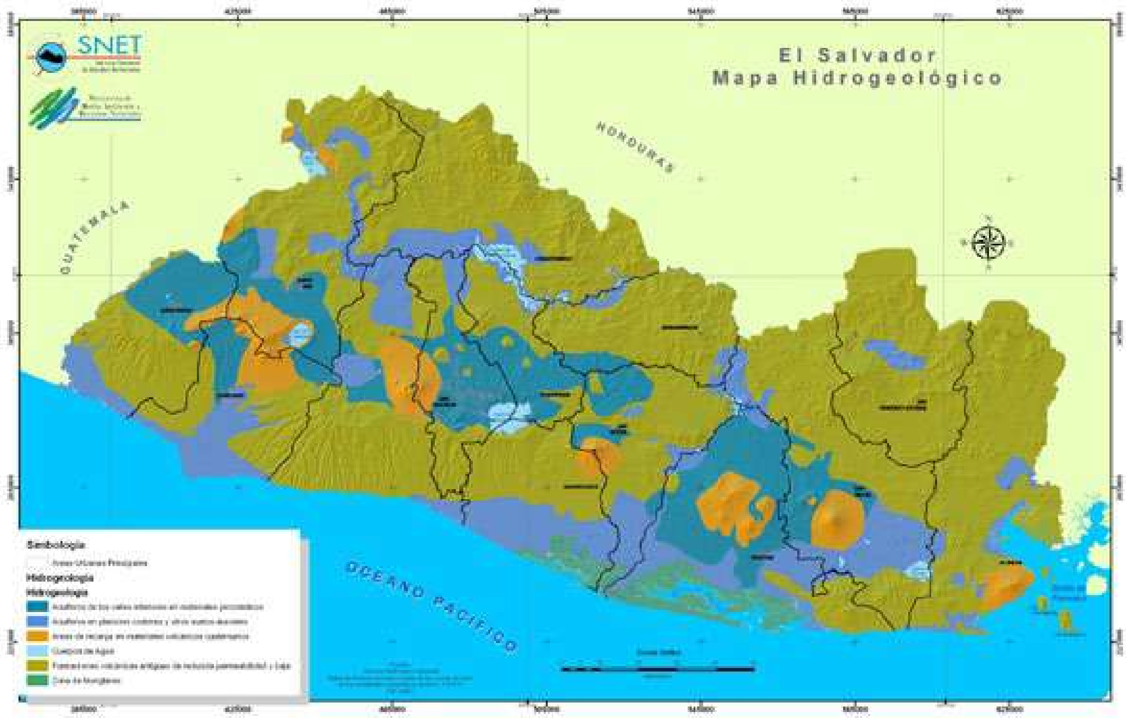


Table 1 presents the country's aquifers and their location is shown on the map in Figure 14. The Santa *Ana-Chalcuapa* and *San Miguel* aquifers supply the majority of water (80%) to *Santa Ana* (560 thousand inhabitants) and *San Miguel* (470 thousand inhabitants), these being the second and third most important cities and departments in the country, after San Salvador and SSMA.

The San Salvador aquifer is the primary supplier of the country's urban waters. It supplies 33% of the capital's water supply. The *Quetzaltepeque-Nejapa*

Figure 13. Hydro-geological map of El Salvador



aquifer supplies another estimated 21% of the capital's water supply.

Surface waters constitute another strategic source of water supply to different cities and lower density populations in the country. The principal source of surface water is the catchment and purification station in the Lempa River known as "*Las Pavas*". This station captures and estimated flow of 2 m^3 per second which it supplies to SSMA and represents approximately 38% of the capital's water supply. Another watershed of importance as a water supply is the *Tamulasco* River located in the department of *Chalatenango*. The National Aqueduct and Sewage Administration (ANDA) has a capture and purification station installed in this river to supply water to the department capital, providing water service to more than 50 thousand inhabitants.

One of the problems presented by making use of surface water has been its availability in terms of quantity and quality. Regarding quantity, the nation's surface waters are undergoing outright decline over the last few decades due to the gradual reduction in the base flow rate, principally during the dry season. This situation was studied in detail by the National Territorial Studies Service (SNET-MARN) in 2005. These studies revealed that a great portion of the country's principal rivers were experiencing a reduction in their baseflow rate primarily during the dry season such that many

Figure 14. Location of aquifer formations across the country with names corresponding to those indicated in Table 1.

Table 1. Characterization of aquifer formations in El Salvador (PNUD-ANDA 1972)

Cod	Name of aquifer	Hydrogeological characterization	Extension Km²	Thick Ness m	Annual recharge m³ /year x 10^6
A-1	Singüil	Redeposit of Quaternary pyroclasts	24	30	7,00
A-2	Texistepeque	Redeposit of Quaternary pyroclasts	40	40	10,00
A-3	Santa Ana-Chalchuapa	Quaternary lava and pyroclasts	200	80	90,00
A-4	Aguilares	Redeposit of Quaternary pyroclasts	60	60	30,00
A-5	Coatepeque	Quaternary pyroclasts	45	60	23,00
A-6	San Salvador	Quaternary lava and pyroclasts	160	100	42,00
A-7	Zapotitán	Pyroclastic Deposits and lake sediments	200	100	200,00
A-8	Quezaltepeque-Nejapa	Quaternary lava and pyroclasts	130	60	100,00
A-9	San Vicente	Quaternary lava and pyroclasts	100	100	55,00
B-1	Chalchuapa-Ahuachapán	Quaternary lava and pyroclasts	250	80	114,00
B-2	Omoa	Quaternary pyroclasts and interleaved lava	100	60	9,00
C-1	Paz-Acajutla	Deposits of alluvial sediments	185	60	81,00
D-1	Izalco	Quaternary lava and pyroclasts	160	40	55,00
D-2	Sonsonate	Quaternary lava and pyroclasts	300	40	143,00
D-3	San Julián	Quaternary lava and pyroclasts	20	20	41,00
E-1	Libertad-Comalapa	Deposits of alluvial sediments	85	40	30,00
F-1	Comalapa-Lempa	Deposits of alluvial sediments and Quaternary pyroclasts	400	60	418,00
F-2	Ilopango	Quaternary pyroclasts	40	100	20,00
G-1	Lempa-Usulutan	Coastal sediments and Quaternary lava and pyroclasts	450	100	298,00
H-1	Usulután	Quaternary pyroclasts	150	100	200,00
H-2	El Jocotal	Lava and alluvial sediment deposits	130	60	100,00
H-3	San Miguel	Quartenary Lava and pyroclasts	150	100	57,00
H-4	Olomega	Alluvial Deposits	100	60	30
H-5	Quelepa	Quaternary lava and pyroclasts	150	60	30

of them could be transformed in the intermediate future into mere natural drains during the rainy season. This problem was attributed principally to a lack of protection, soil conservation and forest cover in various hydrographic basins in the country, as well as to hydro-meteorological variations yielding a gradual loss in infiltration capacity and regulation of sub-surface flow which is what maintains the springs and water sources such as river tributaries. The study carried out a process of classification based on "anomaly levels), establishing the *Tamulasco* River as presenting one of the most critical situations with an anomaly level considered to be "very high", as the river is losing its flow at an accelerated rate during the dry season such that urgent actions must be taken within the framework of integrated water resource management in its high elevation basin, as an important population center depends on this river for their water supply.

Table 2 presents the comparative capacity information obtained by ANDA in some of the principal springs, rivers and capture points which make use of surface water, both above and below the water collection points on the same day. The levels of extraction in many cases extend beyond 50% of availability, and even up to above 80% of water availability, such as in the case of the *Tamulasco* River during the dry months of the year (February and March), which significantly reduces the base water flow rates or environmental flow rates required for maintaining the ecological equilibrium of fluvial systems.

This same situation is repeated in water extractions during some months of the year at various capture points (*Suchitoto, Nueva Concepción, Aguilares y Ahuachapán*).

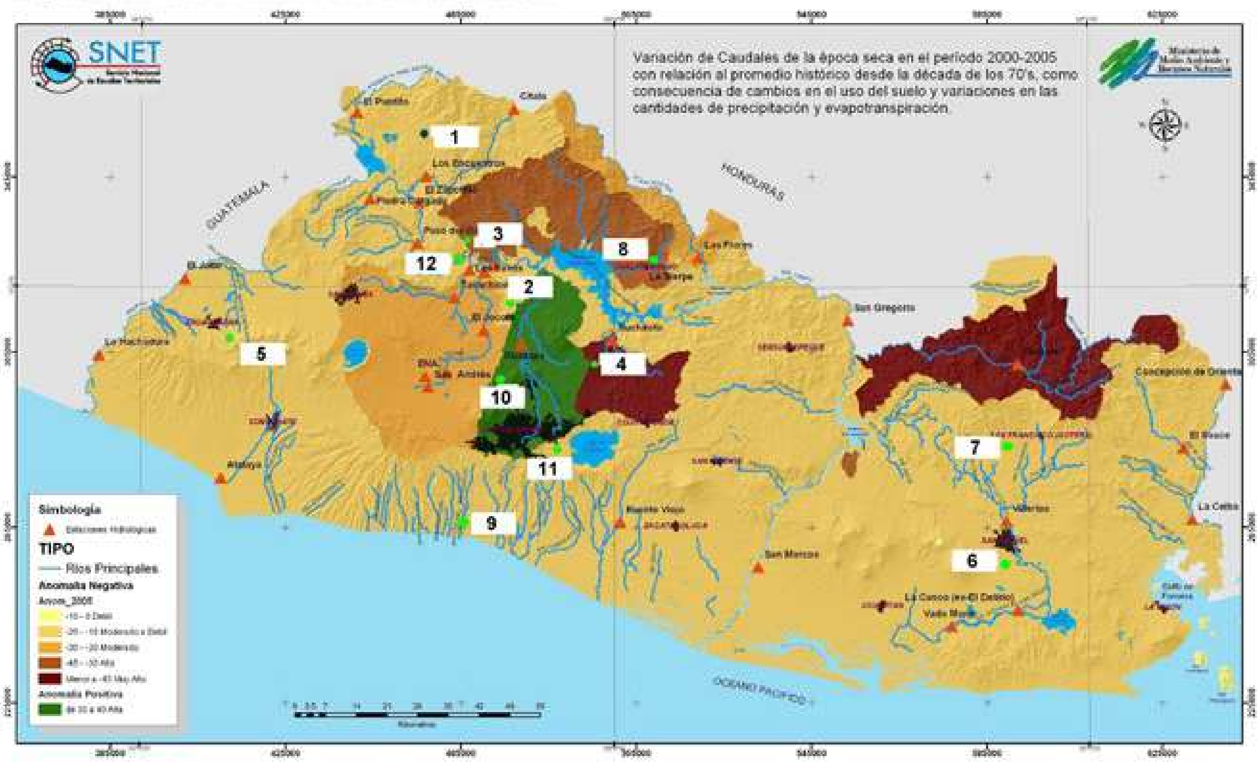
The map in Figure 15 presents the location of some of the most important springs or surface water sources on the national level. This map also illustrates the zones of moderate and greater anomaly levels (light brown and dark brown areas) in terms of the reduction in flow rate during the dry season. An increase in the flow rate (in green) is due to the *Acelhuate* River basin being an urban basin which drains residual water and treated water from SSMA in increasing amounts during the last two decades.

Table 2. Sources of superficial water and capacity provided by ANDA study (2009-2013)

No	Surface water source	Name	Municipality or Population	Date	Department	Flow Rate (l/s)
1	River	El Rosario	Metapán	Feb. 2012	Santa Ana	12.23
	River (Upstream from water intake)	El Rosario	Metapán	15 Jan. 2013	Santa Ana	147.97
	Río (Downstream from water intake)	El Rosario	Metapán	15 Jan. 2013	Santa Ana	64.08
2	Spring (upstream)	Caballeros	Aguilares	08/March 2012	San Salvador	10.34
	Spring (outflow)	Caballeros	Aguilares	08/March 2012	San Salvador	5.45
	Spring (upstream)	Caballeros	Aguilares	07/Dec. 2012	San Salvador	11.17
	Spring (outflow)	Caballeros	Aguilares	07/Dec. 2012	San Salvador	1.74
3	Spring	El Chaguitón I (Total Flow)	Nueva Concepción	27/March 2012	Chalatenango	31.64
	Spring	El Chaguitón I (Outflow)	Nueva Concepción	27/March 2012	Chalatenango	16.39
	Spring	El Chaguitón I (Total Flow)	Nueva Concepción	7/Jun. 2013	Chalatenango	22.73
	Spring	El Chaguitón I (Total Flow)	Nueva Concepción	7/Jun. 2013	Chalatenango	3.88
4	Spring	El Molino	Suchitoto	11/April 2012	Cuscatlán	29.70
	Spring (outflow)	El Molino	Suchitoto	11/April 2012	Cuscatlán	3.87
5	Spring	El Cashal I y II	Ahuachapán	June 2009	Ahuachapán	10
	Spring	El Cashal I y II	Ahuachapán	June 2009	Ahuachapán	1.73
	Spring	El Cashal I y II	Ahuachapán	May. 2012	Ahuachapán	12.11
	Spring (total flow)	Apunián	Ahuachapán	22 Feb. 2013	Ahuachapán	787.41
	Spring (outflow)	Apunián	Ahuachapán	22 Feb. 2013	Ahuachapán	638.88
6	River	El Jute	San Miguel	24/May 2012	San Miguel	192.89
	River	El Jute downstream from ANDA plant	San Miguel	24/May 2012	San Miguel	178.32
7	Spring	El Borbollón	San Francisco Gotera	16/May 2012	Morazán	21.51
8	River(upstream from water intake)	Tamulasco	Chalatenango	January 2009	Chalatenango	126.4
	River(downstream from water intake)	Tamulasco	Chalatenango	January 2009	Chalatenango	49.1
	River(upstream from water intake)	Tamulasco	Chalatenango	March 2009	Chalatenango	74.8
	River(downstream from water intake)	Tamulasco	Chalatenango	March 2009	Chalatenango	0.81
	River(upstream from water intake)	Tamulasco	Chalatenango	16 April 2013	Chalatenango	37.44
	River(downstream from water intake)	Tamulasco	Chalatenango	16 April 2013	Chalatenango	7.62
9	River(upstream from water intake)	Chilama	La Libertad	January 2009	La Libertad	217.3
	River(downstream from water intake)	Chilama	La Libertad	January 2009	La Libertad	130.5
	River(upstream from water intake	Chilama	La Libertad	March 2009	La Libertad	134.3
	River(downstream from water intake)	Chilama	La Libertad	March 2009	La Libertad	62
10	River	San Antonio (before the origin of inflow Tres Piedras)	Nejapa	March 2009	San Salvador	60.8
	River	San Antonio (after the origin. Tres piedras)	Nejapa	March 2009	San Salvador	208.7
	Spring	Tres piedras (inflow of Río San Antonio)	Nejapa	13 March 2014	San Salvador	56.96
11	River	Cuaya (water intake)	Ilopango	January 2009	San Salvador	130
	River	Cuaya (water intake)	Ilopango	Feb. 2009	San Salvador	77.3
12	River	Lempa (Las Pavas)	San Pablo Tacachico	Feb. 2009	La Libertad	815

Source: Author, based on the capacity program carried out by ANDA (2009-2013)

Figure 15. Map of flow rate variation and location of surface water capture sites (numeration corresponding to that used in Table 2)



From the perspective of water quality, the country has a monitoring program (Water Quality 2011) which has been in operation since 2005 through the Environmental Observatory of the Ministry of the Environment and Natural Resources (MARN). Monitoring takes place at 123 sampling sites in 55 of the country's rivers, which are of great importance due to their different environmental uses consisting of water for human consumption, irrigation, recreation, maintenance of aquatic life, etc. The Water Quality Index (ICA) is used for evaluation purposes, consisting of a points scale from 0 to 100 awarded based on national norms for water quality and WHO guidelines. According to results obtained in 2011, 88% of rivers have a level of environmental quality somewhere between regular and bad, as presented in the historical records for river water quality shown in Table 3. According to the report, the principal cause of contamination in the majority of rivers is due to untreated domestic wastewater and a lack of basic sanitation measures, evidenced by the presence of high concentrations of fecal coliforms whose maximum values reach 3.5 million bacteria per 100 ml and BOD (2) up to 122 mg/L, with the consequential reduction of dissolved oxygen.

With regard to the feasibility of applications for purification by conventional methods, the monitoring program reported that barely 23 of the 123 sites evaluation, corresponding to 17% of the total, comply with the requirements of Decree 51 norms, "Regulation on water quality, waste control and protection zones" for purification using conventional methods.

Table 3. Water quality in El Salvador's principal rivers

Environmental Quality	Percentage of Sites				
	2006	2007	2009	2010	2011
Excellent	0	0	0	0	0
Good	17	3	0	2	12
Regular	50	45	60	65	50
Bad	20	46	31	27	31
Very bad	13	6	9	6	7

Source: MARN Water Quality Report 2011

Figure 16. National water quality and monitoring network map

The map shown in Figure 16 presents the location of sampling sites and the level of water quality found. Sites with good quality water are shown in blue while sites with regular, poor or bad quality are shown in grey, yellow and red, respectively.

It is important to note that the water quality in sections of the *Lempa* River before the "*Las Pavas*" capture and purification station present water quality levels between regular and bad, which translate into higher purification costs for ANDA in the strategic production of the water supply system for SSMA.

3. Potable Water Service in Urban Zones

Potable water service is provided throughout the country to El Salvador's populace by the National Aqueduct and Sewage Administration (ANDA), which is an autonomous public entity created by legal decree in 1961 to provide and guarantee potable water service to the population as well as removal and disposal of wastewater. This entity is in charge of carrying out projects and programs aimed at the construction and amplification of infrastructure for aqueducts, sewers and wastewater treatment as well as the administration of financial mechanisms for carrying out the objectives of the institution. ANDA is in charge of creating and putting into practice technical norms for the design and construction of hydraulic projects, emitting "non-encumbrance permits", carrying out hydro-geological studies for exploring subterranean water sources, water purification and quality control at extraction points, water capture and distribution network, and implementation of water consumption tariffs.

3.1 Characteristics of the decentralization process, current situation and production of water and consumption on the national level

Between 2001 and 2004, a decentralization process (SACDEL-2005) was discussed by ANDA's "Decentralization Unit". This process was later implemented by conferring the administration of a small part of services to diverse municipalities or local entities through the legal entity known as Municipal Associations, or to micro-regions or mixed enterprises (municipal-private-community), principally in rural areas. This process was formed without interfering with ANDA's legal obligations, as ANDA continued holding the title and ownership of assets, while transferring the local administration of water resources to these new operators, with an agreement for technical accompaniment, advice, personnel training and shared financial administration for the develop and maintenance of infrastructure to carry out the sustainable operation of the new administrative model.

In this way, ANDA could untangle itself from direct administration in rural zones which required great investment in administrative, technical and logistical resources, and could otherwise continue receiving income under agreement with the new operators through local billing for water supply and sewer services.

In 2009 (*Boletín Estadístico* – Statistical Report, ANDA 2009), ANDA supplied potable water to 122 of the nation's 262 municipalities (representing 46.6% of municipalities). Forty-five municipalities (17.2% of the total) were supplied by decentralized operators and 95 municipalities (36.2% of the total) were supplied by other operators. In general, this spatial distribution throughout the territory does not correspond to distribution in terms of population density and especially in terms of water production, as decentralized operators and other supply operators historically produce all together an average of between 5% and 6% of water production on the national level.

According to generalized data, within an average national production of 366 million m^3 of water annually, the decentralized operators contribute 20 million m^3 as will be shown later. Nevertheless, they play a primary role in providing water services to many rural municipalities categorized with a moderate to high level of poverty and the tariffs are adjusted to meet the economic possibilities of the population on the order of US$ 0.20 to US$ 0.70 per m^3, contributing greatly to combating price speculation and abuse on the part of intermediate sellers using transportation vehicles such as cistern trucks, while having previously sold water by the barrel with a price equivalent to US$ 10.00 per m^3.

Beginning in 2012, the process of decentralization began to be reversed when ANDA began to consider management by decentralized operators as lacking efficiency and technical-administrative capacity which led to increased costs and reduced income for the institution. This dismantling of local institutionalism has resulted in serious conflicts and a rejection of these methods because it implies not only a reversal of administrative management but also a direct impact on the formation of community and municipal organization which was building empowerment of local social actors in local development throughout the last decade.

One of the aspects that prevailed in the political discussion in the years preceding its implementation was the importance and value of the measure in terms of strengthening and developing citizen, municipal and community participation in the rural area, principally in decision-making and in building responsibility for the management of water resources and organized labor efforts around a service essential to the population.

In an initial evaluation of the decentralization process in 2005, carried out by RTI International (Moncada, L., RTI-2005), and cited in the analysis made by SACDEL, the most important achievements in the process carried out by ANDA were seen as "the development of local human resources, respect for users' rights and greater awareness of the need to protect water resources".

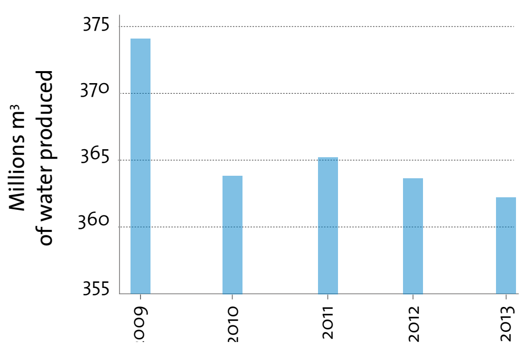
In 2012, the contribution of decentralized units was 16.4 million m^3, while in 2013 the contribution was 9.4 million, representing 2.4% of water produced on the national level. According to the annual account report ANDA 2009-2014, six of the most important decentralized units have been incorporated once more by the institution since 2012, generating in that year an increase in their management costs of US$ 85,100.00. Although it is still too soon to evaluate expected increases from this new centralization process, in terms of efficiency and returns for service on the part of the institution, Table 4 shows that for 2012 and 2013 the national production and consumption levels have remained practically the same, or have experienced a decline compared to previous years as illustrated in Figure 17. However, losses from leaks or illegal connections show a gradual increase between 2008 and 2011.

Table 4. Comparison between water production and consumption on the national level (millions of m³)

Year	Production of ANDA	Production other decentralized systems	Total of Water produced on national level	Consumption from System of ANDA on National level	Consumption of decentralized operators and self-supply on a national level	Total of consumption	Loss due to leaks and illegal connections	% of loss
2008	351.1	20.8	371.9	206.2	35.6	241.8	144.9	41.3
2009	353.4	20.3	373.7	202.4	36.9	239.3	151	42.7
2010	341.4	23.3	364.7	187.5	39.1	226.6	153.9	45.1
2011	345.7	20.4	366.1	179.8	39.7	219.5	165.9	48.0
2012	348.3	16.4	364.7	nd	nd	nd	nd	nd
2013	353.6	9.4	363	186.5	35.9	222.4	167.1	47.3

Source: Author, based on ANDA 2008-2011 statistical reports and ANDA 2013 annual report and ANDA-2009-2014 accounting reports. nd= no information available

Figure 17. National water production levels



3.2 Financial capacity of ANDA in relation to water production and loss due to leaks or illegal connections on the national level

One of the strengths of the institution has been, unlike other state entities or ministries, the fact that the great majority of income and allocated budget is derived from direct billing for services provided such that it is not dependent upon a budgetary line item from national coffers for operation expenses, although it does receive national funding yearly as part of its budgetary support; according to the tariff schedule, water service is provided in a subsidized manner according to the level of consumption. The allocated budget is also comprised of investment loans, non-reimbursable amounts, international cooperation financing, etc.

Thus, the total allocated budget determines the yearly objectives in terms of water and sanitation, improved services, maintenance and rehabilitation, increased coverage, etc.

Table 5 shows that between 2008 and 2013, income from billing for services has seen a notable increase which is attributed to a series of actions related to the modernization of the billing system, opening of branch offices and "express service" centers for easy payment and access for customers, improved customer service, updating and new informatics through implementation of new and improved software packages for managing the database, introduction of portable hand-held computers for meter-reading and better control of wastewater, leaks and illegal connections; better management in recovery of arrears, increased efficiency in operational tasks and logistics of maintenance and repairs of conduction lines and domestic hookup points, and extending services to new users, etc.

At the same time, in some years the allocated budget was strengthened with support from the national budget and through loan financing, and investments by international cooperation, principally during years in which extreme meteorological events have generated damages or disasters in the water conduction/distribution and sewage system. One year that stands out in this regard is 2011, in which Tropical Storm Ida impacted extensive areas of El Salvador. In general, the total executed budget has tended to increase between 2009 and 2011.

One aspect worth mentioning is that in spite of all the significant efforts and increases in yearly budgetary execution, water production nationwide has remained practically unchanged, or has experienced a decline as shown in Table 5, reaching

Table 5. Water production and executed budget amounts

Year	Invoicing and other commercial income (millions of US$)	budgetary reinforcement of the general fund of the Nation, loans and international cooperation (millions of US$)	Total executed budget (millions of US$)	Water produced on a national level (millions of cubic meters)	Index of relation of budget to produced water (US$/m³)
2008	81.1	52.3	133.4	371.9	0.36
2009	80.1	13	93.1	373.7	0.25
2010	102.8	14.6	117.4	364.7	0.32
2011	102.8	64.5	167.3	366.1	0.46
2012	nd	nd	nd	364.7	nd
2013	110.1	25.7	135.8	363	0.37

Source: Author, based on ANDA-2008-2011 statistical reports, ANDA-2013 annual report and ANDA-2009-2014 accounting report. nd= information not available

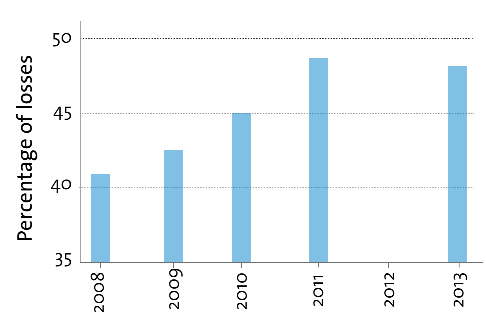
its peak of greatest efficiency in 2009 and its lowest output within dates on record in 2011 (data for 2012 is currently unavailable).

From information provided in institutional reports and taking into account funding destined for emergencies caused by hydro-meteorological events, some of the aspects attributable to the high costs of operation are the high price of energy and the need to increase the energy efficiency of the pumping system, the purification plants and the water supply system, as these costs have risen significantly in recent years. In this regard, inter-institutional agreements have been launched with the national hydro-electric generation entity known as "*Lempa* River Hydro-electric Executive Commission" or CEL, to come to agreement on the energy distributor's prices and not those of large consumers. Another aspect has been the outlay of funding destined for investing in new wells (26) and the rehabilitation of old wells (45) which had been in disuse for many years. In addition, the modernization of the billing system, control of leaks, use of portable instruments for meter-reading, installing software with greater capacity for administrative management and investment in human resources have been other factors which have resulted in increased budget investment in the last few years. Finally, a significant increase in funds destined for disinfection of crude water extracted from deep wells and surface sources must be included. According to institutional records, in 2009, 1.5 million pounds of chlorine (chloride gas and calcium hypochlorite) were used at a cost of US$ 1.02 million; however in 2011 some 14.8 million pounds of chemicals were used, at a cost of US$ 3.24 million, which reflects an increase of 300% in necessary purification costs for the same, and even for a lesser amount of water.

This fact is of great concern because it is an indication of the gradual contamination of water resources or the low quality of crude water that the institution must purify, as was indicated previously with respect to the results obtained from water quality monitoring in sections of the Lempa River prior to the "*Las Pavas*" station.

Leaks in the water distribution system, considered to be between moderate and high, have historically represented a significant problem for the institution, with an estimated value in 2013 of 47.3% nationwide, as presented in Table 4. In Figure 18 one can see that this value has gradually increased although it has decreased slightly this past year, which is associated with ANDA's efforts and improvements within the framework of diverse preventative maintenance and corrective programs for the aqueduct and sewage system on the national

Figure 18



level. This programs have allowed the institution to correct faults brought about principally by the outdated pipes and tubes. On the national level it is reported that during 2013, some 51,257 repairs were made, of which 46,794 (91.72%) were made in the networks and connection points of the aqueduct, and 4,463 (87%) were made in sanitation sewer networks.

3.3 Sources of water supply for the Metropolitan Area, volumes of production and consumption, and situations of water loss due to leaks and illegal connections

Regarding the SSMA, ANDA possesses four systems or primary sources of water production: 1. *Las Pavas,* which consists of a surface water source whose capture point is in the country's principal river, the *Lempa*, which has a current operational capacity of 2.2 m^3 per second. This system constitutes the principal source of surface water in the country human consumption and is located 44 km from the SSMA. It provides approximately 38% of the capitals current water supply. 2. *Sistema Tradicional* consists of water production through deep well extraction, supplying 33% of the city's water supply. 3. *Zona Norte System*, consists of a water production system using deep well extraction and is located in the low foothills north of the San Salvador volcano (¨*Nejapa-Quetzaltepeque-Opico*¨) aquifer, providing 21% of the city's water supply. It is located an average of 18 km from the SSMA, and has strategic importance due to its low level of contamination and good conservation of the water recharge zones, a system which has been maintained for many years due to its restricted development category and limited urbanization efforts in the 1980s and 1990s. However, this system is currently under pressure from a new scenario of urban residential and industrial development and the previously restricted recharge zones' loss of protection, with the opening up of primary highways in the previous decade and the re-categorization of land use, and where it is now common to observe, along the new highways, logistics plants, factories, bottlers, great expanses of impermeable roofs and parking lots, signs indicating land for sale with industrial use permits and ultimately, the initial stage of construction of an extensive high density residential complex, totally incompatible with the strategic hydro-environmental function of this region. 4. *Guluchapa* System, which is a combined system capturing both surface and subterranean

Table 6. Water production system for SSMA water supply administers, by ANDA and other systems (millions of m^3)

Year	Las Pavas	Traditional System	System Northern Zone	Guluchapa	Other Systems	Total
2008	75.7	64	40.4	11.1	0.6	191.8
2009	78	62.3	41.5	10.6	0.51	192.9
2010	75.6	63.7	37.9	10	0.44	187.6
2011	75	65.1	35.7	10.7	0.5	187.0
2012	70.5	*73.5	35.4	---	0.5	179.9
2013	70.5	60.6	38.3	13.9	0.51	183.8

Source: Author, based on ANDA -2008-2011 statistical reports, ANDA-2013 annual reports and ANDA-2009-2014 accounting reports. nd= information not available *Includes Sistema Tradicional and Guluchapa

Table 7. Summary of water consumption by category in the Metropolitan Region in the system administered by ANDA, private exploitation and decentralized operators (2004-2011) (in millions of m^3 per year)

User	2004	2005	2006	2007	2008	2009	2010	2011
Residential	120.7	117.4	121	120.1	102.8	100	93.7	88.9
Industrial	1.9	1.7	1.4	1.3	3	2.6	2.2	2.4
Commercial	14.5	15.2	15.9	14.9	20.5	19	18.6	18
Public Sector	8.3	8.5	8.7	8.5	8.8	9.3	8.3	8.2
Total	145.4	142.8	147	144.8	135.1	130.9	122.8	117.5

Source: ANDA statistical reports

Table 8. Comparison between water production and consumption in the SSMA (in millions of m³)

Year	Produced by ANDA	Production of other decentralized systems	Total Produced	Total consumed	Loss by leaks and illegal connections	% of loss
2008	191.2	0.6	191.8	135.1	56.1	29.3
2009	192.4	0.51	192.9	131	61.4	31.9
2010	187.2	0.44	187.6	122.8	64.4	34.4
2011	186.5	0.5	187.0	117.5	69	37.0
2012	179.4	0.5	179.9	nd	nd	nd
2013	183.3	0.51	183.8	nd	nd	nd

Source: Author, based on ANDA 2008-2011 statistical reports, ANDA-2013 annual reports and ANDA-2009-2014 statistical reports. nd= no information available

Table 9. National status of water supplied for human consumption in the year 2011

Description	Rural		Urban		Country	
	Families	Percentage	Families	Percentage	Families	Percentage
Water Services						
Piped water	348565	63.05%	940137	90.42%	1288702	80.9%
Storage of water in pottery jugs	29073	5.26%	39037	3.75%	68110	4.3%
Excavated well	96440	17.44%	45420	4.37%	141860	8.9%
Spring	70083	12.68%	7047	0.68%	77130	4.8%
Rain Water	6391	1.16%	6252	0.60%	12643	0.8%
Others	2324	0.42%	1864	0.18%	4188	0.3%
Total	**552876**	**100.00%**	**1039757**	**100.00%**	**1592633**	**100.0%**
Bath Services						
Shower	199008	36.0%	843272	65.4%	1042280	65.4%
River or Ravine	57544	10.4%	6728	4.0%	64272	4.0%
Barrel or Open Air Sink	295506	53.4%	189674	30.5%	485180	30.5%
Others	818	0.1%	83	0.1%	901	0.1%
Total	**552876**	**100.0%**	**1039757**	**100.0%**	**1592633**	**100.0%**

Source: Author, based on EHPM-2011

water in the southeastern zone of the capital in the hydrographic region known as *Guluchapa*, whose basin extends from *San Jacinto Cerro* to *Ilopango* Lake. This system provides 8% of the city's water together with a minority contribution from the only decentralized operator contributing to the SSMA water supply. This system is often taken into account together with contributions from the *Sistema Tradicional*, making their joint supply total 41% of the city's water. Table 6 presents water production in millions of m³ from each of SSMA's systems throughout the past six years. Once again, production has tended to decrease during the period analyzed.

Table 7 shows the distribution by category of water use from 2004 to 2011 in the San Salvador Metropolitan Region, which verifies a gradual decrease in total consumption through the period analyzed. Within the residential sector in 2011, water consumption was established as 88.9 million m³. According to the categorization established by ANDA, during that year, the lower economic classes consumed 38.32% of the city's demand for water, with an average of 11 m³ per month; the middle classes consumed 41.2% with an average of 30 m³ per month; and the upper classes consumed 20.6% with an average of 87 m³ per month.

Table 8 shows that the percentage of loss due to leaks in the SSMA is repeated in a similar fashion on the national level, as these percentages have tended to increase, as opposed to consumption which has tended to decrease between 2008 and 2011, while data for 2012 and 2013 is not known.

3.4 National water services coverage in urban and rural zones

The analysis of piped potable water supply coverage, along with a 2011 domestic and multi-purpose survey, reveals that 90.42% of the urban area is covered by this service while only 63.05% of the rural area is covered. Table 9 shows the different kinds of water services supplying the urban and rural populations with water.

3.5 Quality control of water supplied by ANDA

The quality of supplied water is another topic of great importance for potable water consumption on the national level and from the perspective of urban waters, especially in SSMA. ANDA has a recognized Water Quality Control Laboratory which is accredited by the Salvadoran Accreditation Office (OSA) and by the international standard ISO/IEC 17025:2005, making it the national referral center for wastewater analysis for the US/EPA. Some of the characteristics regarding the laboratory's compliance with Obligatory Salvadoran Norms (NSO) are the following (Water Quality Laboratory, ANDA-2014):

- Complies 100% on the national level with respect to minimum, normal and complete samples required by the NSO for evaluating water quality; as well as monitoring according to frequency, number of samples and parameters which are the sanitary requirements established by the NSO for potable water.
- Regarding the number of parameters per type of analysis, the laboratory complies with 100% of the parameters that establish minimum samples. However, only 65% of the parameters that stipulate normal samples are currently met (15 of the 23 parameters required by the NSO). The laboratory's short-term goal is to obtain 100% compliance.
- Regarding the parameters which stipulate complete samples, only 66% of them are met (23 of the 35 parameters required by the NSO). The laboratory's short-term goal is to obtain 100% compliance.
- The gamut of parameters not currently carried out by the laboratory correspond principally to the category of heavy metals (Barium Ba, Cadmium Cd, Chrome Cr, Mercury Hg, Antimony Sb, Selenium Se, Boron B and Nitrites NO2) which have great importance in terms of health, according to NSO criteria. However, efforts are currently underway for the acquisition of an ICP/MS and for updating the informatics software for the chromatography equipment and mass spectrometer for analyzing pesticides. At the same time the laboratory intends to increase its scope in analytical determination of organochlorine, organophosphate and heavy metal pesticides.

According to institutional reports, the establishment of the institutions own laboratory has allowed it better control and monitoring of the quality of the water consumed by the public, with an investment of between US$ 360 thousand and US$ 400 thousand per year, compared to subcontracting a private laboratory which would mean an outlay of funds on the order of US$ 1.6 million.

4. Urban Water Treatment

4.1 Sanitation and wastewater treatment coverage in cities and on the national level

Sanitation services in the country have been characterized as presenting a marked difference between rural and urban coverage, as the urban coverage for black water disposal via a system of sewers reaches 59%; while rural coverage is barely 0.64%; the principal method for disposing of and treating human waste in rural areas being septic tanks (13.1%) and latrines (76.9%), as shown in Table 10.

Although the cities enjoy greater coverage of waste disposal through the sewage system, a sizeable portion of the population disposes of and treats human waste through toilets and septic tanks (13%) and latrines (27%), principally in the peri-urban areas with limited economic resources.

According to the evaluation and analysis of experiences in marginal and peripheral zones, such as those reported in the Home and Multi-Purpose Survey (EHPM-2010), scarcely 24% of the one-family systems for disposing of grey water function adequately with the help of absorption pits, as the great majority have no pits, and in many cases,

Table 10. Sanitation conditions on the national level

Description	Rural		Urban		Country	
	Families	Percentage	Families	Percentage	Families	Percentage
Water Services						
Toilet connected to sewage system	3255	0.6%	610983	59.0%	614238	38.6%
Toilet connected to septic tank	72268	13.1%	137810	13.0%	210078	13.2%
Latrine	425188	76.9%	284553	27.0%	709741	44.6%
None	52165	9.4%	6411	1.0%	58576	3.7%
Total	552876	100.0%	1039757	100.0%	1592633	100.0%
Others	2324	0.42%	1864	0.18%	4188	0.3%
Total	**552876**	**100.00%**	**1039757**	**100.00%**	**1592633**	**100.0%**

Source: Author, based on EHPM-2011

Table 11. Sanitation coverage through a system of wastewater treatment plants with a sewer system. Public and private-municipal administration

Description	Public administration (ANDA) (with sewage system)	Municipal administration private (with sewage system)	Total
Number of treatment plants	20	69	89
Served population with treatment of waste waters (inhabitants)	124,481	349,551	474,032
Percentage of Served population (%)	26%	74%	100%
Anual production of waste waters in sewage system (millions of m^3/year)	111.12	73.82	184.94
Flow rate of waste waters treated in sewage system (millions of m^3/year)	9.46	16.40	25.86
Waste waters with treatment in sewage system (%)	8.52%	22.23%	13.98%

Source: FOCARD-APS 2013

crude wastewater is thrown into the streets without any form of treatment; the system in its entirety functions in a deficient manner such that it doesn't comply with required standards for the removal of the components of wastewater, contributing greatly to the contamination of subterranean and surface waters, soils and foods, principally through the generation of pathogenic microorganisms and the consequential effects on public health.

Within the SSMA, there is no integrated system for the city's wastewater treatment. Instead, treatment is carried out by some treatment plants in residential complexes and other similar private systems, which are not capable of properly treating all of the city's wastewater, as many of them function with a low degree of efficiency. According to the study carried out by the Center for Consumer Defense (Quiñonez, J. CDC-2014), the evaluation done by international organizations such as the World Bank, for 2007, assigned the country a low level of wastewater treatment, on the order of 3%. The study sustains that in regard to investments in this sector, there is currently no clearly established allocation of funding for this purpose, as it is funded in a general manner, directed toward the potable water and sanitation sector. According to the FOCARD-APS 2013 report, cited in the study, combined investment for 2011 between ANDA and FISDL was US$ 56.3 million, with 30% of this amount destined for sanitation. In the same vein, the FOCARD report assets: "This situation is the result of abandonment of this sector for at least the last 25 years in terms of planning and development, delay in tending to reforms in the sector's norms and institutions and the absence of political will to face the administrative challenges. In this sense, the country currently lacks adequate institutionalism to face the challenges inherent in the integrated management of water resources".

Table 12. Sanitation coverage through a system of septic tanks and tanks without a sewer system. Community-Municipal Administration

Description	Comunity-Municipal Administration		Total
	Urban	Rural	
Population (Inhabitants)	3,871,332	2,342,398	6,213,730
Disposal and some degree of treatment with Septic Tank (inhabitants)	124,481	349,551	474,032
Percentage (%)	13	13	
Disposal and some degree of treatment with latrines(inhabitants)	1,045,260	1,801,304	2,846,564
Percentage (%)	27	77	
Total	1,548,533	2,108,158	3,656,691
Percentage	40	90	59

Source: FOCARD-APS 2013

According to FOCARD-2013, there are currently 89 treatment plants in the entire country, 20 of which are administered by ANDA and 69 are administered by municipal and private operators. According to the study and information supplied by ANDA, the volume of wastewater produced in the sewage system is 111.1 million m^3 per year, equivalent to a flow rate of 3.52 m^3 per second, 9.46 million m^3 of which receive treatment each year, equivalent to 0.30 m^3 per second. This means that only 8.52% of wastewater in the sewer system receives some form of treatment prior to being discharged into disposal sites.

According to calculations made by FOCARD-APS 2013, the wastewater systems administrated by municipalities and some residential complexes produce an estimated volume of 73.82 million m^3 per year of which 16.4 million m^3 (22.23%) per year receive treatment prior to being deposited into a receptive body of water. Nevertheless, there is no systematic follow-up by a competent entity of the system's functioning and efficiency, therefore it is unknown if the treated waste falls within established norms and ranges. Table 11 presents the data on sanitation coverage with sewer systems on the national level.

Table 12 presents sanitation coverage through the use of septic tanks and latrines on the national level.

4.2 Evaluation of the institutional approach and the legal framework for disposing of wastewater in the country

The country currently lacks a general law regarding water through which a leading authority could be established to regulate and control the situation of wastewater, and to create an overall plan for purification, and promote a sustainable development approach in line with the framework for adequate protection of resources and hydrographic basins. The draft bill is currently in discussion in the Legislative Assembly.

Historically, various State entities have intervened in this area according to their particular and sectoral competencies, in diverse fields of action regarding control of wastewater, water quality, and sanitation, agro-production and environmental approaches. For ANDA, the primary focus is the protection and control of water quality of waters obtained from surface and subterranean sources, as well as the water present in the transportation, distribution and consumption lines. For the Ministry of Health, importance lies in control and surveillance from a health perspective, in the eradication of vectors, water borne diseases and promoting adequate sanitary practices, principally in rural areas through single family supply systems. For MARN, the emphasis is on regulation and monitoring of wastewater, control of contamination and the environmental protection of disposal sites receiving the waste. Finally, for the Ministry of Agriculture (MAG), their work emphasis is on verifying water quality for agricultural irrigation.

In light of the above, in many instances the State entities have not worked in an inter-institutional format, jointly coordinated and united, but rather in a disperse manner without taking on the responsibility of the problem of contamination and water quality with a comprehensive approach.

It has been only been within the last few years that efforts have been made to develop a coordinated approach and inter-institutional actions that are more systematic and integrated; agreements have been reached through which information is shared, methodology mechanisms have been established jointly and the water problem is seen in all its entirety as something that affects diverse sectors of national life.

However, in spite of all this effort, the existing legal framework for the control and disposal of wastewater presents serious deficiencies in terms of facilitating real protection and integrated management of water resources from a health, ecosystem and sustainable development perspective as in many instances the regulated parameters present permissible ranges, differing greatly from international standards and references.

One example of this is the significant modification that was made in establishing the ANDA-2005 Technical Norm for permissible values discharged into the public sewer system compared to Decree No. 50 of October 1987, which established permissible ranges far lower for this same purpose, i.e., the ANDA-2005 Technical Norm substantially raised the permissible limits of contaminant concentrations which could be introduced into city sewer systems.

This situation must have had a significant impact the treatment system capacity since they were designed for certain flow rates and certain concentrations; and the new ANDA-2005 Technical Norm permitted a substantial increase in these without ordering at the same time, through one of its articles, the rehabilitation or transformation of the treatment systems to the new conditions of non-ordinary effluents.

Table 13 presents a comparison between the modified ranges of the ANDA-2005 norm and the ranges established in Decree No. 50, art. 81, 1987.

At the same time, a similar situation is present in the values defined in the Salvadoran Obligatory Standards (NSO), which establishes permissible intervals for dumping wastewater into the disposal sites, from different industrial sectors, and the guideline values established by the EPA. Table 14 presents some of the comparative parameters.

The Salvadoran Obligatory Standards (NSO) on "Wastewater discharged into a receiving body" NSO 13.49.01.09 was adopted based on executive agreement in March 2009 between the Economic Ministry, business entities and academics. These standards established the value limits of wastewater from industrial use introduced into disposal sites (ravines and rivers), which supersede considerably the permissible values for domestic black water (60 mg/L). In addition, the limits established for one parameter were different depending on the industrial sector from which it came. For example, limits for DBO6 varied between 200 mg/L and 3,000 mg/L; for diary product factories (600 mg/L, distillation of alcoholic beverages (3,000 mg/L), soap manufacturing (300 mg/L) or the textile industry (200 mg/L).

The Salvadoran standards, far from regulating the control and reduction of sources of contamination and promoting the preservation of the wastewater disposal sites and ecosystems, have the opposite effect by officially and legally permitting the dumping of high concentrations of contaminants from industrial use, far removed from the objectives of sanitation and international requirements, guidelines and norms. These contaminants cannot be self-purified by natural currents and by the disposal sites themselves.

It is important to remember that the guidelines promoted by the World Bank for the disposal of industrial waste into surface water and natural drainage systems establish as a fundamental guideline the preservation of the environmental quality of water in the disposal site and establish a legal framework with parameter limits based on Environmental Protection Agency (EPA) and World Health Organization (WHO) guidelines.

According to the CDC study mentioned earlier, "The criteria for preserving good environmental water quality is clearly defined in the water quality recommendations established by the EPA, 'US-EPA National Recommended Water Quality Criteria.' Based on these recommendations, the multi-lateral agency World Bank (WB) created a document on guidelines directed at industry to emphasize preservation of health, the environment and safety, 'Industry Sector Environmental Health and Safety Guidelines (EHS)', in which it is established that all industrial processes must prioritize the incorporation and implementation of internal and *a priori* processes to avoid, minimize and control

Table 13. Maximum permissible values for the disposal of wastewater in the public sewer system

Parameter	Units	Máximum permitted value, norm of anda (2005)	Decrete no. 50 (1987)
Oil and Fats	mg/l	150	20
Aluminum (Al)	mg/l	10	
Arsenic (As)	mg/l	1.0	0.05
Boron (B)	mg/l	3	
Cadmium (Cd)	mg/l	1	
Total Cyanide	mg/l	1	0.10
Zinc (Zn)	mg/l	5	5
Cobalt (Co)	mg/l	0.5	
Copper (Cu)	mg/l	3	0.20
Color	mg/l	Not different to domestic discharge	
Phenolic compounds	mg/l	5	0.005
Hexavalent Chrome (Cr+6)	mg/l	0.5	0.05
Total Chrome (Cr)	mg/l	3	
Biological Oxygen Demand 5	mg/l	400	
Detergents (SAAM)	mg/l	35	
Chemical Oxygen Demand	mg/l	1000	
Fluor (F)	mg/l	6	3
Total Phosphorus Total (P)	mg/l	45	
Total Herbicides	mg/l	0.1	
Hydrocarbons	mg/l	20	
Total Iron (Fe)	mg/l	20	
Total Manganese	mg/l	4	
Floating Materials	mg/l	absent	
Mercury (Hg)	mg/l	0.02	
Molybdenum (Mo)	mg/l	4	
Nickel (Ni)	mg/l	4	0.80
Total Nitrogen (N)	mg/l	100	
Organic Chloride Pesticides	mg/l	0.05	
Organophosphorus Pesticides and Carbamates	mg/l	0.25	
pH	unid	5.5-9.0	5.5 - 9.0
Silver	mg/l	3	
Lead (Pb)	mg/l	1.0	
Selenium (Se)	mg/l	0.15	
Sedimentable Solids	mg/l	20	
Total Suspended Solids	mg/l	450	
Sulfates (SO4)2	mg/l	2000	
Radioactive Substances	-	absent	
Temperature (°C)	°C	20-35	T°< 35
Vanadium (V)	mg/l	5	

Source: CDC Study, Calculations based on technical standards

Table 14. Comparison of permissible value limits for components of wastewater disposed into disposal sites, between the Salvadoran standards (NSO) and the guideline values indicated by the EPA

Contaminants	Unit	Limit of Concentration Norm of El Salvador NSO.13.49.01:09	Limit of Concentration Guide BM-EHS/EPA from industrial use
Biological Oxygen Demand	mg/l	200 – 3000	30
Chemical Oxygen Demand	mg/l	400 – 3500	125
Total Suspended Solids (TSS)	mg/l	150 – 1000	45
Total Nitrogen	mg/l	50	10
Total Phosphorus	mg/l	15	2
Fats	mg/l	30 - 200	10
pH	Uni.	5.5 – 9.0	6 – 9
Total of Coliform Bacteria	NMP/100 ml	10,000	400
°T	°C		37
Color			Not acceptable a distinct color on visual observation
Mercury (Hg)	mg/l	0.01	0.01 – 0.015
Cadmium (Cd)	mg/l	0.1	0.01 – 0.015
Lead (Pb)	mg/l	0.4	0.1 – 0.15
Arsenic (As)	mg/l	0.1	0.010 - 0.015
Cyanides (Cd)	mg/l	0.5	0.20 - 0.30
Copper (Cu)	mg/l	1	0.25 - 0.375
Nickel (Ni)	mg/l	0.2	0.20 - 0.30
Chromium (Cr)	mg/l	1	0.10 - 0.15
Zinc (Zn)	mg/l	5	1.0 - 1.5
Antimony (Sb)		---	Not required for most resources
Cobalt (Co)		0.05	0.03 (Not required for most resources)

Source: CDC Study, Calculations based on Salvadoran standards NSO 13490109 and Guideline Values from "Industry Sector Environmental Health and Safety Guidelines (EHS)" promoted by the World Bank based on "US-EPA National Recommended Water Quality Criteria".

adverse impacts on public health, the environment and the comprehensive security of the population."

A fundamental aspect within the guidelines which stands out is the importance of having knowledge of and a characterization of the waste disposal site in terms of its ability to assimilate the waste and to self-purify, taking into account the seasons of the year, given that the dilution capacity is much greater during the rainy season than in the dry season, and therefore a "seasonal baseline" must be established. Having established the baseline, it is possible to determine and construct a matrix of users and the feasibility of establishing maximum concentrations; volumes to be discharged; frequencies; and the proper moment and locations at which to discharge.

As the CDC document states, "One of the weaknesses of El Salvador's regulatory standards and guidelines is precisely this point. Within the country, a pattern of permissible ranges and limits for wastewater disposal have been established without deep hydrologic knowledge of the discharge site and of the quantitative and qualitative characteristics associated with the rainy and dry seasons and of its true capacities for self-purification. Thus a practice of discharging "treated waste" is exercised with authorization but without truly contributing to the sanitation objective, environmental hydrologic preservation of the disposal site and of it natural surroundings.

From this perspective, a national strategic initiative is still pending; one that will begin to reverse the current degradation process and incorporate sanitation and decontamination of the discharge sites as a fundamental action that must be adopted inter-institutionally and in frank dialogue with the country's social, economic and political actors. This requires effort on the part of institutions, aimed at developing investigative, technological and administrative capacities, as well as financial administration, to allow for not only the realization of important programs and focused actions but to develop and implement in stages a national sanitation system, framed within an appropriate administrative model and in the planning and creation of public policies.

4.3. Evaluation of recycled waters

Recently, efforts were made in the direction of recycled waters through the Social Investment and Local Development Fund (FISDL) in coordination with the Spanish organization *Alianza por el Agua* (Alliance for Water – AxA), which is cooperating in strengthening cooperative links and relationships between the institution and CENTA of Spain. This effort has led to training courses for local technicians and improving manuals and instructions for promoting a new sanitation agenda principally in peri-urban and rural zones. The focus is primarily on launching extensive treatment systems which will provide the opportunity to apply appropriate and low-cost technologies through combined preliminary treatment systems, separation of solids, filtration, horizontal and vertical bio-filters, and treatment ponds. These methods will allow the treated fluids to be re-used on crops and areas planted in forests and fruit trees, as well as in garden maintenance and other landscape environments. Among the requirements for the application of these recycled waters are the preference for a convenient geography that would permit the use of gravity-fed systems to avoid pumping costs; enough space; and appropriate zones for receiving the treated water.

4.4 Per capita spending on the treatment systems within the national sanitation strategy

The investments required for implementing the national sanitation strategy have already been estimated within the FOCARD-APS 2013 framework, which established the total amounts and the costs per capita for the type of treatment system to be implemented, as shown in Table 15.

5. Urban Water and Health

Public health status is directly linked to the availability and quality of water in both rural and urban areas. In general, during the rainy season the country reports an increase in dengue fever, hemorrhagic dengue fever and other illnesses including gastrointestinal, associated with undisturbed, standing water, puddles which facilitate the growth of mosquito larvae (Aedes aegypti), and contamination of water supply, which has a direct effect on food safety. However, according to Ministry of Health (MINSAL) data, this problem exists even during the dry season. Although the coverage of potable water in urban areas via household plumbing is high, only 66.5%

Table 15. Necessary investment in sanitation according to the target population and type of system to be implemented

Description	Population (Inhabitants)	Amount per capita (US$/inhabitant)	Total Amount (Million US$)
Urban Population without sewage system	27,050	325.00	8.79
Rural Population without improved sanitation	243,295	150.00	36.49
Urban Population without treatment of waste waters	2,378,735	275.00	654.15
Improved individual systems	3,090,702	30.00	92.72
Total Amount			**792.16**

Source: FOCARD-APS 2013

of those with plumbing enjoy a continuous supply of water (a condition that is defined as having domestic water supplied for seven days per week for at least four hours daily), while only 34.6% of homes in rural areas have continuous water coverage. This situation forces households to store water in recipients and in laundry sinks, resulting in health risks as evidenced by MINSAL records which reveal that 83% of water stored in recipients inside homes during the dry season test positive for the dengue mosquito vector.

The absence of enhanced black water services, the existence of wastewater without prior treatment and the less than adequate treatment of black water prior to final disposal into natural drainage systems or through infiltration mechanisms are other variables that directly impact public health. Although improved service coverage is high in urban areas, families lacking these services are the most affected and vulnerable, and also those who repeatedly present with infectious illnesses associated with oral-fecal disease transmission such as diarrhea, including intestinal parasites, typhoid fever, paratyphoid fever and salmonellosis, with 303,393 cases reported and attended within the hospital system in 2012. Through sampling and laboratory analysis, these infections can be determined to be in large part due to risk factors related to contaminated water in artisanal wells and sources of surface water which are reported to contain coliform bacteria including fecal coliforms, parasites, virus, E. coli and others. Among them, 615 cases of rotavirus, which affects primarily children under four years of age, were reported in that same year.

In Table 16, the top ten most frequently attended illnesses during ambulatory consultations within the MINSAL health services network are shown. “Other Causes” refers to external injuries (accidents, falls, injuries), neonatal, child and maternal care, and other illnesses. Diarrheal illnesses, although appearing as a low percentage of the total ambulatory consultations, require other related consultations for laboratory and other exam services, which increase health care services for infectious illnesses related to water and health. In terms of hospital services, MINSAL has established that in regard to these top ten causes, 44.3% of the hospital care and expenses are due to infectious-contagious illnesses, among them diarrheal and gastrointestinal illnesses as well as urinary infections and pneumonia. Another 13.8% consist of chronic-degenerative diseases, principally chronic renal insufficiency.

It is important to note that water contamination, both surface and subterranean, stemming from industrial and agricultural practices, has acquired great relevance in recent years and is material for discussion and attention by health and environmental authorities, due to the notorious increase in some areas of the country of chronic renal disease (CRD), associated with the use of pesticides and water contaminated by chemicals and metals, which have as their principal causes the intensive

Table 16. Most frequent causes of ambulatory consultations in MINSAL health services network

Nr in order	Diagnosis	Total
1	Other acute infections in upper respiratory tract	1,525,620
2	Hypertension (Primary)	710,779
3	Acute Pharyngitis and acute Tonsillitis	699,125
4	Other diseases in urinary tract	530,477
5	Persons in contact with health attention services for research and examination	481,498
6	Diabetes mellitus	360,785
7	Diarrhea of probable infectious origin	302,393
8	Other symptoms, signs and findings of abnormal clinic and laboratory, not classified	293,704
9	Other injuries of specific regions, in nonspecific regions, and in multiple areas of the body	287,378
10	Other diseases of the skin and subcutaneous tissues	282,221
	Other causes	5,288,705
	Total	**10,762,685**

Source: MINSAL 2013 annual report

fumigations of the old cotton haciendas and to some degree in the current cane sugar plantations, as the phreatic levels of local aquifers have very low depth, oscillating between 4 m and 12 m, which makes them very susceptible to contamination.

In 2007, health consultations for CRD totaled 16,464, with 505 deaths reported, while consultations and deaths have gradually increased in recent years, reaching 32,366 in 2012 with 809 deaths. Within the departments most affected, the mortality rate for this illness per 100,000 inhabitants is 28.8 and 25.6

Although many of the outbreaks with numbers that have soared have not occurred specifically in urban areas, they are still an important factor for the urban area as the high levels of contamination of surface water produced in the SSMA generates direct impacts all along wastewater's journey to the sea; all along the trajectory there are diverse uses associated with risk such as fishing, recreational use, retention in hydroelectric dams, among others, until the waters finally reach the lower Rio Lempa delta area on the coastal plain, whose wide expanses are repeatedly flooded, affecting artisanal wells, community gardens, domestic animals on family farms, local aquifers and other agricultural uses.

Deaths from all causes reported in 2012 in MINSAL's hospital network totaled 10,024, a reduction of 116 from the previous year. The overall mortality rate for 2012 was 160.4 per 100 thousand inhabitants.

Although MINSAL does not explicitly report investments and spending in regard to the principal causes of ambulatory and hospital care, it is clear that according to the data previously presented, the costs to the country of medical care for illnesses related to water and sanitation are quite significant and could be estimated at 10% - 15% of the total annual budget of US$ 625 million, considering the high percentage of infectious-contagious, urinary and gastrointestinal illnesses, along with chronic renal disease and those requiring the necessary additional exams and laboratory analyses.

The central government's annual budget and financing from diverse MINSAL sources is presented in Table 17. A tendency toward increase in the annual budget can be seen; the annual budget in 2008 was 1.9% of GDP while in 2012 it 2.4% of GDP.

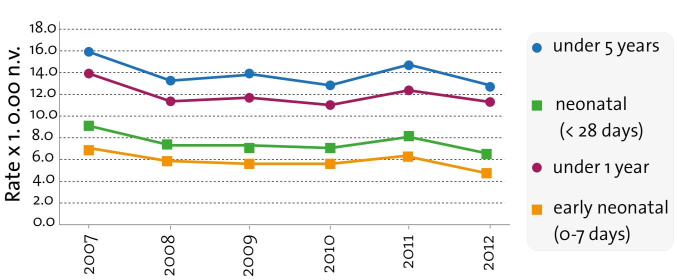
The mortality rate for children under five years and newborns has decreased markedly in the last few years. In 2007, the mortality rate for children under five years was 15.8 per 1,000 live births. In 2012, the rate was 12.5, as shown in Figure 19.

This important decrease in the mortality rate of newborns, infants and children under five years, registered within the last few years, is due in large part to the implementation of a health model that prioritizes Integral Health Primary Care (APSI), which offers extended prenatal sign-up programs to improve maternal-child care, controls and education, which have greatly benefitted and contributed to a reduction in the principal causes of infant death, including perinatal asphyxia, neonatal sepsis and premature birth.

These programs have contributed significantly to reducing maternal death, with 64 cases of death reported in 2011 and 53 cases reported in 2012. MINSAL reports that they have reached the Millennium Development Goal 5 for 2015 which consists of reducing maternal death by two-thirds, equivalent to a rate of 52.8 per 100 thousand live births (LB), in relation to the 1990 rate of 211 per 100 thousand LB. The rate for 2012 was reported as 42 per 100 thousand LB.

From this perspective, it is important to note that the country's principal challenges, including not only: efforts to increase health services in terms of ambulatory and hospital care; increase professional human resources and infrastructure, treatments and medications based on State budgetary allocations; but also generating conditions for promoting a social and economic development model, with equality and hydro-environmental sustainability facilitating conditions for elevating and improving the living conditions of the population in terms of decent

Figure 19. Fluctuations in Child mortality rate



Source: MINSAL 2013 annual report

housing with basic services, protection of ecosystems and population livelihoods; environmental decontamination; integral administration of hydrographic basins for the maintenance of water quantity and quality; promotion of healthy life habits and cultural guidelines that promote less consumer dominated social practices, among others, are all intimately linked to the top ten causes for requiring health services such that an economic-social turnaround in this direction can contribute to regulating and greatly reducing the social burden placed year after year upon the health system, and offering more efficient services with the possibility of strengthening other strategic areas in the development of preventative health services, diagnostics, treatments and cures.

6. Variability and Climate Change - Their Impact on Urban Water Resources

Climate variability and change, and associated impacts on the urban water dynamic have been felt with greater intensity during the last few decades, evidenced by an increase in the frequency of extreme hydro-meteorological events, an increase in the intensity of the rains (mm/min) and their periods of return, a decrease in average precipitation and an increase in temperature in some sectors of the country, an increase in consecutive days without rain during the wet season and a reduction in consecutive days with rain, principally. All these aspects have been studied in previous years from the perspective of climate variability by the National Territorial Studies Service (SNET), known today as the MARN Environmental Observatory, and from the perspective of climate change by different studies carried out collaboratively between national and international entities, through climate projections of temperature and rain variability under different scenarios of emissions and through downscale modeling using results obtained from global circulation models.

Based on interdecadal analysis, the National Hydrological Service of SNET analyzed rain and temperature activity in 2005 in a series of meteorological sub-stations nationwide. Temperature results from ten stations with data spanning more than forty years indicated a generalized tendency for increasing temperatures beginning in the mid 1970s with intervals that varied between 0.4°C a 2.2 °C. Figures 20 and 21 show the tendency toward increasing temperatures in two meteorological stations located in different altitudes in the west of the country in the department of Santa Ana as well as a record of more than forty years.

Table 17. Variation in the annual budget in recent years and sources of funding

Total Budget per Financial Source	2007	2008	2009	2010	2011	2012	2013p
In Millions $US							
Government of El Salvador	307.1	329.4	328.4	384.4	488.3	483.8	555.4
External loans	41.4	40.2	105.1	76.2	38.5	45.3	42.3
Donations	6.7	13.2	8.2	12.8	13.3	15.1	12.6
Own resources	14.8	14.8	15.5	11.3	11.5	14.6	12.6
FAE	1.4	1.7	1.7	1.7	2.3	2.3	2.6
Total Budget	371.4	399.3	458.9	486.4	553.9	561.1	625.5
Rate of Annual Growth	**0.8%**	**7.5%**	**14.9%**	**6.0%**	**13.9%**	**1.3%**	**11.5%**
In Percentage							
Government of El Salvador	83%	82%	72%	79%	88%	86%	89%
External loans	11%	10%	23%	16%	7%	8%	7%
Donations	2%	3%	2%	3%	2%	3%	2%
Own resources	4%	4%	3%	2%	2%	3%	2%
FAE	0%	0%	0%	0%	0%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Source: MINSAL 2013 annual report

Figure 20. Santana El Palma A-2, 725 msnm

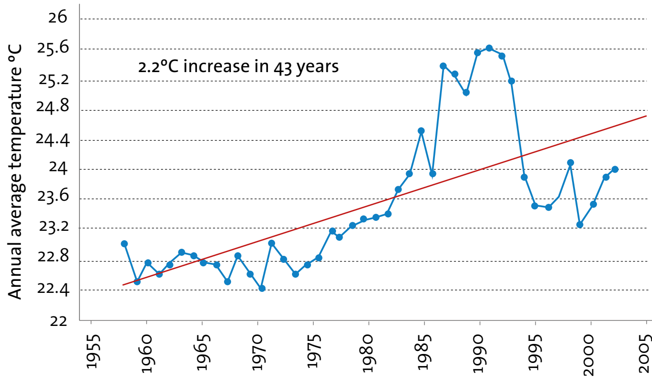


Figure 21. Estación Guija A-15. 485 msnm

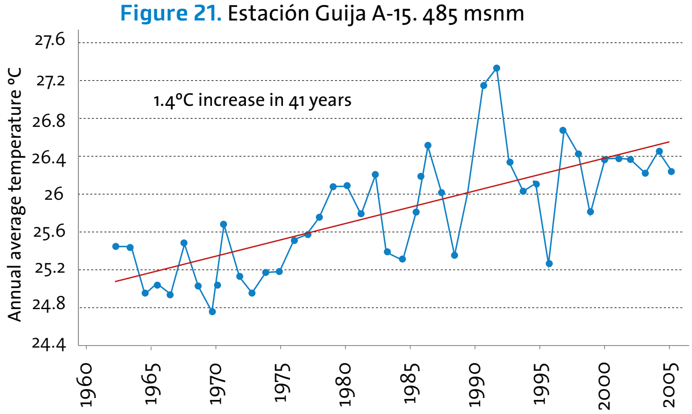
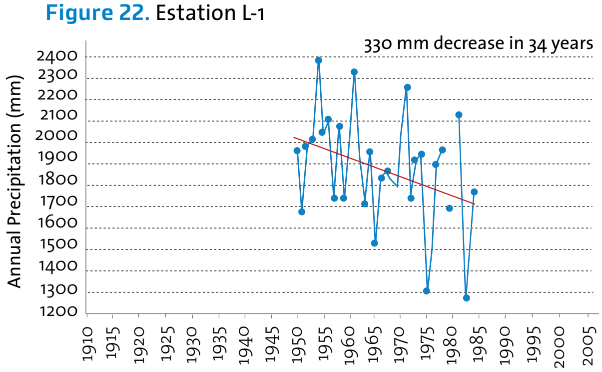


Figure 22. Estation L-1



In terms of rain, an analysis of seventeen stations nationwide was carried out for the period between the decade of the 1950s and the year 2005, in which a considerable reduction in rain was established, principally in some stations in the east of the country, a zone which is being affected yearly by droughts and an increase in consecutive days without rain during the wet season. The analysis determined that approximately 70% of stations analyzed experienced a decrease in rain and 30% experienced an increase in rain. The station reporting the severest reduction was in the department of *La Unión*, with a reduction of 800 mm in 78 years of recorded data, dropping from 2100 mm to 1300 mm on average.

This profound reduction in the amount of rain has caused great concern and occasioned greater attention, with continued analysis and validation of the data, principally of records from the first half of the last century. Figures 22 and 23 present the behavioral tendencies previously mentioned, reflected in the records of two stations.

From the perspective of climate change, one of the first studies of great importance for the country was carried out in 1998 by Abel Centella, an investigator with the Cuban National Climate Center, with support from the University of El Salvador and the Ministry of Agriculture and Livestock (MAG). The study consisted of elaborating climate scenarios (Centella, 1998) constructed from global circulation models outputs (GCM) and through the application of the MAGICC model which is the climatic model that reproduces concentrations of greenhouse gases, temperature and sea level between 1990 and 2100, and the SCENGEN model which contains a database and results of 14 GCM for temperature and sea level and produces scenarios for climate change on the regional level using different suppositions or scenarios for greenhouse gases and their future projections (2020, 2050 and 2100) for warming, combining and reproducing the results of GCM and MAGICC.

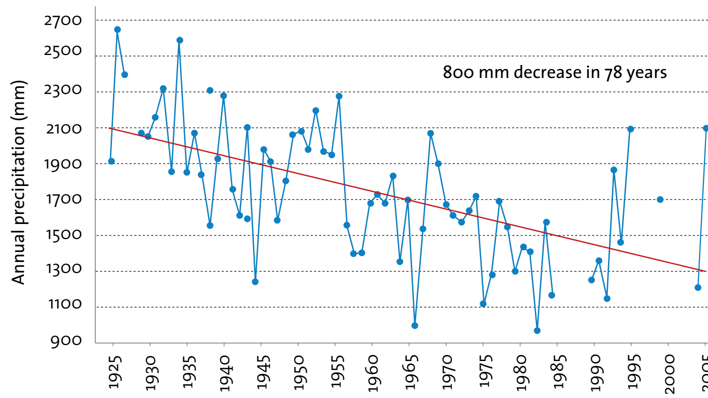
The results of the study, taking into consideration a climatic referential baseline of thirty years (between 1961 and 1990), indicate an increase in temperature between 0.8° C y 1.1 °C for the year 2020, and up to between 2.5°C a 3.7°C for the year 2100. Regarding precipitation, the results indicate intervals of reduced rain from -11.3% to increases of 3.5% in 2020 and reduction from -36.6% to increases of 11.1% in 2100.

Later, in 2006, a new study was carried out on the Central American region coordinated by the "University of Costa Rica (2006)", in which the same techniques and analytical models of the 1998 El Salvador study were utilized, with the difference being an updated application of parameters and algorithms. According to the analysis of regional climatology, the Central American isthmus is divided into a northern zone and a southern zone, each divided by the 10N parallel. In the case of the northern zone, where El Salvador is located on the Pacific slope, the study determined once again an increase in temperature and a decrease in precipitation, which will be intensified during some months of the year due to the El Niño phenomenon and a greater intensity of water use. The results obtained for the emissions scenario, one under B1 and another medium-high A2, indicate an increase in temperature from between 0.8°C - 0.9°C for 2030 and between 2.7°- 3.3°C for 2100. In terms of rain, the results established a decrease from between -2.8% and -4.9% for 2030 and between -11.5% and -20.1% for 2100, principally in the months of May and September, this last month being characterized as the month with the highest annual rain amounts; this study didn't report possibly projections of an increase in precipitation as was indicated in the results of the 1998 study.

In 2008, a new study was carried about by the University of Santa Clara in California (E.P.Maurer 2008) for the purpose of analyzing the impacts of climate change on hydro-electric energy generation capacity by the country's principal dam, the result from this study going in the same direction as results from the previous studies. Establishing the same baseline as a climatic reference point (1961-1990) for the hydrographic basin of the *Río Lempa*, and for the two emissions scenarios (B1 and A2), the results indicated increases in temperature from between 1.9 °C to 3.4 °C for the second half of the 21st century, as well as a decrease in average precipitation on the order of from 5% to 10.4% for the two emissions scenarios and for the same projected period. In addition, results show a reduction in the water flow rates into dams and reservoirs principally during the rainy months of June through September on the order of from 13% to 24% and a decrease in water accumulation capacity in hydro-electric dams on the order of from 33% to 53%, as a result of an increase in the frequency of years with reduced flows and increased evapotranspiration.

In 2010, CEPAL published a study called "*The Economy of Climate Change in Central America*" that ratified the same tendency shown in the previous studies in terms of a reduction in rain amounts and an increase in temperature in El Salvador, expressing as well a greater tendency toward more intense water use by 12.01% in relation to other countries in the Central American isthmus. According to the A2 higher emissions scenario, we might expect an increase of between 0.77°C y 2.03°C for the first half of this century and between 2.9°C y 4.73°C for the second half. In terms of precipitation, we might expect a decrease of between -2.67% a -15.23% for the first half of this century and a reduction of between -15.73% and -31.67% for the second half. The same CEPAL study results show a reduction in net water availability nationwide (precipitation minus losses from evapotranspiration) of -44% for 2050 and of -82% for 2100, as well as a reduction for that same year of 93% of water availability per capita (estimated on the order of 3,200 m^3 per inhabitant per year, according to MARN calculations) which represents the lowest level in Central America.

Figure 23. Cutucu station N-2, 5 msnm



In addition to the analysis of impacts generated by an increase in temperature and a decrease in average rainfall, the projections of the different studies of impacts from climate change reflect a notable increase in rain intensity (mm/min) and an increase in their recurrence, as well as the presence of tropical storms or meteorological events that bring great quantities of rain in short periods of time, as demonstrated in the events of the last few years indicated in this chapter's introduction. The models and analyses project a greater probability of events bringing various consecutive dry days and a lesser duration of periods with various consecutive days with rain greater than 10 mm.

Taking into consideration this situation of high susceptibility to impacts from climate change, in April of 2013 the MARN launched the National Climate Change Strategy (ENCC) which is oriented toward the implementation of priorities of adaptation that converge with key sectoral plans and initiatives of other State economic and social portfolios, such as agriculture and water basin management, transportation infrastructure, hydro-electric energy generation and energy efficiency, land administration, sanitation focused on the control and management of domestic and industrial waste, as well as the promotion of public health, investments in the coastal zone and the restoration of ecosystems and rural landscapes, which are directly interrelated with agro-forestry programs and hydrographic basin management, with the implementation of REDD+ mechanisms for forestry amplification and management as a component of mitigation procedures.

From this perspective, some of the prioritized actions intended as adaptation measures on the national level are oriented, in the agricultural sector, toward the development of diversified family agricultural programs through the implementation of household vegetable gardens, water reservoirs for local irrigation, efficient irrigation systems and soil conservation works, among others. This program has been promoted by MAG for several years with an emphasis on promoting food security and benefiting broad sectors of families with limited resources in rural zones; a short and medium term evaluation and monitoring of results in relation to the reference baseline is pending, for analysis within the focus of climate change adaptation.

In the area of transportation infrastructure, the Ministry of Public Works (MOP) plans to intensify works designed for protection in zones at risk for flooding and overflowing of currents, erosion and the formation of gullies, principally in urban zones, as well as large-scale works destined to improve roadway interconnectivity, primarily in the capital (development of the SSMA Integrated Transportation System, SITRAMSS), as a means of generating greater efficiency in mass transit and thus, contribute to a reduction in greenhouse gas emissions in the country, conceived as a means of making a greater contribution to mitigation rather than adaptation. It is estimated that El Salvador produces 0.04% of global emissions.

In terms of low-carbon urban planning and development, adaptation and mitigation guidelines are directed at promoting land planning based on architectural styles that integrate components of ecological value, promoting the construction of tall buildings and promoting the updating of design and construction codes based on this new perspective of climate change adaptation, as well as placing more emphasis on research and the application of compatible and appropriate technologies, the introduction of ecological guidelines and adaptation to climate change into the education programs of different professions, awareness building for the protection of eco-systems and forest areas in the mid elevation zones of aquifer recharging in the hydrographic basins, controlling levels of impermeability, etc.

Another initiative incorporated into the ENCC is the promotion of energy diversification and efficiency, with priorities already included in the work plans of the National Energy Commission, an agency attached to the Ministry of Economics. One of the initiatives that stands out is the introduction of energy saving lighting, low-consumption wood burning turbo stoves and the redesign of great hydro-electric dams such as "*El Cimarrón*" and "*El Chaparral*", which have been given serious attention in the past because of their high impact on zones of great importance for the conservation of water resources and ecosystems. In the case of "*El Cimarrón*", the attention received stems fundamentally from its location in the principal stretch of the *Río Lempa*, which possesses the best quality surface water in the country, as well as being essential for dilution, for maintenance of hydrodynamics and fluvial geomorphology, and principally for a potable water supply for the SSMA, as ANDA's principal water connection is located downstream, mentioned previously and known as "*Las Pavas*". One of the most important technical and administrative variables is that the hydrographic basin, at the location of the dam, is a trans-border basin with approximately 80% of its extension belonging to neighboring countries, with which there are no international agreements regarding guaranteeing quantity and quality of design flows required for hydro-electric power generation, even more so when sizeable reductions in water flow and water availability have been foreseen for the coming decades, as a result of the impacts of climate change established in different studies.

With the launching of the ENCC, work is currently being carried out on the National

Climate Change Plan (PNCC) and the National Adaptation Plan (PAN), both of which will integrate the central predominating issues and priorities, legal framework, institutionalism, work and administrative agenda for financing; being viewed as essential instruments within the framework of the Third National Communication on climate change, to be held this year.

It is important to point out that the challenge as a country is to have plans based upon and corresponding to the information, analysis and results obtained from studies on climate change so that the projected critical situation regarding availability of water resources, the increase in frequency of extreme events (which are capable of generating losses due to floods and drought), impacts on agricultural cycles from greater evapotranspiration and reduction in periods of soil humidity, as well as loss of ecosystems, are aspects which must be tightly linked to strategic adaptation measures so that application mechanisms, actions and measures that contribute collaterally or marginally to adaptation and respond more to economic and sectoral interests are not incorporated, in consideration of the fact that their implementation can be contradictory and questionable in terms of adverse impacts, and a detriment to the same adaptation objectives that they pursue.

Such is the case with the construction of the great hydro-electric dams conceived in an environment of hydro-climatic crisis, along with transportation infrastructure companies that open preferential throughways which favor urban sprawl precisely in zones that must be conserved, as is the case in the forested zone and hydro-retention zone located in the foothills of the *Bálsamo* mountain range, *Santa Tecla* and the southwestern sector of the capital, as indicated in section 2 of "sources of water in urban zones and impacts caused by urbanization", and which are essential for recharging the San Salvador aquifer, and for the natural restriction of the high level runoff during flooding.

It is important to highlight, from the perspective of *Urban Waters* management, the current development of designs being carried out by the Ministry of Public Works of a system of lamination ponds, many of which make use of the topography of natural drainage channels; or hydraulic regulation projects to be implemented in different sectors of SSMA as part of structural solutions for reducing urban risk and vulnerability to impacts of climate change in terms of the occurrence of extreme events of intense rains and of long duration. These hydraulic regulation projects are designed to restrict and regulate water flow and to avoid possible overflows downstream, hence their placement in mid-elevations of the capital. One of the issues that has been raised in terms of their design and placement is that they should be implemented with a eye toward environmental compatibility and integration in the interior of the city to avoid collateral effects that are counterproductive to the ecological services they provide for the principal drainage basins and ravines situated in the intermediate and high elevation zones. These natural drainage channels, historically maintained in their original condition, are characterized by their abundant forest cover which must be preserved as it provides the only biological corridors for the oxygenation of broad urban areas, habitats of different bird species, thermal regulation resulting from the shade, restriction of solar radiation and carbon capture. In general, as mentioned earlier, the best mitigation effort is the protection of the existing forest cover in broad areas in the intermediate and high altitude zones of the capital and the emphasis on non-structural measures from the perspective of sustainable development.

In regard to recycled water, among ANDA priorities there is currently an intensification of measures concerning sanitation, among them the promotion of recycling treated water aimed especially at business and industry. Recycled waters are governed by the legal framework of the special regulations for wastewater, Decree No. 39, 2000, and defined for different uses (urban, agricultural irrigation, recreation, landscaping, and construction sector), before or in substitution of final disposal. The parameters of the quality of recycled waters are established in part by Decree No. 50, 1987, concerning water quality and control of wastewater.

In addition, efforts have been launched between FISDL, MINSAL and Alliance for Water (AxA) to promote more intensely the use of recycled water in peri-urban, community and rural zones, as was indicated in section 4 concerning urban water treatment.

7. Conclusions

The integral management of Urban Waters is a topic which must continually acquire more importance and a central place in the nation's agenda and in public policy; as a result of it prioritization, key aspects will be discovered and focused upon for a coordinated and inter-institutional effort, with interaction with other social and economic sectors, to approach the fundamental problems related to water availability and supply, sanitation, hydro-environmental land planning and preservation, public health promotion and a strategy for authentic adaptation to climate change.

Through an inter-disciplinary and participative analysis and perspective, the strategic guidelines can be conceived and defined for urban planning and the promotion of a new model for hydro-sustainable development, that regulates, controls and orchestrates the logic of the foundationless progress of the preservation of natural assets, as well as the investments and urban and economic projects, with knowledge and understanding of the current conditions caused by the grave hydro-environmental crisis in which the country finds itself, in order to contribute jointly to generating a process that reverses or neutralizes them in the short and medium term.

In that regard, a fundamental aspect in the legislative agenda is the approval of the General Water Law, the draft for which is currently under discussion and analysis in the Legislative Assembly since March of 2012. The General Water Law will offer the country a legal framework to move toward a strategy of hydro-environmental planning, carrying out the actions required within a national policy and under the public-State governing authority.

In parallel with this effort, it is important to promote the National Water Plan (PNH) and the National Climate Change Adaptation Plan (PAN), which must be based on the studies, analyses and results of the diagnostics and studies of the current critical hydro-environmental situation, previous hydro-environmental behavior over the last decades and projections for the future, and in conjunction with those basic aspects, allow the prioritization of hydrographic areas and actions and measures within the legal, political, economic, social, communications, and financial realms, so as to focus efforts on key topics within the administration of water with an eye on the future, with equality, solidarity and participation, covering with determination the Urban Waters dynamic in all its variables, challenges and dimensions, as has been laid out in this chapter on El Salvador.

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9. Acronyms

SSMA: San Salvador Metropolitan Area
ANDA: National Aqueduct and Sewer Administration
CDC: Center for Consumer Defense
DIGESTYC: National Center for Statistics and Census Data
EHPM: Home and Multi-Purpose Survey
ENCC: National Climate Change Strategy
FISDL: Social Investment and Local Development Fund
FOCARD-APS: Central American and Dominican Republic Forum on Potable Water and Sanitation
MAG: Ministry of Agriculture and Livestock
MARN: Ministry of the Environment and Natural Resources
METROPLAN: Metropolitan Planning 1980
MINSAL: Ministry of Health
NSO: Salvadoran Obligatory Standards
OMS: World Health Organization (WHO)
OPAMSS: San Salvador Metropolitan Area Planning Office
PAN: National Adaptation Plan
PLANDARH: Master Plan for the Development and Use of Water Resources - 1982
PLAMADUR: Master Plan for Urban Development 1996
PNCC: National Plan for Climate Change
PRISMA: Salvadoran Environmental Research Plan
SACDEL: Local Development Advice and Training System
SNET: National Territorial Studies Service
UCA: Universidad Centroamericana José Simeón Cañas