Water in the Time of Drought II: Lessons from Droughts around the World

Water and Sanitation Division

Communications Division

Environment, Rural Development and Risk Management Division

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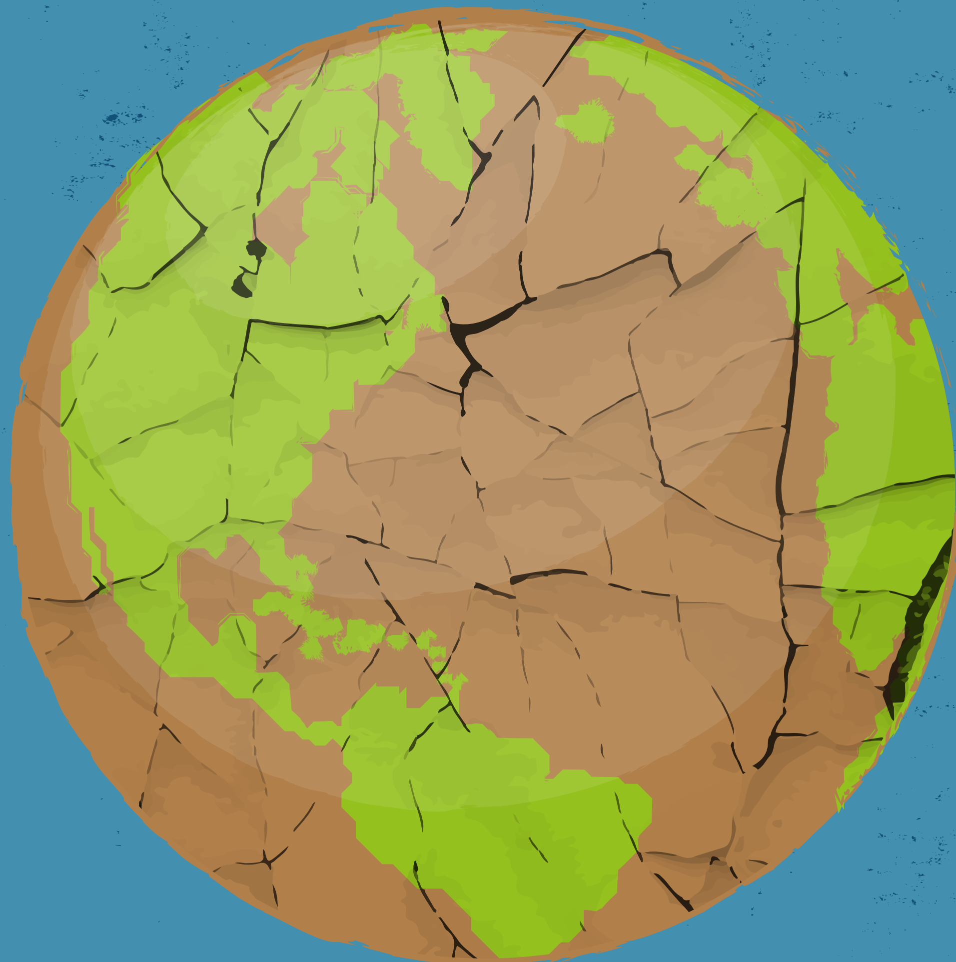

WATER IN THE TIME OF DROUGHT II

Lessons from droughts around the world

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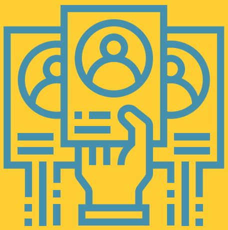
ACRONYMS

ANA	National Water Agency of Brazil
CONAGUA	National Water Commission of Mexico
CNRH	National Council on Water Resources of Brazil
DMP	Drought Management Plan of Spain
DGA	General Water Association of Chile
ENSO	El Niño Southern Oscillation
LPD	Liters per person, per day
MAGA	Ministry of Agriculture, Cattle Raising and Food of Guatemala
MARN	Ministry of Agriculture and Natural Resources of El Salvador
MOP	Ministry of Public Works of Chile
MTE	Ministry for the Ecological Transition of Spain
PES	Special Drought Plans of Spain
PRONACOSE	National Program against Drought of Mexico
RBA	River Basin Authorities of Spain

ECONOMIC IMPACT

of droughts



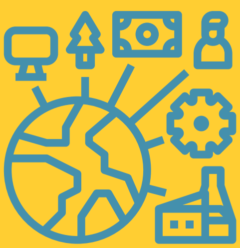
EMPLOYMENT

Drought periods have been proven to **decrease** the general level of employment, the number of hours worked, and labor incomes in **78 large Latin American cities.**[1]

INFORMAL WORKERS

Informal workers are **the most affected** by drought.[2]

Unreliable water can cause informal **sector sales to decline by 35%.**[3]



COUNTRY'S GDP

A 1% increase in the area affected by drought **can slow** a country's GDP by **2.7% per year.**[4]

AGRICULTURE

Droughts caused **15 billion dollars** in agricultural productivity **losses** in Latin America and the Caribbean during the 2005-2015 period.[5]

Drought is one of the main factors **influencing food insecurity and hunger.**[6]

1. Desbureaux, 2019
2. Ibid.
3. Damania et al., 2017
4. Brown et al., 2013
5. ONU, 2018
6. Kogan et al., 2019

INTRODUCTION

Worldwide, water scarcity has become a significant problem in the last few decades. Droughts present a major challenge for water management and environmental protection.[7] Available economic data suggests that drought has a direct negative impact on countries' GDP.[8] The frequency, length, and intensity of droughts is expected to increase on a global scale due to climate change. Although there is no universal definition of drought[9], its environmental and social consequences are obvious and significant.

Droughts affect populations worldwide. Due to their large scale and long-lasting nature, they are particularly difficult to address effectively. Lack of guaranteed access to sustainable sources of water threatens food security in many countries, causing forced migration, and even conflict. About 1.5 billion people - 20% of the global population currently facing water scarcity - are the first victims of the world water crisis, and hardly anyone will remain unaffected for long.[10]

A report by the Intergovernmental Panel on Climate Change (IPCC)[11] projects an increase in the global average temperature of the planet, changes in precipitation patterns and intensity, as well as dramatic glacier melt. Increases in the surface temperatures of water bodies speed up evaporation rates. Warmer temperatures result in more water needed to irrigate crops. Meanwhile, pollution degrades water quality and vast amounts of municipal water are lost to leaks, theft, or neglect. Inefficient management of drought and water resources could put entire aquatic ecosystems under greater stress.[12]

Addressing drought and water scarcity is important in both highly populated urban as well as sparse rural areas. By 2050, 6.4 billion people could live in cities worldwide, demanding 55% more water than that which is currently used. As water becomes scarcer, utilities and governments maintaining taps will face multiple challenges and must work together to develop long-term plans and permanent measures.[13]

Agriculture is the main user of water worldwide.[14] By 2050, the world population is expected to reach 9.1 billion and food production is projected to increase by 70% to meet demand.[15] This will inevitably result in additional pressure on dwindling water resources. The relevance of the agricultural sector is two-fold, given its high vulnerability to water scarcity and droughts and its important share of water demand. Therefore, we need to design and implement integrated management initiatives in the water sector - including policies, strategies, and projects - that contribute to a sustainable and efficient use of the resource.

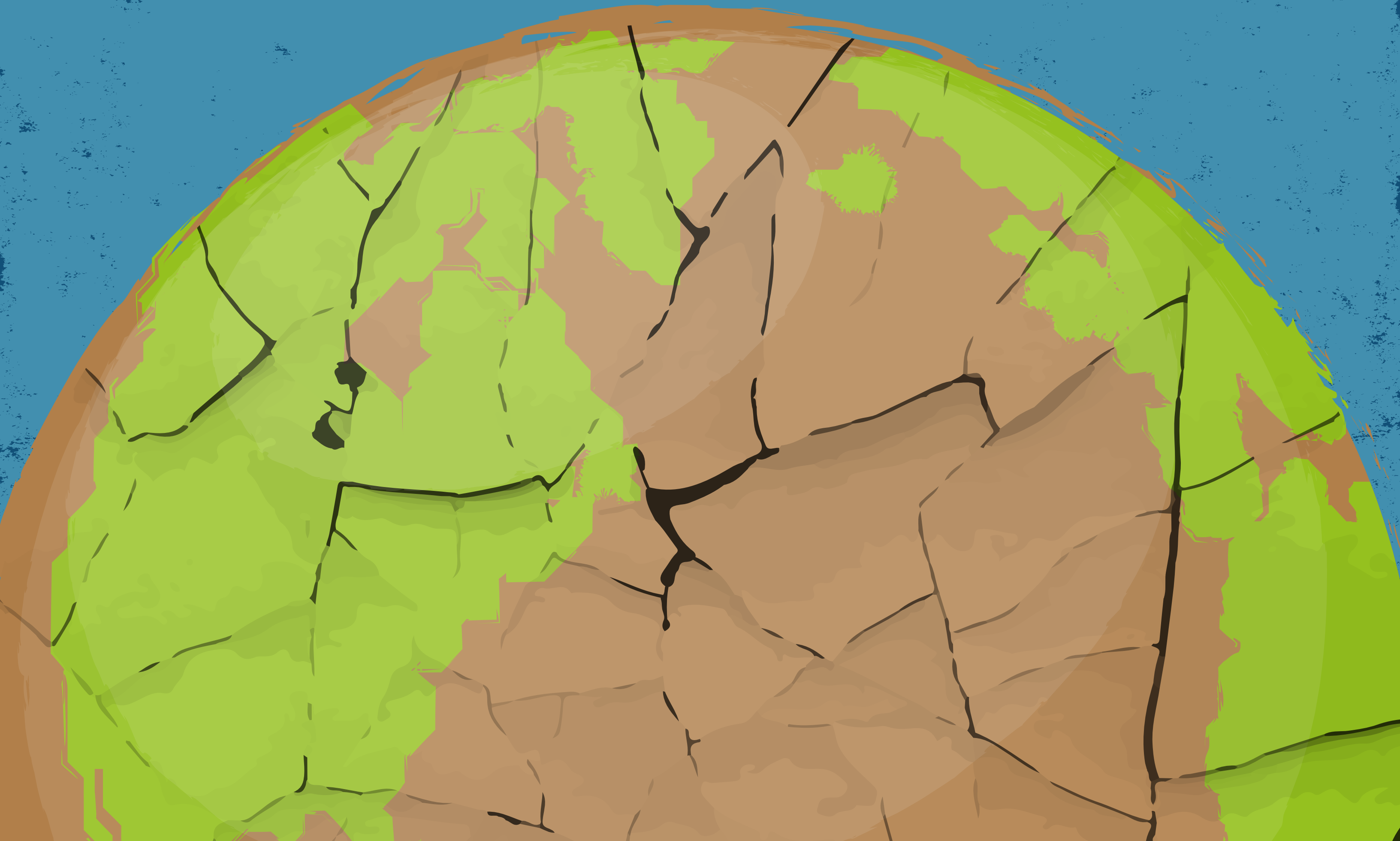
This technical note is an update to the previous **"Water in the Time of Drought: Lessons from Five Droughts Around the World"**, published in 2018. It explores drought situations and policies in Spain (including the Canary Islands), Chile, Mexico, the dry corridor between Honduras, Guatemala, and El Salvador, Brazil, and South Africa. Each of these countries has recently dealt with droughts and/or developed long-term solutions to manage them. HydroBID, a tool developed by the IDB, will be presented through relevant case studies. After defining drought experiences and institutional frameworks in each country, the brief will explore the successes and challenges of national drought and water management policies. Best practices and lessons learned will be extracted from each case study to help policymakers better prepare for droughts.

Note: *The cases featured in this brief were selected based on availability of information to define the policies and key lessons learned for water utilities and policymakers.*

---

7. European Communities, 2007
8. See Economic Impact of Droughts, above
9. While this is true, droughts go through different clearly defined phases: meteorological, hydrological, agricultural, economical, etc.
10. Siegel, 2015
11. IPCC, 2014
12. European Communities, 2007
13. IPCC, 2014
14. FAO, 2011
15. Ibid.

DROUGHT EXPERIENCES AROUND THE WORLD



SPAIN

DROUGHT CONTEXT

According to the Ministry for the Ecological Transition, drought is a "normal and recurrent situation" in Spain.[16] The country experiences highly irregular spatial and temporal rainfall distribution, with a humid north and a dry center and south (Figure 1). Due to temperature increases, heatwaves, high evaporation rates, and decreases in precipitation, available water resources are stressed.[17]

In addition, water scarcity in Spain is driven by intensive irrigation that took place over the last century, first through collective waterworks, and more recently via a surge in groundwater pumping.[18] Today, agriculture consumes approximately 68% of the total water used in Spain, in contrast with the 18% and 14% used by industry and household sectors, respectively.[19] In the early 1950s, there was a substantial imbalance between water consumption requirements and available resources, which was further aggravated by rapid industrialization.[20]

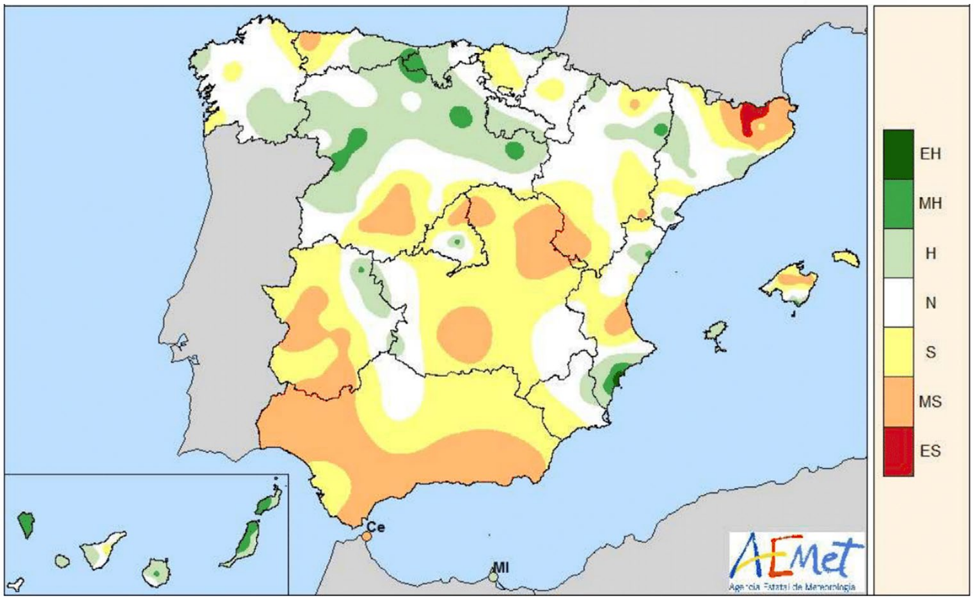
Water scarcity and droughts are most widespread and frequent in the regions along the Mediterranean coast and the southeastern part of the country, creating socioeconomic and environmental challenges.[21] As a result, current water demands cannot be met using exclusively natural sources of water.[22]

The drought spells of 1980-1983, 1991-1995 and 2005-2008 had similar negative effects on water dependent ecosystems. Spain's worst drought to date occurred between 1991 and 1995. It resulted in a 70% reduction in river flows, which led to substantial economic losses in agriculture, hydroelectric generation, and urban and industrial activities. The supply of water for irrigation was banned or halted in both the Guadalquivir and Guadiana basins. The government placed severe restrictions on water supply in most towns in southern Spain. Residents were left without water for up to 10 to 12 hours per day.[23]

The 2005-2008 drought was less severe than the one in the early 1990s. Urban restrictions did not include water rationing measures and only irrigation water was curtailed in some watersheds.[24] Today, the government claims that some regions have experienced drought conditions since 2014.[25] Countrywide, it has rained less since 2014 than the average rainfall between 1971 and 2000 (Figure 2).[26] The hydrologic 2016-2017 year (from October to September) was the eighth driest year since 1981, with 40% less rainfall on average during the fall season.[27]

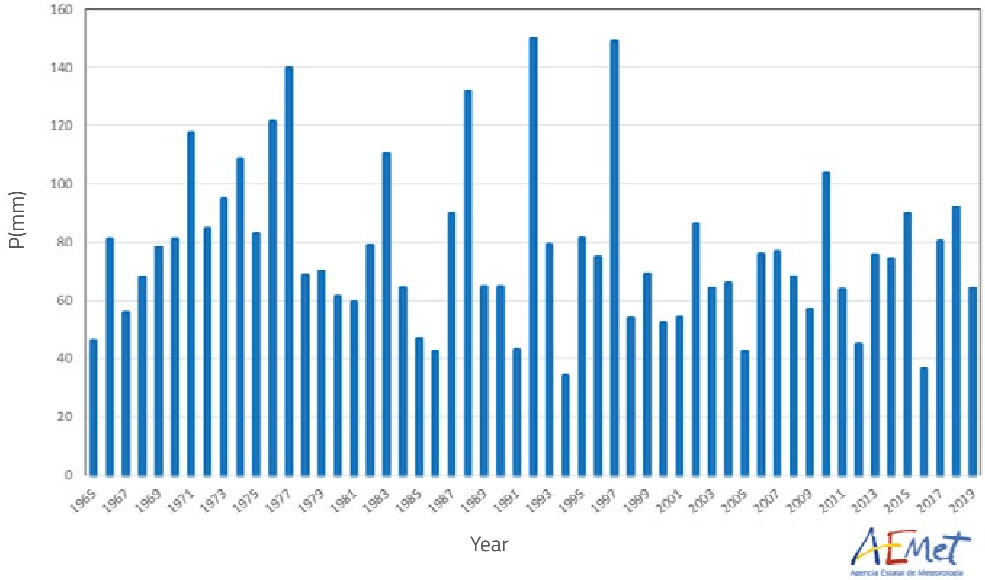
16. MTE, n.d
17. Hervás-Gámez et al., 2019
18. Estrela et al., 2012
19. FAO, 2019a
20. Estrela et al., 2012
21. Ibid.
22. Hervás-Gámez et al., 2019
23. Albiac, 2013
24. Ibid.
25. MTE, n.d
26. MTE, n.d.
27. Ibid.

FIGURE 1. Average national precipitation for summer 2019[28]



Range: **red** = extremely dry **green** = extremely wet

FIGURE 2. Average rainfall between June and August, 1965 to 2019[29]



28. Agencia Estatal de Meteorología, MTE, 2019
29. Agencia Estatal de Meteorología, MTE, 2019

INSTITUTIONAL FRAMEWORK

As one of the countries with the longest record of water legislation in the European Union, Spain has solid drought management policies and practices. Recently, it shifted from the traditional emergency drought response toward a more proactive drought risk reduction approach through local DMPs (Drought Management Plans). DMPs were developed to minimize environmental, economic, and social impacts of droughts. They are prepared, managed, monitored and controlled by the RBAs (River Basin Authorities), updated every six years, and subject to a three-month public consultation period to ensure transparency. Priorities of DMPs include defining techniques to detect drought, setting scenarios to determine the severity of water scarcity episodes, and defining measures to address prolonged drought situations.[30]

In 2018, a diagnosis system was added to the DMPs to differentiate between water scarcity and drought in order to provide recommendations on best practices to address each phenomenon.[31] While drought is a natural phenomenon characterized by a prolonged decrease in rainfall, water scarcity is an area's temporary inability to meet water demands.[32] In addition, water companies or municipalities prepare special drought plans or PESs ("*planes especiales de sequía*") in each area of hydrologic planning, as well as emergency plans for areas serving more than 20,000 people.[33] Like DMPs, PESs are used to improve the understanding of environmental and economic impacts of prolonged droughts, develop reports after the events, standardize the definition of extraordinary drought, and support the implementation of emergency plans.[34] Spain also created a global drought indicator system across all river basins to determine the best practices for regions affected by similar conditions. According to the MTE, DMPs, PES plans, and the indicator system have been effective at avoiding the worst socioeconomic impacts of drought by helping managers make objective, planned, and progressive decisions.[35]

DROUGHT MANAGEMENT PLAN REQUIREMENTS

According to the European Commission[1] and in agreement with the work previously developed by the Water Scarcity Drafting Group, a DMP should contain:

- indicators and thresholds establishing onset, ending, and severity levels of the exceptional circumstances (prolonged drought).
- measures to be taken in each drought phase to prevent deterioration of water status and to mitigate negative drought effects.
- an organizational framework to deal with drought and subsequent revision and updating of existing drought management plans.

A DMP should also include a section dedicated to "prolonged drought" as defined in Article 4.6 of WFD, which includes the following requirements:

- prevention and restoration steps and measures for water bodies.
- measures to be taken in case of prolonged drought.
- indicators for prolonged drought (ie.: impact on drinking water, local biodiversity, socio-economic issues).
- annual review of the effects of prolonged droughts.

Source: European Communities, 2007

30. Hervás-Gámez et al., 2019
31. Ibid.
32. Hervás-Gámez et al., 2019
33. MTE, n.d.
34. MAPAMA, 2017
35. MTE, n.d

DROUGHT MANAGEMENT STRATEGIES

During the drought seasons of 1991 and 1995, basin authorities placed restrictions on trade between water users, and built water conveyance facilities and large-scale drought wells. To face drought impacts, the government shifted from emergency response to drought risk reduction management. Many decrees were passed between 1992 and 1995, creating permanent drought commissions in every basin authority. These commissions can modify or suspend any water use, compel water users to install measuring and controlling devices in public and private water facilities, and build water installations under consideration of emergency waterworks.[36]

In August 2019, Spain's water reserve was at 45.7% of its capacity, or 25,659 billion liters.[37] To address this crisis, the government launched three Royal Decrees of Drought in Segura, Júcar, and Duero to give the population access to an additional 350 billion liters of water.[38] Royal decrees are emitted if there is an extended period of drought over several months at "warning" level; they help local governments take extraordinary measures to address the situation.[39] There are four types of drought levels: "normal", "pre-warning", "warning", and "emergency".[40] The government also increased agricultural security plans through the Common Agricultural Policy to help farmers deal with meteorological conditions and approved action plans to invest in desalinated water in Levante and Castilla La Mancha.[41]

The MTE official website hosts a list of actions consumers can take and directives they should consider to reduce the likelihood of drought, including "turn off the faucet while brushing your teeth", or "showering wastes less water than bathing" (Figure 3 a, b).[42] There is also a live ad campaign, #CadaGotaSuma, that compares the lack of internet to that of water (video) to raise awareness about the effects of drought. All of these efforts try to reduce demand.

FIGURE 3. Water protection campaign on MTE's official website

a) "*Shower instead of taking a bath and you'll save more than 50% of the water*"

b) "*Water gives us life. Let's take care of it.*"

36. Albiac, 2013
37. MTE, 2019
38. MTE, n.d
39. Ibid.
40. Ibid.
41. Ibid.
42. Ibid.

LESSONS LEARNED

Given the persistent nature of drought, Spain must address this phenomenon through multiple channels. Under extreme conditions, the government can launch royal drought decrees to free special funds to assist communities in need. To reduce drought risk, Spain established DMPs and PESs. All drought plans are based on a system of indicators, drought management rules for watershed boards in every basin district, and urban management plans. For these to be effective, they must be living documents that adapt to changing conditions.[43] The government also launched a campaign to encourage citizens to take action to protect their limited water resources. Studies suggest that these management strategies reduced the likelihood of public supply restrictions, reduced and mitigated drought impacts, and highlighted the importance of stakeholders in decision-making processes. The success of these practices reflects an effort to coordinate effectively across all organizations involved at political and institutional levels. In this sense, the country uses both crisis-response and proactive adaptation techniques.

CANARY ISLANDS

DROUGHT CONTEXT

The Canary Islands are an autonomous Spanish archipelago off the coast of Morocco with a mild climate and little seasonal variation.[44] Precipitation is limited[45] and there is less than 300,000 liters of natural water available per inhabitant, per year, a value that is significantly lower than that of most European countries.[46]

In 1957, the island of Lanzarote went through a drought that forced the local government to ration water to five liters per day, per person. Because freshwater resources are limited, underground, and generally difficult to extract, the government decided to invest heavily in desalination technology.[47]

For more information on water management and innovation in the Canary Islands, please read the report: "Canary Islands case: Ingenuity and innovation in the water value chain" (available in Spanish).

INSTITUTIONAL FRAMEWORK

The Canary Islands have a unique governance structure and they are divided into the Las Palmas and Santa Cruz de Tenerife provinces. Each island has a "*cabildo insular*", otherwise known as a town hall, that allows them to address local issues. The territories are further divided into 88 municipalities, 21 of which are located in Gran Canaria, the third largest island. Each of these municipalities is headed by a mayor.[48] The GDP per capita of the Canary Islands reached 21,000 euros in 2018, with tourism contributing more than 35%; unemployment was less than 20% in 2018.[49]

Water legislation in the Canary Islands is complex because there are multiple legislative levels. The European Union created legislation (2000/60/CE) for the management of superficial, continental, transitional, coastal, and subterranean waters to reduce contamination, promote sustainable use, protect aquatic ecosystems, and mitigate drought and flood impacts within the union.[50] This directive became part of Spanish legislation in 2003. Additionally, the territorial law of December 1990 subjected all waters to the general interest under the framework of environmental protection and created insular water councils (public and autonomous entities that make management and planning decisions). Each council is tied to a "*cabildo insular*" that works directly with the Canarian government to protect resources and find funding for these projects. Although the archipelago is increasingly vulnerable to climate effects, it has yet to develop and implement a comprehensive climate change adaptation strategy.[51]

43. Hervás-Gámez et al., 2019
44. Rodriguez, 2019
45. Ibid.
46. Schallenberg-Rodríguez et al., 2014
47. Ibid.
48. SpainGranCanaria, 2020
49. Canarian Statistics Institute, 2019
50. The Canary Islands are part of the outermost regions (OMR) of the European Union
51. Hernandez et al., 2018

DROUGHT MANAGEMENT STRATEGIES

The Canarians have a long history of innovation, always able to adapt to dire circumstances. Some of the more unique solutions to water scarcity include bringing water tankers from Madeira and shipping icebergs from the North Atlantic. Supposedly, the first inhabitants of El Hierro harvested water during horizontal precipitation events, when strong winds push the rain sideways against the trees. Today, that practice continues with the use of fog collectors. Between 1912 and 1962, the government sent water from Gran Canaria and Tenerife to smaller islands by boats from the Spanish Armada or the Trans Mediterranean Company. Donkeys and camels then brought the water to each island's reservoirs. Today, water cisterns are common in each island and they are exploring water reuse for agriculture, industry, public gardens, and street cleaning.[52]

For over 50 years, the Canary Islands have used desalination plants to meet their increasing water demands due to population growth and tourism.[53] In 2018, the population was over 2.1 million and more than 15 million tourists visited the island in 2017 and 2018.[54] The price of water increased by 45% between 2000 and 2016. More than half of the islands' water consumption comes from desalination plants.[55] In 2014, the desalination capacity of the Canary Islands represented about 1% of total *global* desalination capacity,[56] a feat for an archipelago of only 7,500 km^2.[57]

LESSONS LEARNED

One of the challenges of seawater desalination is its reliance on conventional energy sources.[58] In Lanzarote, 20% of the island's energy is used for desalination.[59] However, the development of efficient technologies such as reverse osmosis has resulted in desalination plants' reduced energy consumption.[60] Desalination plants running on renewable wind or solar energy are common and the Canarians are exploring strategies to expand this practice to remote areas.[61] Thus, desalination represents a solution to water scarcity in the Canary Islands.[62] Today, engineers from around the world travel to the Canary Islands to learn about desalination technology and innovation.[63]

52. Martel et al., 2008
53. Schallenberg-Rodríguez et al., 2014
54. Statista, 2019
55. Schallenberg-Rodríguez et al., 2014
56. Ibid.
57. Oishimaya, 2017
58. Sadhwani et al., 2008
59. Martel et al., 2008
60. Sadhwani et al., 2008
61. Ibid.
62. Schallenberg-Rodríguez et al., 2014
63. Martel et al., 2008

CHILE

DROUGHT CONTEXT

Due to its geographic location, exposure, sensitivity, and ability to adapt, Chile is highly vulnerable to climate change.[64,65] Local interannual rainfall variability is tied to the ENSO phenomenon in the Pacific Ocean.[66] Because cloud cover and convective activity drop during La Niña events (see ENSO review box), significant droughts affect the central and northern regions of Chile[67], with precipitation between 35% and 100% lower than the annual average.[68]

For the past ten years, Chile has been experiencing a *megadrought*, the most severe drought phenomenon recorded in over 60 years.[69] It started in 2010 in the Atacama and Biobío regions; agricultural effects were the worst in Coquimbo and Valparaíso in 2015.[70] In Central and Southern Chile, the forest area destroyed by fire increased 70% during the megadrought, exceeding 100,000 hectares, which is unprecedented in the last 50 years.[71] According to estimates from the Ministry of Agriculture, at least 10,000 animals have died and another 50,000 animals are at risk.[72] As of 2015, 76% of Chile's surface area was severely affected by drought, desertification, and degraded soils.[73]

Historically, central Chile has repeatedly witnessed droughts lasting one or two years due to natural climate variations.[74] However, this megadrought differs from these intermittent, short drought periods due to its duration and spatial extent.[75] After ten consecutive dry years, this drought will have unprecedented ecological consequences.[76] Already, the Andean snowpack is diminishing and there are significant declines in river flows, reservoir volumes, and groundwater levels.[77] According to the Ministry of Public Works, water availability has decreased 37% and the reservoir deficit has reached 23% in the last five years.[78] Vegetation productivity has decreased considerably, resulting in substantial browning in the north.[79] Higher temperatures due to climate change lead to greater water loss from snow-covered areas, crops and natural vegetation (evapotranspiration), and lakes and reservoirs (evaporation), worsening the water deficit.[80]

Water scarcity impacts multiple sectors of life in Chile.[81] Because most of the population is concentrated in the arid and semiarid climates of the center and north[82] (Figure 4), there is not enough water to meet local domestic and industrial demand.[83] The south-central region has suffered

64. UNW-DPC, 2015
65. Bretas et al., 2020
66. Valdés-Pineda et al., 2014
67. Bretas et al., 2020
68. Quintana, 2000
69. Guzman, 2019
70. UNW-DPC, 2015
71. CR2, 2015
72. Guzman, 2019
73. UN Convention, 2015
74. CR2, 2015
75. Ibid.
76. Paúl, 2019; Garreaud et al., 2017
77. Garreaud et al., 2017
78. Guzman, 2019
79. Garreaud et al., 2017
80. CR2, 2015
81. Ibid.
82. Valdés-Pineda et al., 2014
83. Aitken et al., 2016

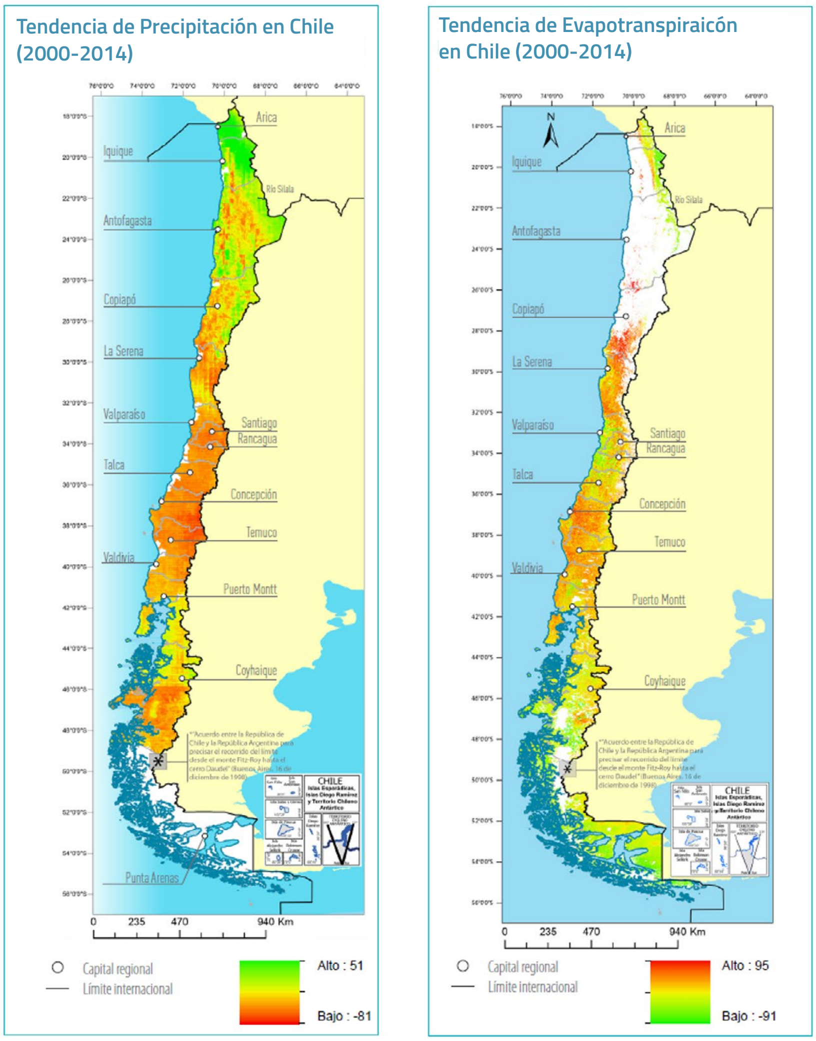
significantly as it is home to 74% of the Chilean population, approximately 12.8 million inhabitants.[84]

The megadrought has had significant impacts on sanitation, the agricultural and livestock sector, industry, and mining.[85] Over one hundred municipalities are affected and 1.4 million hectares lack irrigation, causing considerable agricultural losses.[86] To date, small agricultural communities suffer the most and sadly, many older farmers are committing suicide as a result.[87]

INSTITUTIONAL FRAMEWORK

Unlike many countries, Chile uses a system of private tradable water rights.[89] These rights were converted into private property to be regulated by the economic market under the Water Code of 1981.[90] Today, Chileans can only use a given water resource if they have the corresponding right.[91] Water rights apply to both surface and groundwater resources. They are measured in volume by unit of time and are proportionally distributed to the population

FIGURE 4. Average national rainfall and average evapotranspiration for 2000-2014.[88]



Source: Elaboración propia. Escenarios Hídricos 2030, basado en Galleguillos et al., 2017.

84. CR2, 2015
85. Ibid.
86. IDB internal data, 2019
87. Ibid.
88. Fundación Chile, 2018
89. Budds, 2009
90. Budds, 2009
91. Ibid.

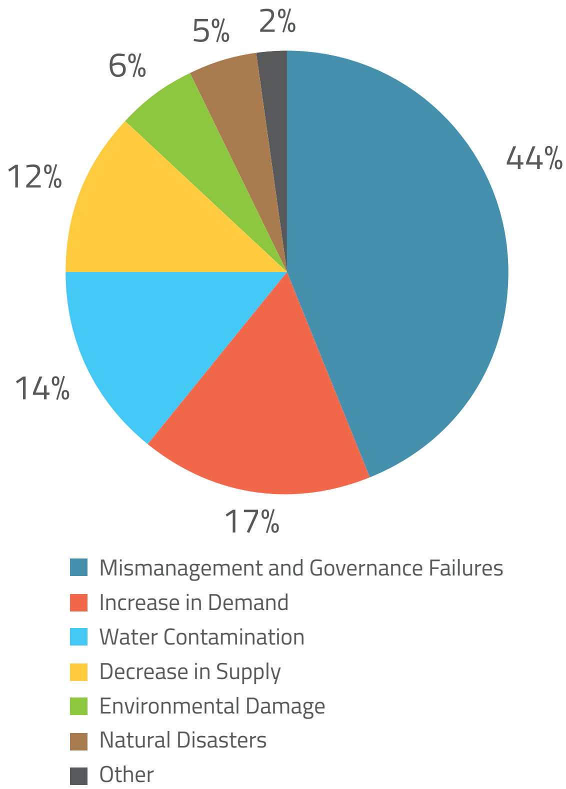
if supply is insufficient.[93] Urban water services, including sewage, have been privatized as well.[94]

The *Dirección General de Aguas* (DGA), which is part of the Ministry of Public Works (MOP), monitors and enforces water rights through the National Water Policy.[95] Nonetheless, it has limited authority due to the restricted role of the neoliberal state.[96] The Ministry of Commerce sets the maximum limit on urban water fees based on the market price of water and infrastructure costs.[97] User associations own and manage water infrastructure, define rights allocations, and address conflicts.[98]

Advocates for this system believe that tradable rights improve water allocation efficiency.[99] When well- designed, water rights can empower water users by requiring their consent for reallocation and can incentivize farmers to grow water-conserving crops.[100] In fact, active water markets are more frequent and visible in areas of extreme water scarcity, such as the center and north of the country.[101] Market-based allocation can also free up government resources for other programs.[102] However, large commercial farms located upstream are known for diverting water away from traditional farms with fewer financial resources.[103] Therefore, it is difficult to ensure that this system is equitable.

Challenges within water risk management infrastructure stem from several sources. In a presentation on water scenarios for 2030, Fundación Chile outlined the following causes[104] (Figure 5):

FIGURE 5. Causes of water basin gaps and risks in Chile by percentage.[105]



- **Mismanagement and governance failures** are due to lack of information, coordination among institutions, fiscalization, and definition of norms by the integrated management of water resources (GIRH in Spanish).
- **Demand increases** are due to more agricultural productivity and public grants.
- **Water contamination** is the result of agrochemical product use, mining leaks, and lack of rural sanitation infrastructure.
- **Supply decreases** are due to low precipitation, drought, glacier retreat, and overexploitation of aquifers.
- **Environmental damages** entail degradation of water ecosystems, lack of conservation practices, and drastic changes in land use.
- **Natural disasters** include the increase in extreme events, such as floods.
- **Other causes** include the increase in electricity costs.

Due to these challenges, most of the country does not believe it can resolve its water allocation problems through

92. Ibid.
93. Rosegrant et al., 1994
94. Ibid.
95. Hearne et al., 2005
96. Ibid.
97. Ibid.
98. Rosegrant et al., 1994
99. Ibid.
100. Ibid.
101. Hearne et al., 2005
102. Rosegrant et al., 1994
103. Budds, 2009
104. Galleguillos, 2019
105. Galleguillos, 2019

market transfers.[106] Many of these markets are informal and lack transparency, particularly in indigenous and vulnerable communities.[107] Strong environmental protection laws are lacking in the national Water Code.[108]

To address some of these issues, the MOP created a National Strategy for Water Resources for 2012-2025 focused on: (i) creating efficient and sustainable management; (ii) improving institutions; (iii) confronting drought; (iv) supporting social equity; and (v) informing citizens. According to Fundación Chile, the state and its institutions need to lead the water transition by developing partnerships with the public and private sectors.[109] Chile also needs a national water policy that supports diverse initiatives, such as climate change adaptation.[110]

DROUGHT MANAGEMENT STRATEGIES

In 1925, 1968, and 1989, water shortages exceeded 50%, causing the government to build artificial reservoirs and establish agricultural subsidies to help the country cope with these extreme events. Civil engineering works and infrastructure were traditionally the most frequent measures undertaken.[111]

Today, at a national level, the MOP uses drought indicators to declare water shortages for a maximum of six months. This allows the MOP to intervene in the private market to protect human consumption and other necessary water uses. However, regional policymakers have the final say on drought interventions, even if the indicators might not be available in those areas. County officials can ask for governmental financial resources for water delivery by trucks during droughts. Thus, drought policies are more catered toward crisis response. These policies are based on the assumption that drought is temporary. The megadrought afflicting the region since 2010 challenges this hypothesis. Multiple levels of agencies with jurisdiction over water resources also affect coordination efficiency and prevent effective action against drought. Many of Chile's drought management policies are linked to objective indicators without a feedback mechanism to adjust to new conditions.[112]

After the drought of 2007-2008, the Ministry of Agriculture implemented a national System of Agricultural Emergencies and Agroclimatic Risk Management to improve efforts at the ministerial and property levels, with the objective of moving away from emergency response toward proactive risk management.[113] This system has made protocols available for droughts, regional diagnoses of vulnerable areas, as well as an information system that shares current and past weather conditions, possible impacts on agriculture, and technical recommendations.[114]

The private sector and civil society have worked together to make plans to deepen water wells, increase automation, adopt new technologies, build irrigation infrastructure, or organize seminars on water conservation at the local level. Municipal governments also try to mitigate the effects of the mega-drought by renting water trucks or increasing emergency deliveries of drinking water.[115]

During the more recent megadrought, the Chilean government was forced to declare six regions - Atacama, Coquimbo, Valparaíso, Metropolitana, O'Higgins, and Maule - as agricultural emergency zones in order to activate plans and allocate water resources for farmers and ranchers.[116] While the government invested USD 63 million in irrigation, sanitation companies committed more than USD 5 billion to reduce losses in the urban drinking water system, currently estimated at 35%.[117] The DGA is applying new technologies to care for and combat speculation about the non-use of water rights and to improve the processes of control of illegal extraction.[118] Another measure taken by the government is to prioritize the construction of 26 new reservoirs.[119] The steep drop in the level of reservoirs also results in energy saving measures, as hydropower plants produce energy from water.[120]

106. Hearne et al., 2005
107. FAO, 2015
108. Rosegrant et al., 1994
109. Galleguillos, 2019
110. Ibid.
111. CR2, 2015
112. Garreaud et al., 2017
113. UNW-DPC, 2015
114. Ibid.
115. CR2, 2015
116. Guzman, 2019
117. CR2, 2015
118. Guzman, 2019
119. Guzman, 2019
120. UNW-DPC, 2015

Emergency relief funds are also used. They focus primarily on providing water for human consumption and food baskets to the most affected regions. Regarding agricultural systems, the aid delivered can be classified in two categories: direct aid funds and targeted incentives. While direct aid funds are short-term, targeted incentives cover development programs and credit access to improve irrigation systems, with the aim of preparing better for the next water deficit. Amounts allocated to these services reached close to USD 35 million in 2008 and 2012.[121]

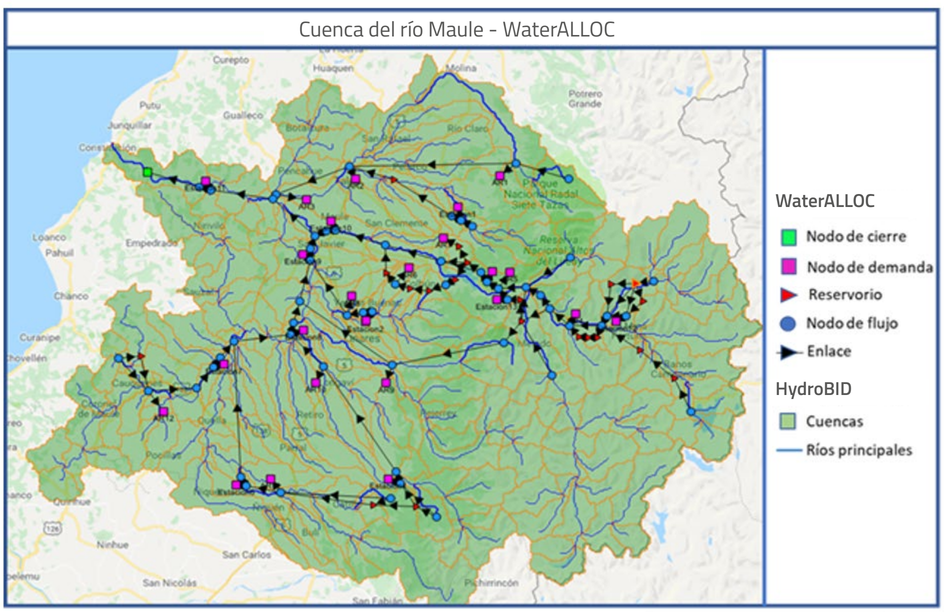
To address the current crisis, the IDB (through the Water and Sanitation Division) is working with the Ministry of Agriculture (MINAGRI), which created a commission of six ministries to deal with the megadrought. It also assigned funds to the national irrigation commission and prioritized 26 strategic reservoir projects. MINAGRI is promoting the use of water meters and opened a discussion to revise the Water Code. The IDB has proposed to support the development of a National Water Safety and Action Plan for priority basins, launch models to analyze supply and demand flows in 104 basins, and provide technical support in implementing water reuse projects and designing multipurpose desalination plants. The IDB also offered to support the design of projects to artificially refill aquifers and to expand projects to build wells in other regions of Chile.[122]

HydroBID: HYDRO-ECONOMIC ANALYSIS OF THE MAULE RIVER BASIN

While all of Chile experiences a megadrought, the Maule region has been particularly affected. The Maule River basin is characterized by intensive use of the water resource for the agricultural, hydroelectric, and forestry sectors. Additionally, this resource is also used to meet drinking, industrial, and livestock demands, as there has been an increase in agro-industries and sawmills with high water consumption in the region. This intensive use has resulted in drastically low flow in some sections of the river at certain times of the year.[123]

In this context, water utilities used HydroBID to support decisions on the allocation and use of water resources by analyzing quantitative (water levels) and socio-economic (cost/benefit, optimization) components (Figure 6). Rationing baselines and predictions for 2030 and 2050 were defined based on current sector water balances (supply vs. demand). HydroBID can facilitate technical and economic evaluations to determine the viability of infrastructure projects.[125] The IDB also plans to implement the European Commission's DMP benchmarks[126] as part of a pilot project to manage drought in the Maule River basin.

FIGURE 6. HydroBID model of surface system network flow of the Maule River basin.[124]



121. Ibid.
122. IDB, 2019
123. Rueda et al, 2020
124. Rueda et al, 2020
125. Ibid.
126. European Communities, 2007

LESSONS LEARNED

Given the complexity and cross-cutting nature of its water management problems, the growth rate of productive activities, and the need to optimize policies and management of drought risk across an expansive territory, Chile could develop capacities in the following areas:[127]

1. **Development and implementation of integrated water resources management** in order to maximize economic results and well-being in an equitable way without compromising the sustainability of vital ecosystems;

2. **Dissemination techniques** to share information on water scarcity, its scope, consequences and impact, in order to educate all those involved;

3. **Monitoring and exploitation of satellite data** to generate maps and indices on current water status and preparation of future scenarios, as a support tool for productive sectors that are highly dependent on water;

4. **Local adaptation** to climate change and drought risk management;

5. **Training in adaptive management of water resources** through the integration of hydrological, social climate, and economic development analyses to generate and/or promote coordination to generate multidisciplinary proposal projects;

6. **Design and implementation of incentives** to promote sustainable water management

ENSO REVIEW

Many countries throughout Latin America experience drought due to the El Niño Southern Oscillation (ENSO) phenomenon in the Pacific Ocean. Here is a brief overview of this climate phenomenon.

ENSO refers to a significant shift in oceanic circulation every two to ten years. It consists of three states: El Niño, La Niña, and neutral. El Niño happens when the surface of the central and eastern tropical Pacific Ocean *warms* above average temperatures. As a result, rainfall decreases over the east (ie. Indonesia) and increases over the tropical Pacific (ie. Hawai'i). Easterly winds weaken and sometimes switch direction. By contrast, La Niña happens when the surface of the central and eastern tropical Pacific Ocean *cools* below average temperatures and rainfall increases over the east and decreases over the tropical Pacific and easterly winds are stronger. Neutral conditions happen when the Pacific Ocean has an average temperature or when the warming or cooling of the ocean does not cause atmospheric changes.

Source: L'Heureux, 2014

127. UNW-DPC, 2015

MEXICO

DROUGHT CONTEXT

Mexico's climate mirrors that of Chile. While the north is desertic, with less than 100 mm of rainfall on average every year, the south is wet and tropical, with an average annual rainfall of over 2,000 mm.[128] Interannual rainfall is highly variable and droughts are recurrent.[129] Aquifer over-exploitation is a major challenge in many regions because economic and demographic growth have placed pressure on these limited resources,[130] particularly in the center and north of the country.[131] Additionally, many of these aquifers are shallow and thus more susceptible to agricultural contamination or other forms of pollution.[132] Unfortunately, droughts are often severe in Mexico, particularly in the north, where between 10 and 20% of the total planted area can be lost.[133] The 2011-2012 drought[134] was the most severe of the last 70 years, as it affected 86% of the Mexican territory and resulted in an economic loss of approximately USD 1.3 billion.[135]

INSTITUTIONAL FRAMEWORK

Mexico, like Chile, reduced the role of the state in water management activities. In the early 1990s, farmers started to make production and commercial decisions without the input of the government under the new Agrarian Law. Restrictions on the size of farms and the prohibition of foreign land ownership were lifted. Irrigation districts became water user associations that provided water rights to individuals or, more frequently, groups.[136]

Until 2012, drought management policies were essentially reactive. After a severe drought, local authorities would request a declaration of natural disaster from the National Water Commission (CONAGUA) to gain access to federal funding from the National Fund for Natural Disasters (FONDEN). FONDEN was designed to address short-term and concentrated natural disasters and thus not suitable for prolonged and widespread drought periods. Additionally, the federal government and local authorities took emergency measures such as water delivery through tankers, distribution of groceries, or farm subsidies, which were not effective in the long-term.

DROUGHT MANAGEMENT STRATEGIES

In 2013, the government launched PRONACOSE, the national program against drought, to implement preventive and mitigation activities to reduce the population's vulnerability to drought.[137] It is based on the following principles: prevention, decentralization, governance, capacitation, investigation, measurement and evaluation, and institutional coordination.[138] CONAGUA is responsible for its overall coordination.[139] Activities include monitoring early warning signs to design drought prevention and mitigation programs by basins and user groups; establishing a legal administrative framework for emergency declaration to guarantee water supply for human consumption during the event; and coordinating the allocation of federal resources.[140]

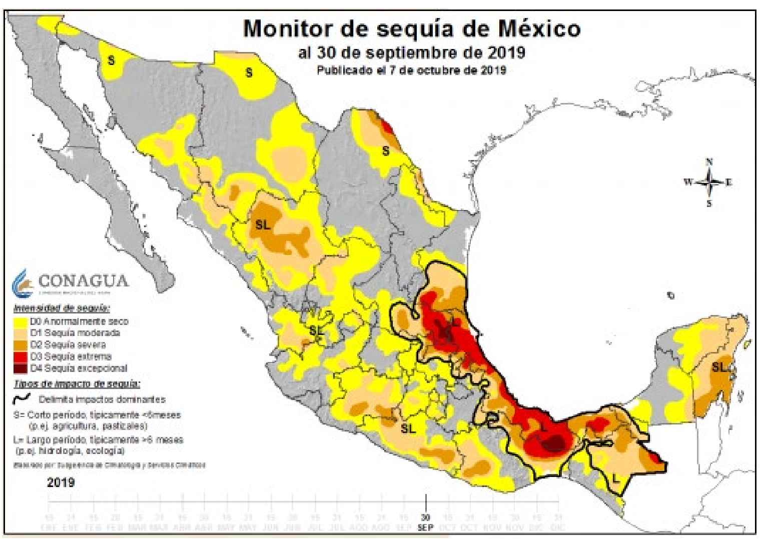
128. Liverman, 1999
129. Ibid.
130. Neri et al., 2015
131. Bretas et al., 2020
132. Ibid.
133. Liverman, 1999
134. Bretas et al., 2020
135. Ortega-Gaucin et al., 2016; Neri et al., 2015
136. Rosegrant et al., 1994
137. Ortega-Gaucin, 2016
138. CONAGUA, 2018
139. Ortega-Gaucin, 2016
140. Ibid.

PRONACOSE also developed a standardized precipitation index (SPI)[141] to measure the extent of drought and facilitate dam management decisions based on differences in surface and subsurface water availability.[142] This standardized precipitation index was used to develop a drought monitoring system.[143] Each drought-affected region is classified based on five types of drought: abnormally dry (D0), moderate drought (D1), severe drought (D2), extreme drought (D3), and exceptional drought (D4) (Figure 7).[144] CIASI, the Inter-Secretarial Commission on Droughts and Floods, is responsible for the implementation and follow-up of PRONACOSE.[145]

In an attempt to synthesize drought research, the government of Mexico developed a Master Plan on Drought Research ("*Plan General Maestro Estratégico de Investigación*") in 2015. This program combined hydrological, agricultural, and socioeconomic findings to support PRONACOSE. It was implemented by CONAGUA and financed by the National Council on Science and Technology. The results of the program are not yet available online and the national development plan for 2009-2021 "*Plan General de Desarrollo 2009-2021*" does not discuss drought once.[146]

Through PRONACOSE, 26 river basin specific Programs of Preventive and Mitigative Drought Measures (PMPMS) were designed to minimize social, economic, and environmental effects of possible droughts.[148] These plans attempt to guarantee water availability for human consumption, protect ecological flows, and maintain priority economic activities defined by the water legislation during droughts.[149] Mexico also developed a national climate strategy (ENCC) to assign funds to address climate change, promote development of a climate culture, strengthen collaborations, reduce vulnerability, increase resilience, conserve ecosystems, accelerate green energy transition, promote sustainable cities, and reduce pollution.[150] To achieve water security and sustainability, ENCC aims at strengthening integrated water management, increasing resilience against droughts and floods, increasing access to clean and potable water and sanitation, and consolidating Mexico's participation in water issues at a global scale.[151]

FIGURE 7. CONAGUA's drought monitoring map for September 30, 2019.[147]



141. There is a database of national drought monitoring reports for 2014 to 2019 available online.
142. Gobierno de México, n.d. a
143. CONAGUA, 2018
144. Ibid.
145. Ortega-Gaucin, 2016
146. UNCDD, 2018
147. https://smn.conagua.gob.mx/tools/DATA/Climatolog%C3%ADa/Sequ%C3%ADa/Monitor%20de%20sequ%C3%ADa%20en%20M%C3%A9xico/Seguimiento%20de%20Sequ%C3%ADa/MSM20190930.pdf
148. Ortega-Gaucin, 2016
149. Gobierno de México, n.d. b
150. CONAGUA, 2018
151. Ibid.

LESSONS LEARNED

Through these programs, Mexico shifted from a crisis response strategy to a national risk management program.[152] Nonetheless, multiple actors, diffuse responsibilities, and coordination challenges stand in the way of effective, forward-looking, integrated, and preventive drought management policies.[153] National water policies continue to prioritize flood efforts over drought, and funding sources for drought mitigation plans are unclear.[154] Of the 38 initiatives presented in the National Water Agenda 2030, none explicitly target drought, while nine address floods.[155] Despite progress in institutional capacity building, Mexico still needs to take proactive measures to adapt to climate change and mitigate the impacts of drought.[156]

Local communities have developed many strategies to cope with drought, such as planting diverse crops, constructing reservoirs, and rationing water.[157] In urban areas, higher water tariffs encourage residents to consume less.[158] However, wastewater treatment and reuse account for less than 20% on average.[159] Thus, Mexico can take additional actions to address water scarcity, such as increasing water use efficiency for human and agricultural use. Other policies can be developed under the framework of ensuring water security to cities, industry, and agriculture.[160] However, for these to be successful, the structural challenges previously mentioned must be addressed.

152. Ortega-Gaucin, 2016
153. Aguilar-Barajas et al., 2016
154. Ibid.
155. Ibid.
156. Bretas et al., 2020
157. Liverman, 1999
158. Neri et al., 2015
159. Ibid.
160. Aguilar-Barajas et al., 2016

THE DRY CORRIDOR

EL SALVADOR, GUATEMALA, AND HONDURAS

DROUGHT SITUATION

As droughts in the Dry Corridor worsen, millions must choose between staying and facing insurmountable climate-related challenges or leaving their homes. Once droughts destroy farmers' crops, farmers typically sell their valuables to survive, and if that doesn't work, they move to nearby cities or attempt the arduous journey to the United States.[161] The number of Guatemalans seeking asylum in the United States grew from 5,000 in 2008 to 97,000 in 2018, indicating an increase in the number of climate refugees from the Dry Corridor.[162]

The Dry Corridor is an area of tropical dry forest in Central America that extends from the tip of Mexico to the north of Panama (Figure 8). The worst hit rural areas are divided among Guatemala, Honduras, and El Salvador,[163] which are all in the top 15 most vulnerable countries to drought and floods worldwide.[164] According to the FAO, half of the 1.9 million smallholder, subsistence farmers of Central America live in the Dry Corridor.[165] The Corridor has experienced one of the worst drought periods in the last decade, with over 3.5 million people in need of humanitarian assistance due to a significant reduction in the agricultural production of basic crops such as maize.[166] In 2016, Guatemala lost more than 200,000 metric tons of maize and black beans, or a loss of USD 133.1 million.[167] Honduras lost 60% of all maize production and 80% of all bean production for smallholders that same year.[168] In 2015, El Salvador's crop failures resulted in economic losses of nearly USD 100 million.[169] In 2018, a delayed start to the rainy season ruined approximately 70% of the Corridor's first harvest and torrential rains destroyed up to 50% of the second harvest.[170]

These erratic weather patterns are caused by climate change and the ENSO phenomenon. During ENSO years, the region's precipitation drops by 30 to 40%, with extended heat waves that deplete food stocks, decrease dietary diversity, and result in more instances of malnutrition in children under five.[171] Levels of poverty and malnutrition are particularly high for rural and indigenous populations.[172]

Food insecurity and water shortages drive conflict in this region, which is already notorious for gang violence.[173] Central American governments estimated that 2.2 million farmers lost crops due to prolonged droughts and as a result, 1.4 million of these urgently needed food assistance in 2018.[174] Conditions are not likely to improve in the future; the FAO predicts that basic crop (maize, beans, wheat, and rice) yields will decrease by up to 10% and encourage more migration.[175] This vicious cycle is depleting the Dry Corridor of economic opportunities and social cohesiveness.[176]

161. Ritter, 2019
162. McGillivray, 2019
163. Some studies indicate that the Dry Corridor extends from Mexico to Panama, but the most impacted area is between Guatemala, Honduras, and El Salvador.
164. FAO, 2020; FAO, 2017
165. FAO, 2019b
166. FAO, 2020
167. McGillivray, 2019
168. Ibid.
169. Ibid.
170. FAO, 2019b
171. FAO, 2020; FAO, 2017
172. Burgeon et al., 2015
173. Ritter, 2019
174. FAO, 2019b
175. McGillivray, 2019
176. Ibid.

FIGURE 8. **Map of the dry corridor of Central America.**[177]

INSTITUTIONAL FRAMEWORK

REGIONAL LEVEL

In 2010, the Central American Integration System (SICA), the Central American Commission for Environment and Development (CCAD), and the Central American Coordination Center for Natural Disaster Prevention (CEPREDENAC) launched the "Strategy and Plan for the Integrated Management of Water Resources" in Central America. SICA and CCAD also developed a Regional Climate Change Strategy that same year. In 2016, CCAD started to develop an agenda to build resilience in the region that would focus on providing resources to the most vulnerable. The Ministries of the Dry Corridor countries also met in 2016 to develop strategic guides with the support of FAO and UNEP.[178] Furthermore, in 2017, CCAD released its regional integrated water resource management that focuses on: (i) promoting governance systems for sustainable water use, (ii) supporting the development of capacities and technologies to guarantee water security, (iii) developing instruments for the integrated management of international water resources, and (iv) promoting the conservation of surface and underground water sources.[179]

HONDURAS

Droughts and water scarcity have been recurring challenges in Honduras. Their impact has been exacerbated by climate change and socio-economic conditions. In fact, climate change projections indicate an overall decrease in precipitation and a 1-4°C increase in temperature.[180] The Honduran section of the Dry Corridor has a very low capacity to manage and adapt to climate variability due to a considerable share of livelihood options with high reliance on weather conditions, and limited access to basic services. In 2017, Honduras launched the 2017-2030 Water, Forest, and Land Master Plan to strengthen local governance for the integrated management of water resources.[181]

According to the World Bank, Honduras's current institutional framework for water resources management needs to be strengthened. The government has limited capacity as the National Water Law of 2008 is yet to be properly regulated and there is no effective National Water Authority. Several institutions with differing technical capacities administer water resources without a formal coordination mechanism. As a result, compliance with legislation related to water rights and the protection of watersheds is not enforced. Additionally, financial instruments and technical policies are required to be developed to foster public-private partnerships that could yield necessary hydraulic infrastructure investments.[182]

177. McGillivray, 2019
178. FAO, 2017
179. CCAD and GWP, 2017.
180. Prager et al, 2020.
181. World Bank, 2019
182. Ibid.

In 2014, the government of Honduras launched the "Alliance for the Dry Corridor" with the objective of coordinating efforts to reduce poverty and malnutrition through the implementation of strategic actions where water figured as a central element. In fact, under this umbrella, projects financed by a myriad of actors -including the World Bank, the European Union, USAID, and the government of Honduras- promote sustainable agricultural development, providing resources for irrigation infrastructure, water reservoirs and watershed management, as well as technical assistance, among others. Water security has remained a continuous concern in the Honduran dry corridor and the country as a whole, given recurrent droughts and water shortages.

Guatemala

Droughts are among the major climatic challenges in Guatemala, a threat that is being exacerbated as rainfall is projected to decrease up to 30% by 2050.[183] Public institutions and non-governmental aid agencies are increasingly working toward a more integrated drought risk management approach. In 2012, the Ministry of Agriculture (MAGA) prepared a "Plan Institucional de Respuesta" (PIR) (or Institutional Response Plan) to manage agricultural drought; it is embedded in national legislation on disaster prevention and reduction. This PIR defines a series of actions and protocols to evaluate the situation and inform decision-makers. It also establishes communication flows and chains of command within MAGA. If the information collected through this PIR suggests that the authorities should declare an emergency, national and international funds are released to ensure food security. The PIR is part of the "*Plan Nacional de Respuesta*" (PNR) (National Response Plan) under the national coordination entity for disaster reduction, CONRED (the "*Coordinadora Nacional para la Reducción de Desastres*," the National Coordinator for Disaster Reduction), which is responsible for coordinating public and private institutions, civil society, and international donors to implement these plans. CONRED also started working on drought response and damage prevention plans. Today, the response protocol for droughts consists of five steps: (i) monitoring of the situation in the field; (ii) alert declaration; (iii) emergency declaration; (iv) actions during the drought; and (v) actions after the drought. Ministers and vice ministers determine whether to continue with the next step throughout this process. The slow, progressive nature of drought makes it difficult to move from the first to the second step, when decision makers define a status of emergency. Additionally, the PIR faces several challenges, such as the high and frequent turnover of MAGA technical personnel; lack of institutional preparedness for major events; communication failures that prevent internal decisions from reaching dependencies; drought data manipulation by staff in the field; lack of representativeness of damage evaluations; and poor access to supporting infrastructure.[184]

El Salvador

The average temperature in El Salvador is expected to increase by 1.4°C to 2°C by 2050, and the number and intensity of extreme weather events are expected to increase as well. Meanwhile, rainfall is expected to decrease between two and 15%. As a result, agricultural productivity will decrease, water stress will become more intense, and loss of biodiversity and food insecurity will become more widespread.[185]

Rural populations in El Salvador depend on rain-fed agriculture and their subsistence economy is highly vulnerable to droughts. As in Mexico, Salvadoran public land management organizations are undergoing neoliberal structure changes. However, civil society is attempting to prevent the privatization of water resources. During the dry season of 2018, the Ministry of Agriculture and Natural Resources (MARN, in Spanish) determined that the nation was facing extreme drought after 39 dry days in the San Vincente department. The ensuing USD 24.9 million loss in agricultural productivity demonstrated the State's failure to coordinate efforts to mitigate the effects of drought.[186]

The Ministry of Agriculture (MARN) is responsible for leading efforts to curb effects of climate change.[187] Moreover, MARN and the Ministry of Public Works, Transportation, Livelihoods, and Urban Development each have their own climate change divisions. El Salvador also launched a National Adaptation Plan in 2017 and a national law on the Climate Change Framework in 2019 to improve its response to drought through different ministries.[188]

183. Prager at al. 2020.
184. Müller et al., 2019
185. USAID, 2017
186. Campos et al., 2013
187. USAID, 2017
188. Ibid

Nonetheless, the national constitution does not reference water protection and no single entity oversees water resources management. The Executive Commission on Hydropower in Río Lempa (CEL, in Spanish), The National Administration of Aqueducts and Sewers (ANDA, in Spanish), the Ministry of Agriculture (MAG, in Spanish), the General Direction of Natural Resources (DGRN, in Spanish), MARN, and the Ministry of Public Health and Social Assistance (MSPAS, in Spanish) each have a stake in water resource management. Each of these acts independently and applies its own policies and regulations. Because the institutional and judiciary framework has not changed significantly in the last decade, the ensuing limited coordination has created access inequality, contamination, the absence of tariffs or water plans, and conflicts between ANDA and local municipalities.[189] As a result, institutions support contradictory regulations and practices; programs have limited continuity and oversight; most solutions are short-term; and knowledge and research need strengthening.[190]

DROUGHT MANAGEMENT STRATEGIES

To compensate for the loss of crops, farmers are resorting to several strategies to face severe drought episodes.[191] The Food and Agriculture Organization (FAO) and World Food Programme (WFP), among others, have developed projects to protect their crops and diversify their sources of income. They also strongly encourage subsistence farmers to replace water-dependent crops with sorghum (a drought-tolerant cereal) or to sow short-cycle crops during the first rain cycle of the year.[192]

In El Salvador, farmers have attempted several strategies, such as varying the maize planting schedule, diversifying crops (ie. adding drought-tolerant fruits and vegetables), or utilizing pseudo-organic agriculture (ie. avoiding chemicals and recovering native seeds) to adapt to climate variability and change.[193] Economic instability and limited agricultural productivity (harvest or stock loss) may encourage migration from El Salvador.[194]

Since 2009, FAO has been working on increasing resilience in Central America. It developed a Regional Disaster Risk Management Strategy in Latin America and the Caribbean and adopted a Resilience Agenda with the WFP, the Central American Agricultural Council, the Central American Commission on Environment and Development, the Coordination Centre for the Prevention of Natural Disasters in Central America, the Regional Committee on Hydraulic Resources, and the Inter-American Development Bank (IDB). Through these partnerships, FAO has worked with local stakeholders to protect agricultural resources and determine strategies to mitigate risks, as well as governments to strengthen institutions, develop drought mitigation policies, invest in monitoring systems, and improve coordination for timely emergency responses. Similarly, the WFP supported communities in El Salvador, Guatemala, and Honduras with funding from the European Union to adapt to drought impacts by rehabilitating former productive agriculture areas, generating other sources of income, helping schools provide food to students, increasing human capital, building capacity, and providing safety nets.[195] The IDB has been supporting –through technical assistance, reimbursable and non-reimbursable funds, and access to international climate funds– the implementation of projects and programs aimed at increasing resilience to water scarcity and droughts. These include, for instance, the implementation of adaptive forest management activities in critical watersheds and the adoption of climate-smart agricultural practices. In fact, in Honduras, IDB and Green Climate Fund resources are financing the implementation of forest management activities as well as the creation and establishment of a water fund for long-term financing of these activities, with the aim to increase superficial water availability during the dry season.

HydroBID: EVALUATION OF THE SEASONAL AND CLIMATE VARIABILITY FOR WATER STRESS MANAGEMENT IN GUATEMALA AND HONDURAS

In Guatemala, HydroBID was used to analyze the variation in the availability of water resources on a seasonal time scale. Emphasis was placed on the Chixoy River basin (Figure 9), the third largest river and site of a major hydropower plant that contributes 20% of Guatemala's energy generation on average. The tool was particularly useful for decision-making because it was able to generate data from remote sensors in a basin where

189. FAO, 2013
190. Campos et al., 2013; USAID, 2017
191. FAO, 2019b
192. McGillivray, 2019
193. Campos et al., 2013
194. Halliday, 2006
195. Halliday, 2006

information availability is typically limited. Findings indicated that the negative impact of climate change and seasonal drought conditions could reduce rainfall by up to 30%. Because this could have negative effects on water availability and the plant's generating capacity, the preparation of contingency plans became a priority for this basin. This study illustrates the importance of proper water resource management for both the water and energy security of a country.[196]

In Honduras, HydroBID is supporting the development of a strategy to reduce the effects of water stress from seasonal droughts. It is used to develop a model based on hydrological, socioeconomic, and infrastructure data (Figure 10) to prepare strategies and investment plans to meet urban, agricultural and energy demands and support sustainable development. The study uses the current situation as a baseline and calculates the effects of increased demand, climate change, projected infrastructure development, and adaptation or mitigation efforts on variations in water supply.

FIGURE 9. Chixoy River basin and computation nodes for the HydroBID model.[197]

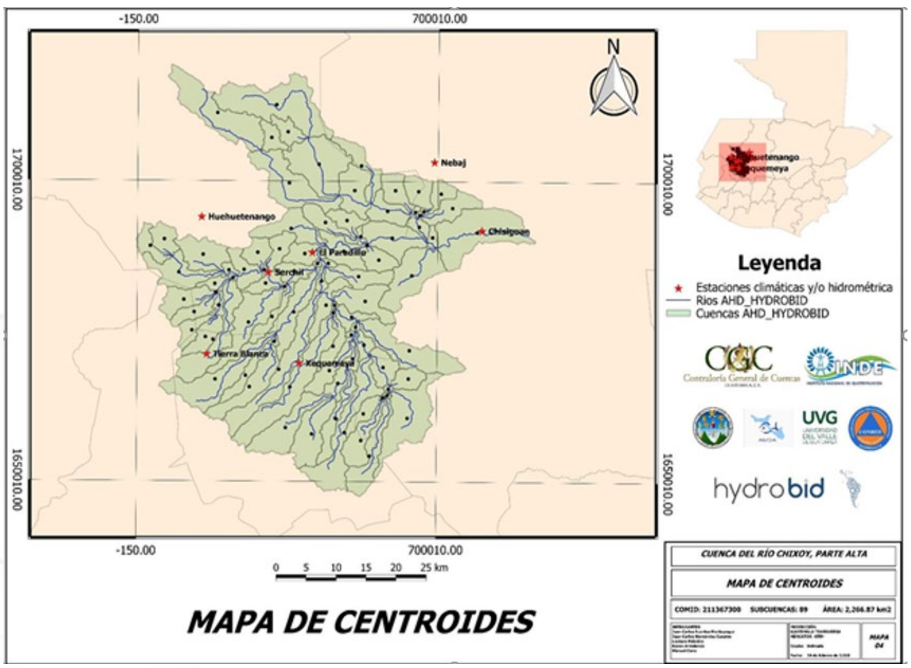
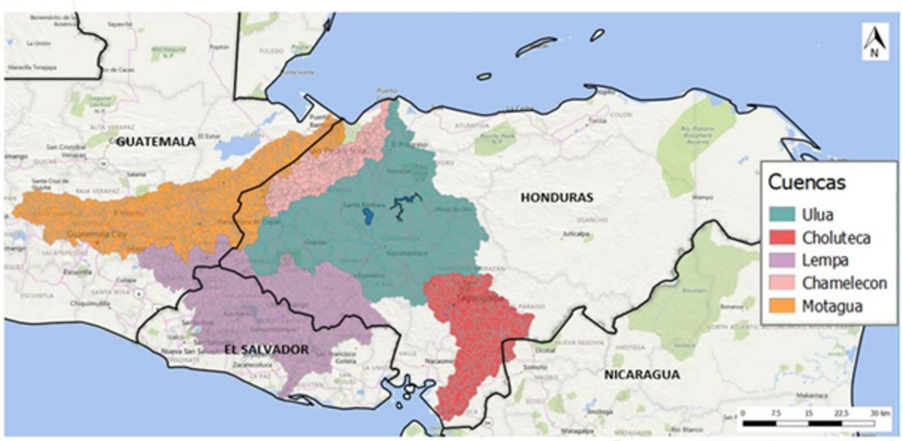


FIGURE 10. Watersheds under analysis by HydroBID in the Dry Corridor.[198]



196. Nalesso et at, 2020
197. IDB, 2020
198. IDB, 2020

LESSONS LEARNED

According to the FAO, governments need to revitalize the Dry Corridor to protect the livelihoods of these communities and dissuade mass migration. Supporting their efforts to produce food and diversify their sources of income (ie: beekeeping, pottery, raising poultry) has helped Dry Corridor residents cope with climate change.[199] Projects completed by the FAO and WFP found that including women was key to strengthening communities' resilience.[200] Sustainable and efficient water resource management is critical to maintaining productive sectors and reducing rates of poverty.[201] The absence of irrigation increases farmers' vulnerability to climate change and variability.[202] Nonetheless, limited data availability makes it difficult to define all available drought management strategies.[203,204]

Studies suggest that the following practices could improve the Dry Corridor's drought management plans[205]:

- Strengthen institutional capacity and involve local stakeholders in decision-making and teaching technical staff how to implement drought plans, such as Guatemala's PIR.
- Homogenize instruments used to evaluate damage and loss to better compare estimates of drought consistently.
- Create a supportive infrastructure with multiple meteorological stations to facilitate mapping of the most drought-vulnerable and water-scarce areas using climate variability and change trends, and improve access to accurate and reliable information.

- Improve inter-institutional cooperation, particularly between local organizations and national agencies.
- Plan, promote, and implement climate change adaptation strategies that involve efficient water use and management, crop varieties and animal breeds that are better prepared for drought, and production practices to increase productivity while promoting efficient use of natural resources and other inputs.
- Conduct practice drills to reveal the failures and strengths of drought management practices. This could also be done virtually through gaming-simulation techniques. Policy exercises can allow a user to determine strategies to address communication problems within the increasing complexity of organizational environments.
- Support implementation of integral programs that include inter-sectoral and inter-ministerial actions as well as local participation in the identification and design of activities.

199. WFP, 2018
200. WFP, 2019
201. World Bank, 2019
202. Wernick, 2019
203. Schubert, 2014
204. Bretas et al., 2020
205. Müller et al., 2019; Geurts et al., 2004

BRAZIL

DROUGHT CONTEXT

As the largest country in South America, Brazil experiences a variety of climates, ranging from the temperate south to the humid center, to the semi-arid northeast.[206] It contains over 12% of the planet's water reserves.[207] Paradoxically, most of the population lives in areas away from Amazonia, where the largest water reservoirs are located.[208] The Amazon River basin holds approximately 50% of the country's water and less than 5% of the population.[209] Meanwhile, São Paulo, which hosts over 22 million residents, receives water from six separate dam systems.[210] The largest dam is the Cantareira, supplying nearly 10 million people. For over 80 years, approximately 40 million liters per second (l/s) flowed through into this system each year. In 2014-2015, the rate trickled to 10 million l/s. Suddenly the prospect of Day Zero loomed for São Paulo; the city had less than 20 days of water left in 2015.[211]

Large portions of Brazil's northeast experienced an intense and prolonged drought between 2010 and 2015, which had significant agricultural and industrial impacts.[212] The agricultural sector incurred an estimated USD 6 billion in crop losses.[213] As in Chile, dried up reservoirs killed many cattle between 2012 and 2013.[214] Federal lines of credit available to farmers and the distribution of water by tank trucks could not prevent these damages.[215] Tensions over the allocation of limited resources rose among agricultural communities at the peak of the drought in 2012 and 2013.[216] The drought also affected the supply for human consumption in cities.[217] Schools and health centers had to close early due to lack of water.[218]

In the south of the country, three reservoirs that supplied water to 63 inland cities reached historically low levels, preventing 15 million residents from accessing water for up to 12 hours a day in 2014.[219] Water was rationed in 19 cities in 2015 and hydropower stations struggled to operate.[220] Six cities experienced blackouts, including São Paulo, where subway trains remained at stations for over an hour.[221] The drought also reduced crop yield potential in the south;[222] coffee bean production declined 15%, causing the global price to increase by up to 50%.[223]

Droughts are frequent in the most inhabited areas due to decreases in rainfall and consequences of deforestation.[224] Deforestation prevents evapotranspiration, a natural process that transfers water from the vegetation into

206. Gutiérrez et al., 2014
207. We Are Water Foundation, 2017
208. Ibid.
209. Maddocks, 2014
210. 50 Liters, 2018
211. Ibid.
212. Gutiérrez et al., 2014
213. Marengo, 2016
214. Campos, 2015
215. Marengo, 2016
216. Marengo, 2016
217. Gutiérrez et al., 2014
218. Maddocks, 2014
219. We Are Water Foundation, 2017
220. Day, 2015
221. Watts, 2015
222. Day, 2015
223. Watts, 2015
224. Maddocks, 2014

the clouds.[225] Brazilian climate projections indicate a decrease in rainfall of 40% below the average by 2100.[226] Thus, droughts are expected to become more frequent and lengthier in the south and north of Brazil.[227]

Drought experiences vary significantly by socioeconomic class in Brazil. While some residents are connected to the water infrastructure, many informal communities and rain-fed farmers do not have reliable access to water. Four million people do not have access to safe water and over 20 million lack adequate sanitation. Future climate stresses on available resources threaten the likelihood of connecting these communities to the water system.[228]

INSTITUTIONAL FRAMEWORK

In 1988, the federal government launched the National Policy of Water Resources, the National System of Water Resource Management, and the National Water Agency (ANA).[229] Ten years later, the national council on water resources (CNRH) was launched. CNRH analyzes water policy proposals, establishes directives for the national water resources plan (PNRH[230]), promotes water resource planning, arbitrates conflicts, deliberates on projects to harness water resources, approves proposals for the institution of water committees, establishes criteria for water use and coverage, and approves the PNRH and accompanies its execution.[231] In contrast to Chile, Brazil considers water to be an inalienable public good that belongs to the federal or state government.[232] ANA, the councils and committees of the Water Resource Management System, basin agencies, and civil society stakeholders award water use permits, known locally as "*outorgas*".[233] ANA also tracks the changes in reservoir levels for each region.[234]

Effective water management has faced several hurdles in Brazil. Until the approval of the current Water Act of 1997, water resources were primarily designated for hydropower. The energy sector had a hegemony over reservoir use. The Water Act led to the creation of 218 state river basin committees and 10 federal committees that mediate conflicts over water resource issues. State and federal water councils and governmental water agencies also participate in managing water.

These councils are composed of representatives from the government, water companies, and civil society. Unfortunately, due to political, technical, and operational issues, these committees have not successfully reached consensus or addressed drought issues. Transparency concerns persist; much of society does not have access to essential water management information. To alleviate some of these challenges, the government launched the ProGestão program in 2013. It consists of a voluntary money transfer from ABA to participating states in exchange for meeting: (i) cooperative and interactive management goals involving the state and federal levels, and (ii) state water management empowerment goals. A recent survey indicated that states support the program because it is a useful tool to track progress toward achievements.[235]

During the 2010-2015 drought, the presidency created the Integrated Committee to Combat Drought to monitor and coordinate drought responses in the semi-arid northeast. Ceará, the most affected state, developed its own Committee to Combat Drought to coordinate emergency activities and address the effects of drought with the participation of local, state, and federal institutions, municipality officials, farmers, and agricultural companies. Moreover, water management became more integrated with the river basin's planning and implementation unit.[236]

At a national level, several ministries and environmental organizations support drought monitoring and early warning systems, including the Ministry of Science, Technology, and Innovation, the Ministry of Environment, the National Water Agency, the National Institute for Amazonian Research, the Center for Weather Forecasting and Climate Studies, and the National Center of Monitoring and Early Warning on Natural Disasters. Although all these actors

225. Bagley et al., 2014
226. Day, 2015
227. Ibid.
228. Gutiérrez et al., 2014; Water.org, 2019
229. Gutiérrez et al., 2014
230. PNRH defines guidelines and public policies to improve the supply and quality of water, manages demands while supporting sustainable development and social inclusion. (Ministério do Meio Ambiente, n.d.)
231. CNRH, n.d
232. Gutiérrez et al., 2014
233. Gutiérrez et al., 2014
234. ANA, 2019
235. Júnior et al., 2016
236. Gutiérrez et al., 2014

work together to mitigate the effects of drought, their roles and responsibilities could be better defined.[237]

DROUGHT MANAGEMENT STRATEGIES

A region facing drought can be declared in a situation of emergency (less severe) or in a state of public calamity (more severe). During the peak of the 2010-2015 drought, over 50% of the districts were declared in a state of emergency. This status releases federal funding to address the situation. However, contrary to Spain, the process of defining the disaster level does not follow a specific methodology. Situations of emergency or public calamity are declared on a case-by-case basis, without a specific list of criteria. As a result, declarations can be politically motivated and can lead to ineffective responses. To reduce demand during the drought in São Paulo, the government developed financial incentives and reduced water pressure by 75% in the evenings. Other less affluent cities only had access to water once every three days.[238]

To address the drought of 2014-2015 in São Paulo, SABESP, the city's water utility, encouraged residents to use less water by rewarding those who dropped their water use significantly. The program aimed to reduce water use by 20% in comparison to the previous year. In cases of success, customers would get a 30% bonus on their water bill. The tariff bonus program encouraged the population to adopt more conservative water consumption. SABESP awarded bonuses to 53% of its customers. Another 23% used less water, but not enough to qualify for the discount.[239]

Despite advertising campaigns calling for responsible water use and the bonus, 24% of residents still used more water. As a result, SABESP introduced a contingency fee to charge people who used more than the desired amount. The contingency tariff was applied to everyone, including clients with established demand contracts, such as industry and commerce companies. SABESP's financial stability was affected by the drought. Net profit fell by almost two-thirds in 2014 and 2015. SABESP increased water and sewerage tariffs by 15.2% to try and recover some funds.[240]

By July 2015, 83% of people in the metropolitan area dropped their water usage and 73% received bonuses. SABESP also replaced old pipes, altered water pressure, and provided guidance on the use of water meters. This led to an estimated 23% drop in water use and the discount incentive scheme achieved a further 19% drop in domestic use. Authorities diverted water from systems that still had enough left. Pipe systems led water from the Billings reservoir, the Río Pequeño, and the Río Grande to the Taiaçupeba water treatment station. Within a couple of months, they expanded the treatment capacity of another, the Guarapiranga system, from 14 to 16 million l/s. They also launched intense and comprehensive programs to cut water losses. By February 2016, water levels at the main reservoir had more than doubled due to rains.[241]

HydroBID: REDUCING VULNERABILITY TO DROUGHT EVENTS AND THE EFFECTS OF CLIMATE CHANGE IN PERNAMBUCO

The state of Pernambuco has 1,300 cubic meters (1,300,000 liters) per capita of water reserves, which is below the limit of water stress conditions (1,500 cubic meters or 1,500,000 liters). As one of the nation's main textile centers, the region has significant economic potential. The water supply needs to be optimized through a system of 26 reservoirs to meet urban demand. HydroBID was part of a decision-making support system for the *Agência Pernambucana de Águas e Clima* (APAC). The system was implemented to help APAC evaluate different strategies focused on maximizing available supply during drought periods (Figure 11).

HydroBID was used to facilitate operational decision-making by establishing a water supply and demand management system based on short- and medium-term forecasts. The system focused on emergency response and early warning signs to manage sectoral and seasonal demand and to define vulnerabilities. The system also incorporated economic projections and pre-established strategies for emergency management.

237. Ibid.
238. Gutiérrez et al., 2014; Marengo, 2016; Watts, 2014
239. 50 Liters, 2018
240. Ibid.
241. Ibid.

FIGURE 11. CAPAC's main operating reservoirs in Pernambuco, according to HydroBID data.[242]

LESSONS LEARNED

Lessons learned that can be highlighted include:

- Action across many areas is necessary to manage drought, including public opinion, political, legal, and technical points of view.
- Rules for allocating and rationing water should be decided together by stakeholders before the drought.
- Rules for public participation should be set before drought hits.
- Water systems are complex and should be analyzed as a whole.
- Technical expertise is essential.
- A drought management plan must be in place before drought starts.
- A communication plan is key.

LEARN MORE

To find out more information about water security and infrastructure needs throughout the LAC region, please read:

- A CLEWS Nexus Modeling Approach to Assess Water Security Trajectories and Infrastructure Needs in Latin America and the Caribbean

To find out more about the IDB's efforts to build adaptive capacity in the region, particularly in Bolivia, please read:

- Building Transformative Institutional Adaptive Capacity: Assessing the Potential Contribution of PPCR to Build a Climate Resilient Water Governance Framework in The Plurinational State of Bolivia

242. IDB, 2020

SOUTH AFRICA
AN UPDATE ON CAPE TOWN

BACKGROUND

In 2018, Cape Town was on the verge of running out of municipal water. City officials designated "Day Zero" as the exact time all taps would be turned off, if dam levels reached below 13.5%.[243] At that point, residents would get daily allocations of 25 liters.[244] The middle class would have to queue for their daily ration, like informal settlements do every day, regardless of drought conditions.[245]

Cape Town's water system was originally designed for the predictable climate of the region.[246] Six inter-linked reservoirs, fed by rainfall and runoff from the Boland Mountains, provide 95% of Cape Town's water, as well as water for the region's agriculture needs and other urban areas.[247] The combined total storage volume is about 900 billion liters of water, which should provide enough water for approximately 1.5 years of normal agricultural and urban usage.[248] The integrated WCWSS (Western Cape Water Supply System) is managed by the National Department of Water and Sanitation (DWS) in cooperation with the city.[249] The city receives water from the WCWSS and is responsible for providing basic services to its residents and planning current and future water management.[250] Unfortunately, after years of record drought (Figure 12), this system lacked the capacity to meet the demand of Cape Town.[251] In fact, in 2017, rainfall was the lowest ever recorded since the first written reports in the 1880s.[252]

AVOIDING DAY ZERO

Cape Town began addressing drought years before its most acute period in 2017. Water conservation and demand management have been central to the city's water management since the early 2000s. Water strategies included fixing leaks and installing water management devices. Household water management devices that restrict supply to a predefined daily quota of 350 liters were introduced in Cape Town as early as 2007.

In October 2017, the mayor launched a daily water meeting with a broad group of people, ranging from technical to communication experts. The Water Dashboard was launched in November 2017, which gave weekly updates on dam levels and water use on the city's website. The dashboard became widely accessed at the height of the drought as a reliable source of information.

City Council appointed a Water Resilience Task Team in May 2017, headed by the Chief Resilience Officer, based in the Directorate of the Mayor. The team was politically accountable to the Executive Mayor, and the mayor was closely engaged in the process. The Task Team finalized a Water Resilience Plan on May 31, 2017 that prioritized the emergency and tactical phases. It set a goal of securing 500 megaliters of non-surface water and a target of reducing water usage to 500 megaliters a day, down from 1,000 megaliters in early 2016.[253]

243. LaVanchy et al., 2019; Ziergovel, 2019
244. LaVanchy et al., 2019
245. Ziergovel, et al., 2019
246. LaVanchy et al., 2019
247. Ziergovel, 2019
248. Ibid.
249. Ibid.
250. Ibid.
251. LaVanchy et al., 2019
252. Wolski 2018
253. Ziergovel, 2019

FIGURE 12. Change in % of total capacity of Cape Town reservoir system between 2014 and 2017.[254]

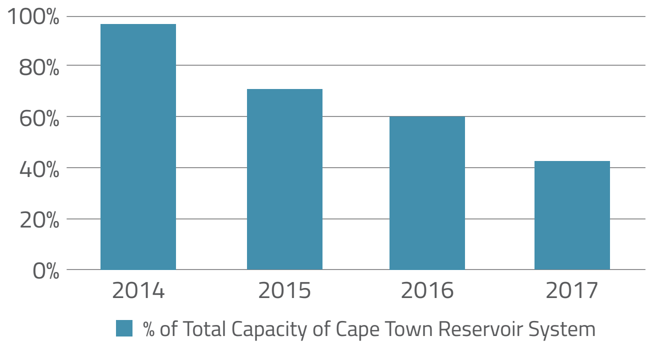


FIGURE 13. City campaigns samples.[258]

a) City campaign sign "*Together we can avoid Day Zero*"

b) City campaign sign offering guidance on how to limit daily water usage to 50 L.

A focus was put on ensuring everyone in the city was aware of the crisis. During the drought, the implementation of flow restrictors, or Water Management Devices, were scaled up to target households using large amounts of water. This led to installations in both high-income and low- income areas, unlike previously when they were targeted at low-income households. Treated effluent reuse schemes were scaled up to increase the amount of potable water that could be off-set.[255]

All residents had to limit individual daily use to 87 liters (87 LPD) and outdoor use was restricted to bring collective consumption to 500 million LPD. Seeing that these restrictions were not enough, the city placed a limit of 50 LPD in February 2018. Water ambassadors rallied around the city and a Facebook page was created to build peer pressure to reduce consumption among affluent residents. Cape Town launched a large marketing campaign, "Together we can avoid Day Zero" (Figure 13 a, b). Water meters were installed on pipes of heavy users, fines were levied for excessive outdoor use, and an online map[256] was created to shame households that did not comply. As a result, daily total demand fell to 481 million LPD. No other city has ever achieved this level of reduction without resorting to intermittent supply. In 2018, the IWA recognized that accomplishment with an award for achieving a 55% reduction. Eventually, citizen efforts and the arrival of winter rains led the city to call off "Day Zero". [257]

254. LaVanchy et al., 2019
255. Ziergovel, 2019
256. The map was discontinued in January 2019 and data from previous years is not available.
257. LaVanchy et al., 2019; Ziergovel, 2019
258. LaVanchy et al., 2019

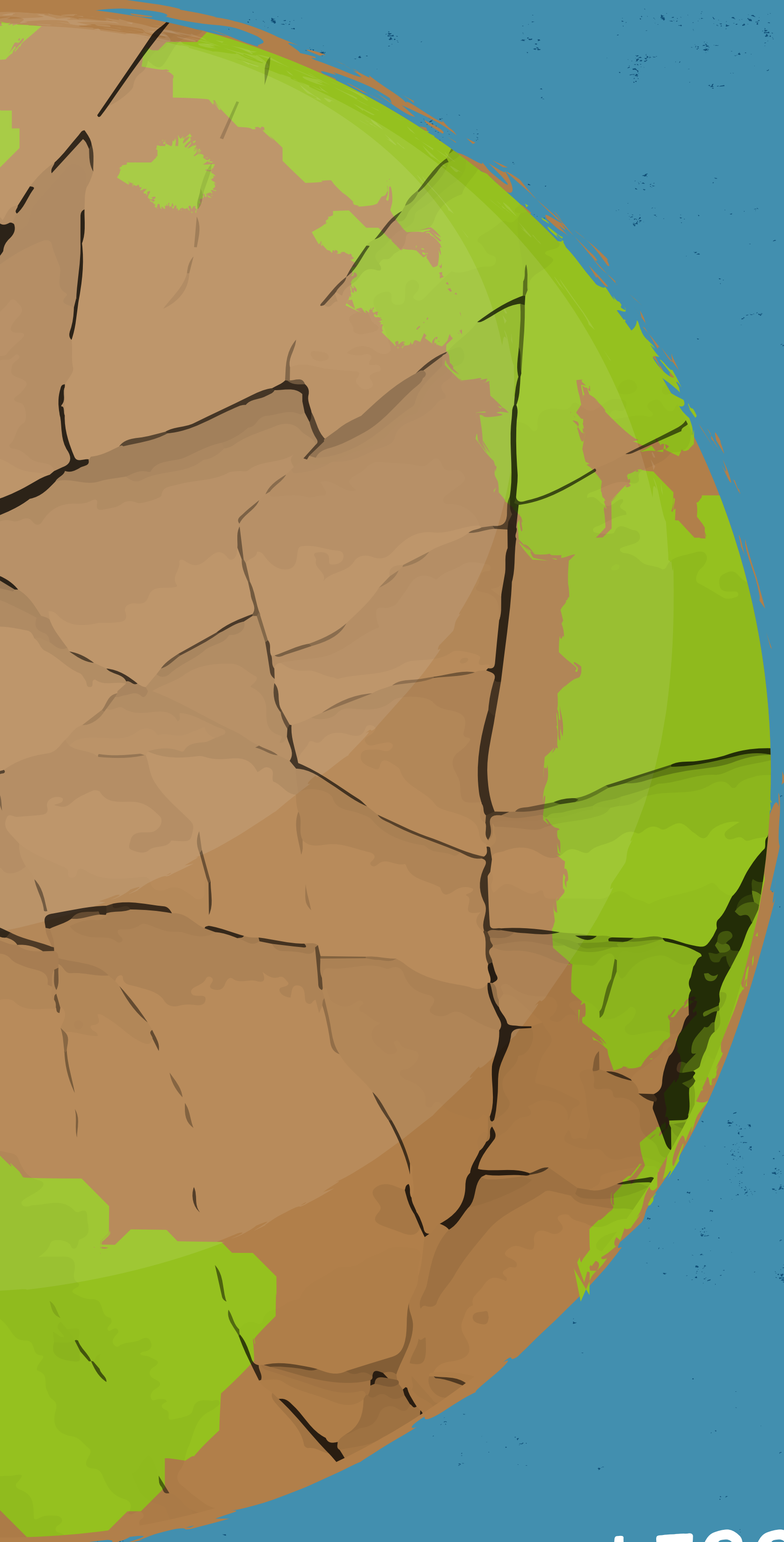
Although incrementally reducing water targets helped Cape Town avoid Day Zero, it is not an effective long-term drought management strategy.[259] While dam levels have increased since the drought, they have yet to reach pre-drought levels.[260] Daily water use has also increased since the lifting of the 50 LPD limit.[261] Cape Town's Deputy Mayor, Ian Neilson, is aware of the limitations of current water practices: "*[Although] we can safely get through the summer of 2019, we have to ensure that we make a permanent change to our approach to water usage*".[262] Diversifying water sources by adding groundwater or desalinated water is more sustainable and places less pressure on the end consumer.[263] Improving data collection, knowledge, and communication efforts will also help Cape Town better address the next significant drought situation.[264] Approximately 20% of Cape Town's population lives in townships, crowded, poor neighborhoods that do not have access to stable water and sanitation services.[265] Township residents face daily water restrictions and only consume 4% of the city's water.[266] The city's failure to diversify water supply with groundwater, recycled, or desalinated water contributed to the severity of the Day Zero crisis.[267]

LESSONS LEARNED

The water crisis has prompted changes in the way the city works and responds to crises; however, it is not clear whether these changes will be permanent or whether some of them rely on personal relationships formed during the 2015-2018 water crisis. The city's water department also now has a clear understanding of the need to engage more with its customers, water users, and it is setting up a customer relations unit. During the crisis, the city took ownership of issues that had previously been within the domain of national government. When there is a crisis, the utility wants people to reduce their use, which also means less revenue, and yet, infrastructure still needs to be financed. The water crisis has prompted changes in the way the city works and responds to crises.[268]

The main recommendation was that highest priority should be given to demand management and to developing groundwater sources, and that the city consider reducing the number and size of the emergency small desalination plants. Concern was raised about how to finance emergency investments. The restrictions went hand-in-hand with tariffs. Special permission was obtained from the National Treasury to change the tariff within the year. The cost of water for non-domestic use, which accounts for about 30% of city usage, more than doubled, making it very expensive to use more water than restrictions allowed. Commercial and industrial water use declined by about 20%. Domestic water savings accounted for most of the drop in demand. On March 7, 2018, Day Zero was cancelled. Cape Town developed a water strategy that was finalized in 2019.[269]

259. Ibid.
260. Alexander, 2019
261. Ibid.
262. Shapiro, 2018
263. LaVanchy et al., 2019
264. Ziervogel., 2019
265. Shapiro, 2018
266. Ziergovel, 2019
267. LaVanchy et al., 2019
268. Ziergovel, 2019; Nicolson, 2019
269. Ziergovel, 2019



LESSONS LEARNED

TOP 5 LESSONS LEARNED

for future droughts

1. ADAPT TO CLIMATE CHANGE

Become better prepared to deal with prolonged droughts. Cape Town was and continues to be underprepared. **Over 95% of the city's water comes from surface water dams.** After three years of below average rainfall, the lowest on record, the dams are now running on empty.

2. FOSTER CITY LEADERSHIP

Local governments are in a better position to take decisive action and act at a local scale, where **they can engage citizens, communities, and businesses in averting the water crisis.** National governments are often slow to intervene, and when they do, their actions are often not at the right scale or timely enough.

3. MEASURE MORE, MANAGE BETTER AND PLAN FOR UNCERTAINTY

A city or town **without reliable data struggles to implement strategic plans and priorities.** If cities are going to be more resilient and responsive to climate change, a search for new water supplies will be necessary. It is also essential to establish new forms of governance. Innovative approaches need to be explored because we might not yet know what these should look like.

4. AVOID MIXED MESSAGES

Public responses to communication and messaging put out by local authorities is often unpredictable. **What citizens really want to know is what actions are being taken to alleviate the crisis and alleviate the risk.** In the case of Cape Town, the city has been reporting on the state of water by supplying information on dam levels, water demand, models and water quality. Challenges persist, such as containing the level of disinformation shared in the public domain and media.

5. BUILD PUBLIC TRUST

Trust is strengthened by honest, transparent and credible messaging when progress toward averting the crisis is demonstrated and understood. It gains momentum when citizens' voices are heard and when politicians and officials respond accordingly.

LESSONS LEARNED FOR FUTURE DROUGHTS

Effective drought preparedness surpasses traditional crisis response, is site-specific, strategic, proactive, and well-coordinated. It involves prevention, mapping, monitoring and early warning systems, as well as disaster response. All members involved should have clear and specific roles and responsibilities.[270]

The following section includes a list of lessons learned by theme. These lessons can be used to improve water scarcity and drought management worldwide.

GOVERNANCE

- Governments should promote and support the empowerment of communities to holistically manage water resources.[271]
- Governments should plan, support, and promote the implementation of best agricultural practices, particularly for small-scale farmers, suited to the local environment and context.[272]
- Local authorities should use accountability tools to build confidence and encourage purposeful dialogue between the state and communities to improve public investment and preparation for drought events.[273]
- Water management planning and practices should be directed by technical criteria; a sound technical entity is key.[274]
- Water decisions should be based on a transparent and well-informed process with inter-institutional, interdisciplinary focus and participation of key stakeholders (including central and local authorities, academia, and civil society, among others).[275]
- Ensure the implementation of water resource and drought management plans.[276]
- Incentivize research and development focused on improving efficiency in water use, planning, and management.

PLANNING

- The long-term responses to drought by the state, private sector, and civil society are essential.[277]
- Proactive water management and use is the most effective or cost-efficient practice in the long-term.[278]
- Governments should prioritize slope protection to guarantee adequate water quantity and quality for human, agricultural, and other uses.[279]
- Governments should conserve, protect, and restore key forest areas for the provision and regulation of water supply. Watershed management is key to protect water sources and conserve soil humidity, which, in turn, can support crops during times of crisis.[280]
- Accurate monitoring and information management systems on hydro meteorological conditions, including drought cycle, facilitate proactive decision-making.[281]
- Planners should recognize the heterogeneity of access and develop context-specific solutions.[282]
- There should be a comprehensive national archive on the effects of water scarcity and droughts to determine if programs are effective in risk reduction.[283]
- Diversifying water sources can reduce the likelihood of municipal water cuts.[284]
- Include climate change adaptation and mitigation actions in water management and planning. The implementation of actions to reduce vulnerability to water scarcity is key, as well as measures oriented toward decreasing greenhouse gas emissions.

270. Gutiérrez et al., 2014
271. Accion contra el Hambre et al., 2014
272. Ibid.
273. Ibid.
274. Ibid.
275. Júnior et al., 2016
276. Ortega-Gaucin et al., 2016
277. Garreaud et al., 2017
278. Hervás-Gámez et al., 2019
279. Accion contra el Hambre et al., 2014
280. Ibid.
281. Ibid.
282. Gutiérrez et al., 2014
283. Ibid.
284. LaVanchy et al., 2019

MANAGEMENT

- There is no "one-size-fits-all" solution to droughts. Diversifying water sources can reduce the likelihood of municipal water cuts in regions with multiple water sources.[285]
- Governments should develop and implement watershed management plans to effectively mitigate droughts.[286]
- The community diagnostic is an important tool for consultations, empowerment, and drought incidences.[287]
- Governments should use local water scarcity and drought risk management plans to coordinate responses.[288]
- Evidence-based records of water scarcity and drought incidence at the national and local level are necessary to improve drought cycle management.[289] Considerations of climate change scenarios are essential to adequately design and implement water management and planning actions.
- Local nonprofits should integrate water scarcity and drought risk management into official and non-official educational tools to promote the appropriation of this content.[290]
- Water scarcity and drought monitoring systems should be user-friendly to help planners develop effective and forward-thinking policies and practices.[291]
- Drought management plans (DMPs) should be live documents that adapt recommendations to changing climate conditions. They should also set clear strategies for water use priorities and drought management systems.[292]
- Water managers should mitigate the effects of water overexploitation to protect ecosystems and biodiversity.[293]
- Water management including drought policies should have clear definitions of the roles and responsibilities of the river basin committees and other management parties.[294]
- Although not part of a sustainable strategy, launching campaigns, installing water meters, developing a usage map, enforcing fines, and reducing water targets incrementally can reduce citywide consumer demand significantly in crisis situations.
- Water managers should understand water users' behavior during water shortages to manage supply and demand effectively.[295]
- Integrated water management is key with intersectoral and interdisciplinary coordination as well as participation of stakeholders from the public and private sectors, academia, and civil society.

INFRASTRUCTURE

- Local communities should establish seed banks to ensure access to quality seed during periods of drought.[296]
- Desalination projects should be adapted to local conditions, contain a specific control system to maximize the life of the equipment, and involve local communities in the initial stages.[297]
- Reuse of municipal wastewater provides a stable source of water for irrigation purposes, reduces pressure on conventional sources of water, and reduces pollution from municipal sewage.[298]
- Consider nature-based solutions. Healthy ecosystems increase drought resilience.
- Updating/maintaining infrastructure can reduce water waste.

285. Ibid.
286. Accion contra el Hambre et al., 2014
287. Ibid.
288. Ibid.
289. Ibid.
290. Accion contra el Hambre et al., 2014
291. Iglesias et al., 2009
292. Hervás-Gámez et al., 2019
293. Friedler, 2001
294. Gutiérrez et al., 2014
295. Booysen, 2019
296. Acción contra el Hambre et al., 2014
297. Subiela et al., 2008
298. Friedler, 2001

BEHAVIOR CHANGE

- Promote rainwater collection in areas with a water deficit, through culturally appropriate and socially sustainable technologies.[299]
- Develop awareness campaigns on sustainable water use and drought risk management to inspire an efficient water use and management culture.[300]
- Involve local promoters through participative processes to guarantee the diffusion, appropriation, and replication of water scarcity and drought knowledge and best practices by communities.[301]
- Implementing a broad nationwide campaign on sustainable water use with focus on water scarcity and drought scenarios and their consequences can encourage more responsible consumer behavior.[302]
- Water conservation should be part of curricula to educate the next generation.[303]
- Empowered communities can better manage water resources, particularly if women are included in the dialogue.[304]

INNOVATION

- Developing virtual drought and water scarcity scenarios and decision support planning systems (ie.: robust decision-making, info-gap theory, dynamic adaptive policy pathways) should help facilitate better site-specific drought management policies.[305]
- Governments should incentivize innovation for the development, adaptation, and real-world testing of innovative solutions.[306]

299. Acción contra el Hambre et al., 2014
300. Ibid.
301. Acción contra el Hambre et al., 2014
302 .Ortega-Gaucin et al., 2016
303. Siegel, 2015
304. Accion contra el Hambre et al., 2014
305. Ortega-Gaucin et al., 2016
306. Siegel, 2015

Conclusion

Drought preparedness measures are part of increasing the adaptive capacity and resilience of cities and countries. While the countries studied differ on exact drought strategies, most have shifted from crisis responses to more proactive mitigation efforts. Spain developed drought mitigation plans to manage water resources under drought conditions in each region. The Canary Islands have dealt with water scarcity for decades through desalination and wastewater reuse. Chile and Mexico privatized their water, giving the consumer more control over the resource. By contrast, Brazil maintained public water and developed national water management policies. Thanks to a combination of demand reduction strategies and the arrival of winter rains, Cape Town was able to avoid Day Zero.

Nonetheless, several challenges persist, particularly in the Dry Corridor, including the update of existing legal frameworks and/or incentives to promote sustainable water use; enforcement of the aforementioned legal frameworks; the establishment or strengthening of institutional settings and technical capacities; the establishment and consolidation of partnerships with the private sector; and coordination with and participation of national and local stakeholders, including indigenous communities; among others. International organizations such as the IDB can help countries address these issues. This compilation of case studies offers valuable information on the variety and success of drought responses.

COVID-19 reinforces the need for access to water, access that is hampered by water scarcity and droughts that are being exacerbated by climate change. This situation highlights the urgency for improved water management in response to climate change as well as climate action that will contribute to sustainable development while tackling the ongoing health crisis.[307]

307. Armitage and Nellums, 2020.

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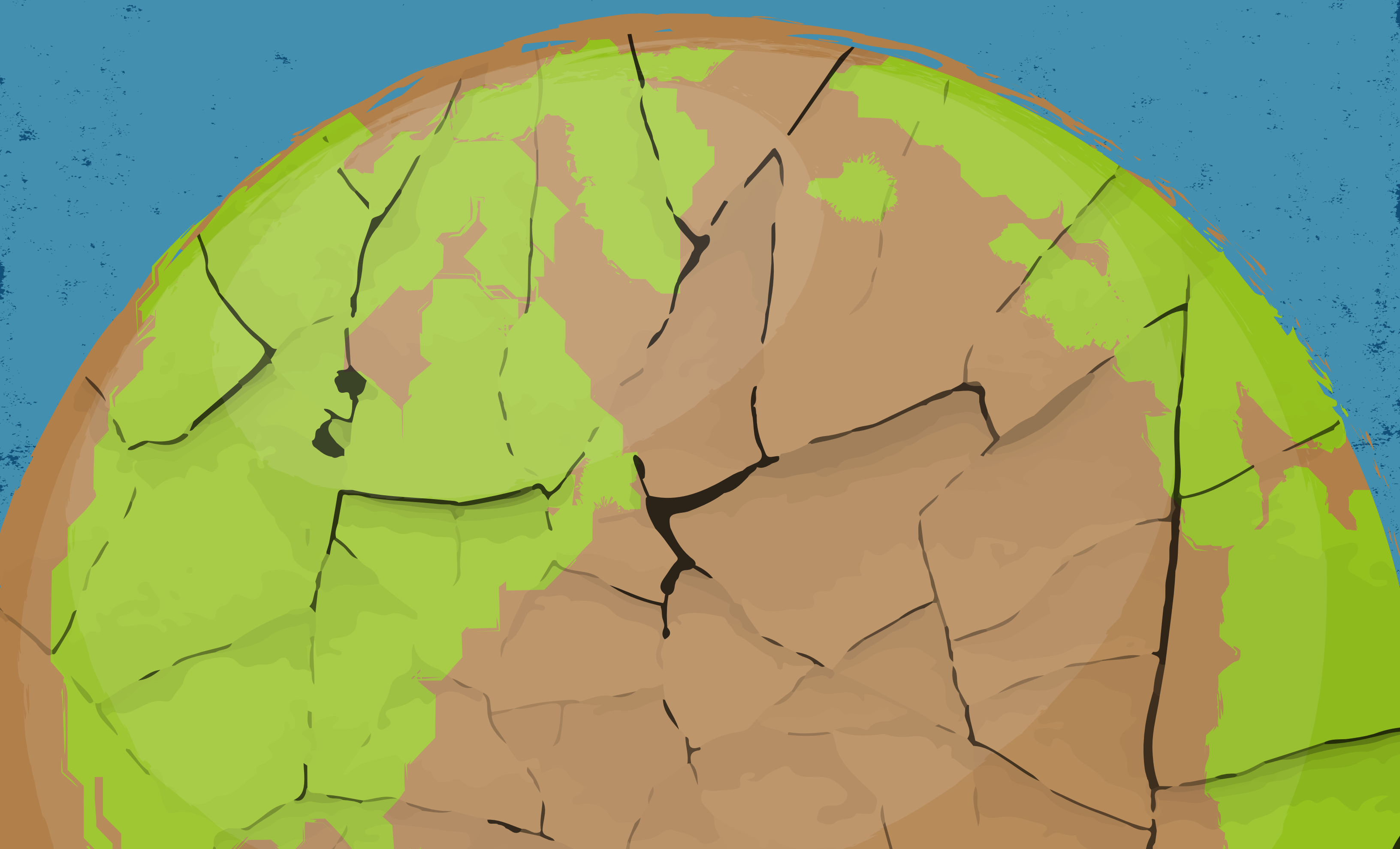
APPENDICES



APPENDIX 1:

HydroBID a tool to support water resource management in Latin America and the Caribbean

The sustainable development of Latin America and the Caribbean depends on the region's ability to achieve water, food, and energy security. Effective water resource management has become essential to maintaining water availability. Analyzing short-, medium-, and long-term variations in water levels helps decision makers design and implement measures that mitigate the negative effects of anthropogenic changes (ie. population growth, changes in soil use, infrastructure development) and climate change (ie. temperature and precipitation variations, and changes in the incidence and frequency of extreme events such as droughts).

Efficient resource management requires accurate climate information and estimates of the changes in water levels of hydrographic basins due to natural and artificial pressures. That is why the IDB supported the creation of HydroBID, a hydrologic simulation tool specifically developed for Latin America and the Caribbean. The system contains a database of characteristics and topology of more than 300,000 basins connected to rainfall/runoff and demand models to analyze daily, monthly, and annual water balances at the basin, sub-basin, and micro-basin levels. The tool also integrates the effects of climate change through statistical downscaling (using the Delta method).

HydroBID has been implemented by agencies and operators in **17 countries since 2016**.

Drought analysis played a major role in most of these implementations, particularly in Chile and Brazil (see country sections).

For more information on HydroBID, please visit:

WWW

iadb.org/en/water-and-sanitation/hydrobid

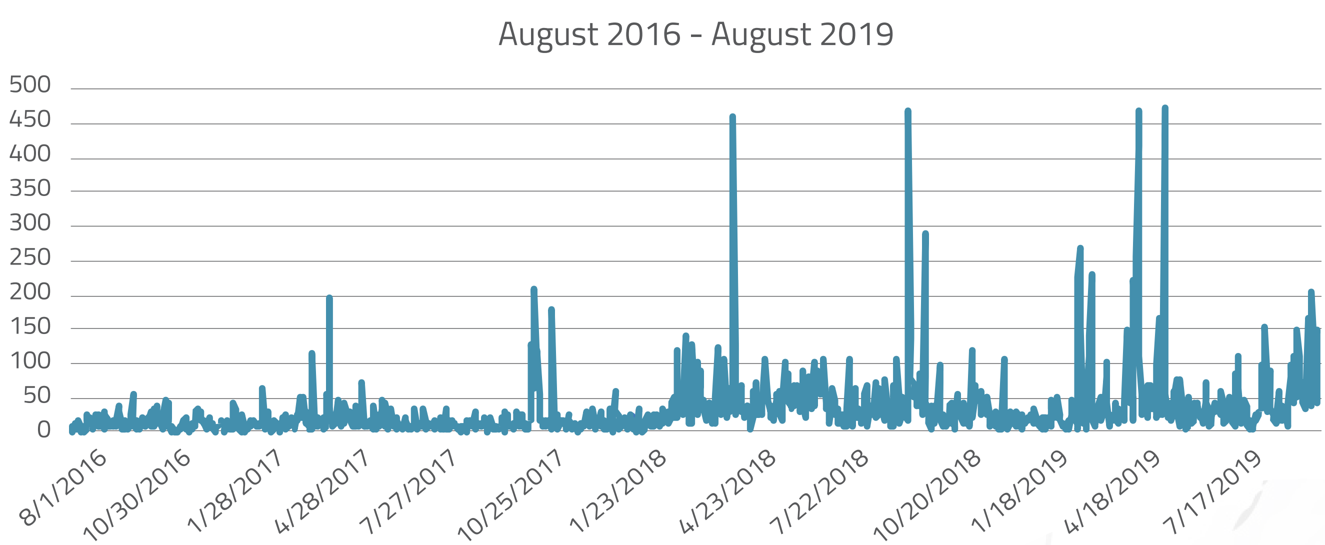
Source: Moreda *et al.*, 2014; Nalesso *et al.*, 2014

APPENDIX 2:
Digital Conversations on Drought

Numerous social media users have shown an increased interest in climate change, drought, and its impact on water resources and economies around the world. In today's age of social media, it is possible to track how often people tweet about drought at a national level.

Using Brandwatch software, we determined how many times Twitter users tweeted drought-related terms (ie. "sequía", "escasez de agua", "gestión de recursos hídricos", "recursos hídricos", "cambio climático", "falta de agua" or "faltar agua", "falta de lluvia", or "cuenca") in Bolivia, Chile, El Salvador, Guatemala, Honduras, and Mexico between August 2016 and 2019. Over half of the tweets studied were from Mexico, due to the higher number of Twitter users relative to the other countries. Most of the Mexican tweets discussed the water shortage and high levels of contamination in Monterrey due to population growth and failure to adopt water-saving practices. Overall, the highest volume of tweets occurred on April 14, 2019, with the majority coming from El Salvador (411/475 tweets). Most of these tweets discussed the drought in Metapán, a region in the north of El Salvador, and lack of government action. The second highest volume of conversation in each of the countries analyzed was March 22, 2019, coinciding with World Water Day. There was also a high number of drought-related tweets on March 22, 2018.

GRAPH 1. **Total number of drought-related tweets in Bolivia, Chile, El Salvador, Guatemala, Honduras, and Mexico.**

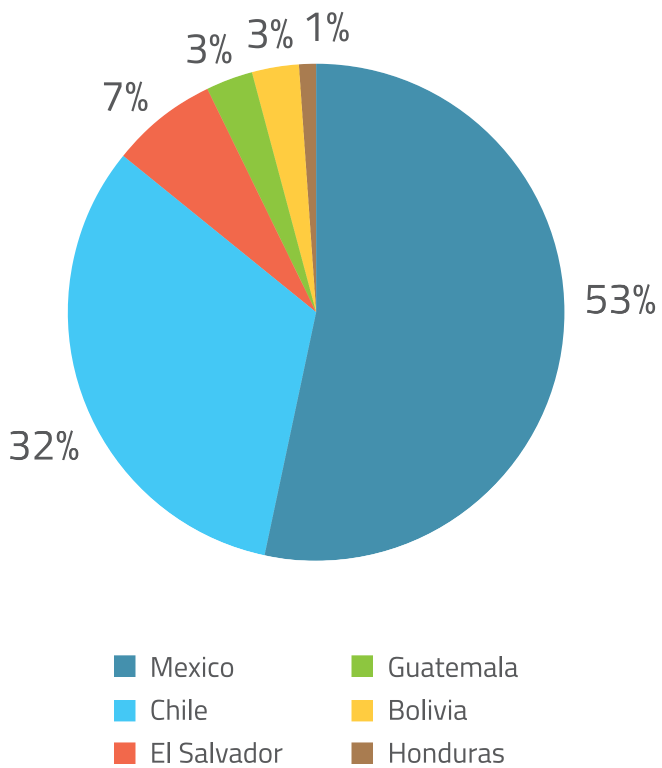


Over half of the tweets studied were from Mexico due to the higher number of Twitter users, relative to the other countries.

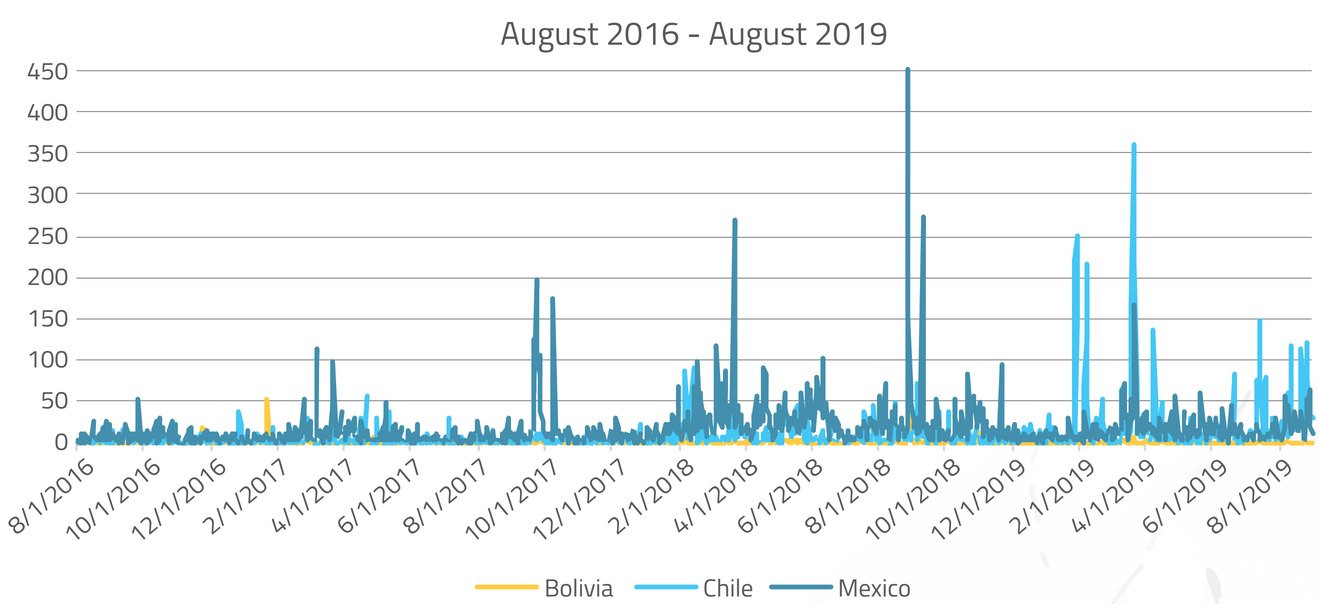
Citizens from Chile and Mexico tweeted more about drought than those from Bolivia. The highest number of tweets from Chile occurred on March 21, 2019, the day before World Water Day. Bolivia reached the peak number of tweets on January 21, 2017, when the government announced it would guarantee 12 hours of water per day for southeastern neighborhoods of La Paz affected by drought.

Residents from Honduras tweet less about drought than those from El Salvador and Guatemala. The number of tweets from Guatemala was highest on June 2, 2018 when José Fernando Mazariegos, a famous local inventor, passed away. He was known for developing the Eco Filter[308] after studying water access issues in rural areas. Honduras tweeted the most about drought on March 22, 2019, World Water Day.

GRAPH 2. Origin of tweets analyzed.

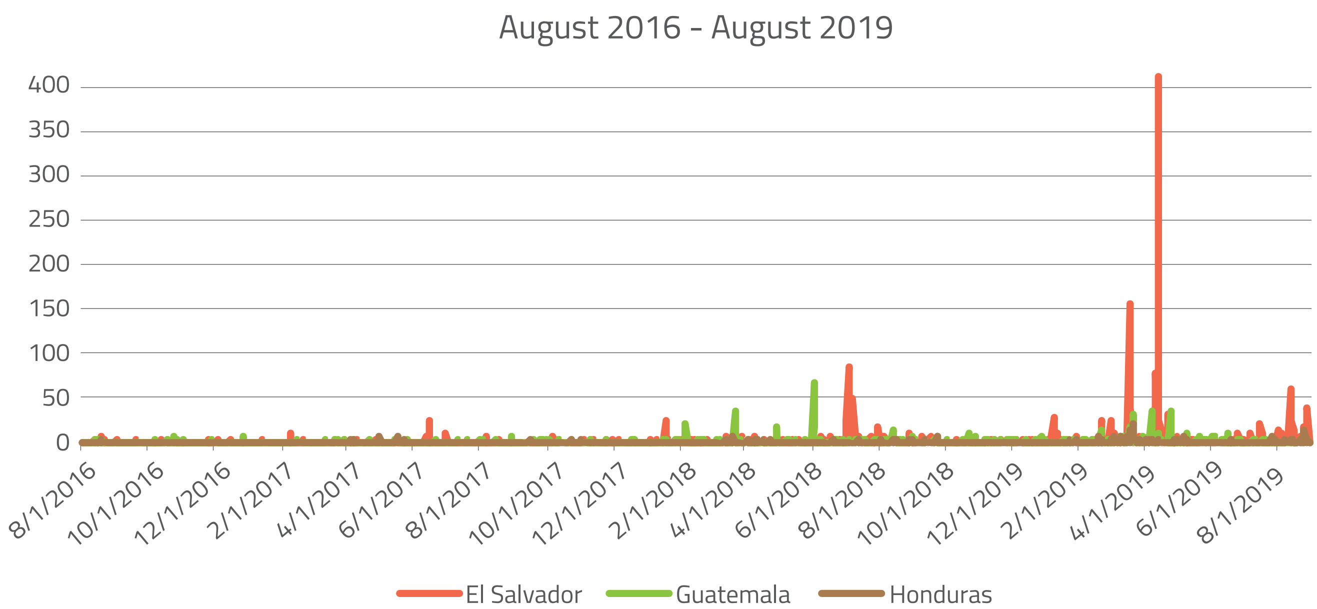


GRAPH 3. Overview of peak number of tweets for Bolivia, Chile, and Mexico.



308. The eco filter "Ecofiltro" purifies water at a low cost and is made of pine sawdust, mud, silver and a natural antibacterial. (Morales et al., 2018)

GRAPH 4. Overview of peak number of tweets for El Salvador, Guatemala, and Honduras.



APPENDIX 3:

Water Fund Alliance

An excellent example to promote water security through nature-based solutions (NBSs) across LAC is the Water Funds Program, funded by the IDB in alliance with TNC and the Femsa Foundation. Water funds promote long term watershed conservation for both humans and biodiversity, and as of 2014, there were 30 funds in operation or development in LAC. Such programs can promote water security in cities and reduce flood risks, but there is a current lack of sufficient information to develop NBS that are city and watershed specific. To date, the most effective use of NBS has been for small watersheds, where small conservation areas are needed and lower financial input can be expected. Finally, while assessment of societal values from ecosystem services is well developed in LAC, payments for services have received considerable attention but have received limited attention throughout the region.

Currently, 40 Water Fund initiatives, at different stages of implementation, are providing a financing mechanism to protect water basins and support long-term environmental services. The funds facilitate water resource management, promote conflict resolution, and support the conservation of green infrastructure in Brasil, Mexico, Colombia, Peru, Ecuador, and the Dominican Republic.[309]

For more information on the Water Fund Alliance, please visit:

www.fondosdeagua.org/en

309. Bretas et al., 2020

APPENDIX 4:
IDB's Transboundary Waters Program[310]

The LAC region contains some 67 international drainage basins. In fact, 60% of the land area in South America are international drainage basins. Nonetheless, management and governance of these waters are not effective; none of the countries have ratified global conventions providing the basis framework for transboundary cooperation. There has been a reluctance to develop legally binding instruments or to ratify global conventions. Only 11 of the 67 basins have operational arrangements for water cooperation. Thus, the region is not well equipped to address environmental issues that extend across international borders.[311]

The IDB's Transboundary Waters Program aims at enhancing the governance and management of transboundary waters in LAC to guarantee the sustainability and scalability of investments. It relies on solid alliances among countries and specialized organizations, such as the Spanish Agency for International Development Cooperation (AECID), the Cooperation Fund for Water and Sanitation (FCAS), and the Latin American Investment Facility (LAIF).[312]

For more information on the IDB's work on transboundary water issues, please visit:

WWW

https://publications.iadb.org/publications/english/document/Joined-by-Water-JbW-IDBs-Transboundary-Waters-Program.pdf

310. Transboundary waters designate any surface and/or subsurface water which form a unique drainage basin and are situated in two or more states. (Muñoz-Castillo et al., 2020)
311. Muñoz-Castillo et al., 2020
312. Muñoz-Castillo et al., 2020

IDB