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SWP SUSTAINABLE WATER PARTNERSHIP

WATER RESOURCES PROFILE SERIES

The Water Resources Profile Series synthesizes information on water resources, water quality, the water-related dimensions of climate change, and water governance and provides an overview of the most critical water resources challenges and stress factors within USAID Water for the World Act High Priority Countries. The profile includes: a summary of available surface and groundwater resources; analysis of surface and groundwater availability and quality challenges related to water and land use practices; discussion of climate change risks; and synthesis of governance issues affecting water resources management institutions and service providers.

Haiti Water Resources Profile Overview

Haiti is considered to be moderately water stressed. Total annual renewable water resources per person (1,278 m^3) are below the Falkenmark Water Stress Index[i] threshold for water stress.[1] However, freshwater abstraction rates relative to total renewable resources (13.4 percent) are below the water stress threshold under SDG 6.2[ii]. Haiti has 30 river basins but the Artibonite Basin covers approximately one-quarter of the country. Mountainous landscapes and extreme storms contribute to high geographic and inter-annual variability in rainfall and water availability.

Haiti is extremely vulnerable to water-related weather and climate impacts such as flooding and landslides. Climate change is also projected to make hurricanes and tropical storms more intense and cause more extreme droughts in the north. Vulnerability to climate change is compounded by high poverty, limited monitoring and disaster risk reduction systems, and poor infrastructure.

Deforestation has increased flood risks, reduced low-season flows, and hindered groundwater infiltration. Increasing erosion has also increased sedimentation in surface water, near dams, and on coastlines. Water quality has also declined due to turbidity. Deforestation has also increased vulnerability to climate change impacts. Reducing deforestation and restoring degraded watersheds is important for increasing water security.

Untreated municipal wastewater and effluent have increased pathogenic contamination and nitrates in surface water. This has increased public health risks and led to eutrophication in key surface water resources. Shallow groundwater is also susceptible to pathogenic contamination from untreated wastewater. This has increased public health risks in Port-au-Prince, Cap-Haitien, and Gonaïves where communities depend on shallow groundwater for drinking.

Overexploitation of coastal aquifers has increased the saltwater intrusion and degraded key resources for drinking water supply. Coastal aquifers in the Plaine du Cul-de-Sac, Île de la Gonâve, Plaine de l'Artibonite, Plaine du Nord, and Plateau Centrale are particularly at risk.

A lack of systematic groundwater monitoring of water availability and quality increases over-abstraction and contamination risks. These risks are especially pronounced in urban and coastal areas, including Port-au-Prince. A lack of information on groundwater also limits the potential for strategic use of these resources to buffer against surface water variability.

Poor coordination among water management entities and limited institutional capacity, financial resources, and enforcement impede water management. Haiti depends extensively on external funding from donors and foreign assistance to fill budget gaps.

[i]The Falkenmark Water Stress Index measures water scarcity as the amount of renewable freshwater that is available for each person each year. A country is said to be experiencing water stress when water availability is below 1,700 m^3 per person per year; below 1,000 m^3 is considered water scarcity; and below 500 m^3 is absolute or severe water scarcity.
[ii]SDG 6.4.2 measures water stress as the percentage of freshwater withdrawals against total renewable freshwater resources. The water stress thresholds are: no stress <25%, low 25%-50%, medium 50%-75%, high 75%-100%, and critical >100%.

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Water Resources Availability

KEY TAKEAWAYS

- Haiti has 30 river basins. The largest is the Artibonite Basin, covering approximately one-quarter of Haiti. Mountainous landscapes and exposure to extreme storms contribute to high geographic and inter-annual variability in rainfall and water availability.
- Many of Haiti's watersheds are understudied and there is limited knowledge of their water quality, volume, and resources.
- Although there is high uncertainty regarding groundwater availability and quantity, most groundwater is concentrated in alluvial plains and valleys covering a small portion of land area.

This section summarizes key characteristics of surface and groundwater resources. Table 1 summarizes key water resources data and Figure 1 presents key surface water resources, wetlands, and dams.

Surface Water Resources

Haiti has 30 basins and two-thirds of total water resources are in the west, center, and north.[2] The Artibonite Basin in central Haiti is the most water abundant and covers 25 percent of the country. The average flow of the Artibonite River is ten times greater than any other river in Haiti and is the largest in the Caribbean.[2,4] The Artibonite originates in the Dominican Republic and flows northwest through Lake Péligre, a 30 km^2 manmade reservoir. The lake is the second largest in Haiti and is used for hydropower and rice irrigation.[3] Lake Péligre is formed by the Péligre dam on the Artibonite River. The dam is the largest of eight main dams.[2] The brackish Étang Saumâtre (Lake Azuei) in the southern Cul-de-Sac Plain is the largest lake with an area of 113 km^2 and is shared with the Dominican Republic.[2,4]

The next largest basin is the Les Trois Rivières in northern Haiti.[3] Other important basins include the Estère in the center, Grande Rivière du Nord in the northeast, Grande Rivière du Jacmel in the southeast, and Grand'Anse in the southwest.[4] Most rivers originate in the Massifs du Nord, de la Hotte, and de la Selle mountain ranges in the north, southwest, and southeast, respectively.[2] Due to high temperature and evaporation rates, many smaller streams do not reach the ocean during the dry season.[5] Many of Haiti's watersheds are understudied and more research is needed to understand their water quality, volume, and resources.[3,6]

Groundwater Resources

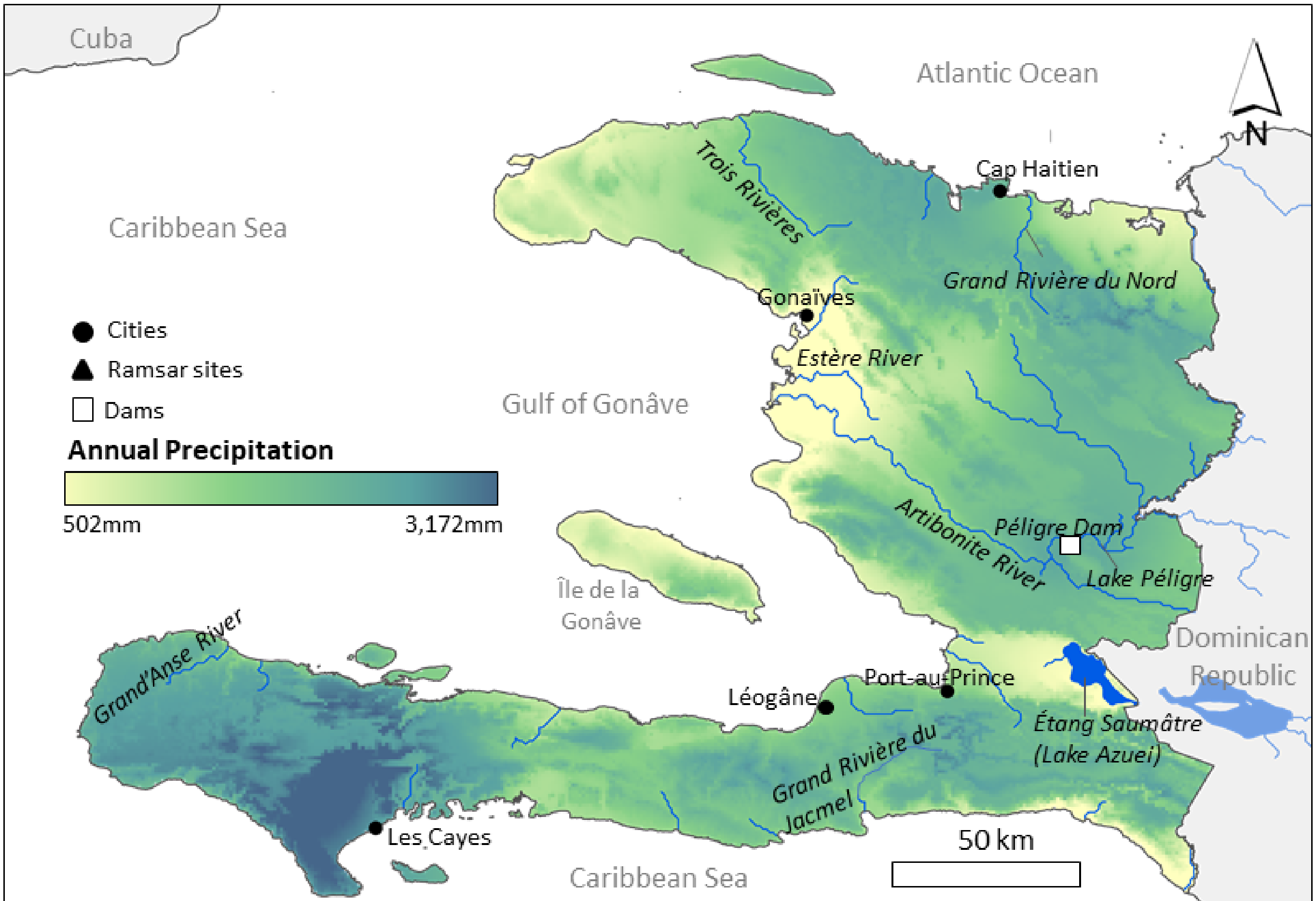
There is considerable heterogeneity in groundwater and uncertainty about aquifer characteristics, abstraction and recharge rates, flow regimes, and water quality. Approximately 84 percent of groundwater reserves are in alluvial plains and valleys that comprise just 17 percent of the country.[4] There are five main aquifer types:

TABLE 1. WATER RESOURCES DATA

	Year	Haiti	Central America and the Caribbean (median)
Long-term average precipitation (mm/year)	2017	1,440	1,880
Total renewable freshwater resources (TRWR) (MCM/year)	2017	14,030	12,425
Falkenmark Index - TRWR per capita (m3/year)	2017	1,278	2,756
Total renewable surface water (MCM/year)	2017	11,870	23,095
Total renewable groundwater (MCM/year)	2017	2,157	6,315
Total freshwater withdrawal (TFWW) (MCM/year)	2002	1,450	1,402
Total dam capacity (MCM)	2015	297	1,230
Dependency ratio (%)	2017	7.24	0
Interannual variability	2013	2.40	1.25
Seasonal variability	2013	1.90	2.40
Environmental Flow Requirements (MCM/year)	2017	3,188	2,687
SDG 6.4.2 Water Stress (%)	2002	13.37	5.30

Source: FAO Aquastat

FIGURE 1: MAP OF WATER RESOURCES



Source:
Cities: World Cities – ArcGIS Hub, **Country Borders:** GADM, **Dams:** FAO Aquastat Dams Database, **Ramsar Sites:** Ramsar Sites Information Service, **Lakes and Wetlands:** WWF - GLWD (Level 1), **Rivers:** WWF – HydroRivers, **Precipitation:** WorldClim, **Flood and Drought:** WRI Aqueduct 2019

unconsolidated alluvium (26 percent of land area), interior sedimentary (32 percent), reef carbonate (5 percent), semi-consolidated (21 percent), and igneous (15 percent). The unconsolidated aquifers, which make up most of Haiti's alluvial plains and valleys, are the best understood and most exploited. Wells in these aquifers have an average depth of 41 m and the highest yields.[8]

Surface Water Outlook

KEY TAKEAWAYS

- Surface water is vital for rice production in the Artibonite Basin and other lowlands.
- Land degradation and deforestation have exacerbated seasonality in water flow and availability. Severe erosion has led to sedimentation of surface waters and degraded water quality for drinking and irrigation.
- Inadequate wastewater treatment has rendered much of Haiti's drinking water non-potable. This has led to major public health crises and increased eutrophication, particularly near large cities including Port-au-Prince.

This section describes key sources of demand and uses of surface water, and associated challenges stemming from water availability and water quality challenges.

Surface water is vital rice irrigation. Around 13 percent of agricultural production is irrigated[2] and irrigation accounts for 83 percent of all freshwater withdrawals.[1] Approximately 82 percent of these withdrawals are from rivers and reservoirs.[2,9] Irrigation demand is highest in the lowland regions of the Artibonite Basin in central

Haiti, the Estère Basin in the west, the Plaine du Nord and Fort-Liberté Basins in the north, the Plaine du Cul-de-Sac near Port-au-Prince, and the Plaine de Cayes in the south.[2,11] An estimated 97,000 hectares (ha) are currently irrigated, though total irrigation potential is between 135,000-400,000 ha.[1,2,9] Rice is the most irrigated crop, accounting for 57,500 ha.[2]

Widespread deforestation has led to severe erosion, which has affected surface water flow and water quality. Forest coverage has declined from 60 percent in the early 1900s to 1.5 percent today.[8] Deforestation has increased soil erosion and runoff.[4,5] Every year, Haiti loses approximately 1,319 tons/km^2 of soil due to erosion. This has increased risks of landslides, particularly in rural areas.[9] Overall, 25 of 30 basins have experienced heavy erosion,[14] which have led to uneven flows throughout the year, sedimentation in dams and along the coasts, and more frequent floods in cities.[2] Sedimentation in Lake Péligre has reduced the reservoir's storage capacity by 58 percent since 1952[15] and total sediments in the lake have increased by 7.6 percent.[5] Deforestation and changing rainfall patterns have reduced surface water availability during the dry season[4,5] and caused many perennial streams to become seasonal.[8]

Deforestation has degraded water quality and increased turbidity. Since 1958, at least 7.9 million metric tons of sediment have been deposited in the Port-au-Prince Bay, increasing turbidity and total dissolved solids in surface waters.[5] The increased sediment has led to lower fishing catches, coral reef necrosis, fossilization of seagrasses, and migration of filtering organisms away from the bay.[5] Turbidity in Lake Péligre, which is 30 percent higher than the recommended limit to support aquatic life,[17] reduces aquaculture potential and leads to higher fish mortality.[18]

Limited sanitation and wastewater treatment has increased nitrification and microbial contamination of surface water.[2] In 2020, only 37.1 percent of the population had access to at least basic sanitation services and less than one percent used sanitation services connected to sewage networks.[21] Fecal coliforms have been detected in the Artibonite Basin[13] and Cryptosporidium oocysts, which are generally attributed to human fecal matter, have been found in surface water near Port-au Prince.[22] Untreated wastewater and industrial effluent has allow lowered concentrations of dissolved oxygen in the Port-au-Prince Bay.[23] High concentrations of nitrates and phosphates have also led to eutrophication in the bay[23] and in northern Haiti.[24]

Groundwater Outlook

KEY TAKEAWAYS

- Groundwater demand is driven by domestic and municipal use, particularly in Port-au-Prince, Gonaïves, Cap Haitien, and Logane. Groundwater is also used for industry and limited irrigation.
- The Cul-de-Sac, Gonaïves, and Massacre aquifers are overexploited. Low rainfall and land degradation have also reduced recharge rates.
- Municipal waste and industrial effluent contaminate shallow groundwater while coastal aquifers are increasingly threatened by saltwater intrusion.

This section describes key sources of demand and uses of groundwater, and associated challenges stemming from water availability and water quality challenges.

Groundwater is a vital resource for domestic and municipal use and provides up to 90 percent of the country's drinking water.[8] Information on groundwater abstraction is limited, but data suggest withdrawals for domestic use, industry, and irrigation range from 600 to 1,000 million cubic meters (MCM) per year.[8] This accounts for just under half to two-thirds of total water withdrawals.[1] Industrial demand is low at approximately 4 MCM per year.[5] Some regions rely almost exclusively on groundwater for drinking water supply. In Port-au-Prince, water is abstracted from springs (60 percent) or the Cul-de-Sac aquifer.[26] Groundwater is also used for irrigation in the northwest, north, and southeast, but at significantly lower volumes than surface water irrigation.[9]

The Cul-de-Sac aquifer is increasingly overexploited.[2,5,8,28] Port-au-Prince's municipal wells abstract an estimated 63,000 m^3 per day from the Cul-de-Sac aquifer[8] for industry, drinking water, and some agriculture.[26] Saltwater intrusion has become an issue as the water table has declined.[8] Over-abstraction is compounded by low recharge rates (5.4-6.9 percent), which have been exacerbated by extreme deforestation.[4,8] An additional 11.6 MCM of abstractions per year are planned in Port-au-Prince, which would exceed the aquifer's recharge potential and threaten its long-term sustainability.[29]

Contamination of shallow groundwater caused by municipal waste and industrial effluent is widespread near Gonaïves,[30] Cap Haitien,[24] and Port-au-Prince.[28] Cryptosporidium oocytes, indicating contamination from human or animal fecal waste, have been documented in groundwater near Les Cayes and Port-au-Prince.[22,31] Approximately 89 percent of wells near the town of Deschapelles in the Artibonite Basin were found to be contaminated with *E. coli*.[32] Bacterial contamination has also been documented in most hand dug wells on Île de la Gonâve.[27] Elevated concentrations of iron in the reef carbonate aquifer on Île de la Gonâve[8] and lead near Port-au-Prince are attributed to factory effluent.[28] In mountainous igneous aquifers, lead levels approach or exceed WHO guidelines[8,33] while high levels of lead, arsenic and chromium have been reported in hand-dug wells near the Étang Saumâtre.[20]

Aquifers are at risk of saltwater intrusion, particularly near coastal cities where there is over-abstraction.[8] Over-abstraction in coastal areas decreases groundwater flows towards the ocean and lowers the water table, allowing inflow of saline water. Rising sea levels and storm surges due to climate change could exacerbate these issues in the future. Salinity is increasing by approximately three percent per year near Port-au-Prince.[5] Aquifers on Île de la Gonâve, in the Artibonite Basin, in the Plaine du Nord, and in the Plateau Centrale also experience high salinity.[8,27]

Water Resources and Climate

KEY TAKEAWAYS

- Haiti is considered the most vulnerable country in Latin America and the Caribbean to climate change and is particularly susceptible to extreme storms and weather events. Climate change will intensify these events and increase the risk of flooding and widespread damage to infrastructure. Annual precipitation is expected to decrease while the risk of severe drought will increase.
- Climate change risks are compounded by high population growth, poverty, environmental degradation, poor infrastructure, and lack of monitoring and response mechanisms.

This section covers climate variability and climate change, their impacts on water availability and water quality, and the risks they pose to local communities and their economies.

Climate change is expected to reduce overall rainfall and increase drought severity. Haiti is considered the most vulnerable country in Latin America and the Caribbean to climate change.[39] Average annual rainfall is 1,440 mm,[2] however, mountains covering 75 percent of the country[34] influence rain and wind patterns, leading to regional and seasonal differences in precipitation.[2] Annual precipitation is up to 3,000 mm in mountains on the southwestern peninsula[6] and as low as 550 mm in the northwestern and southern lowlands.[4] Southern Haiti experiences two rainy seasons (March-June and August-October), whereas central and northern Haiti have one rainy season, from April-October and September-June, respectively.[2] Climate models project that annual rainfall will decline by the end of the century. In all modeled emissions scenarios, Haiti will experience reductions in overall water balance conditions, while the frequency of extreme drought will increase. The Nord-Ouest, Nord-Est, and Artibonite Departments are most susceptible to drought[11] and have already experienced delayed rainy seasons.[11] Droughts are expected to become more frequent in the Nord-Est, Nord-Ouest, Artibonite, and Centre Departments (Figure 1).[35]

More intense storms and flooding threaten livelihoods, health, and food security. Haiti is extremely vulnerable to hurricanes and tropical storms, which contribute to high inter-annual rainfall variability[8] and seasonal fluctuation of river flow.[2,8] Models suggest that for every 1°C increase in tropical sea surface temperature, hurricane surface wind speeds and rainfall rates in the Atlantic will increase by 1-8 percent and 6-18 percent, respectively.[37] By the end of the century, temperatures in Haiti are expected to increase by approximately 1.5° to 3°C[38] and overall hurricane intensity is projected to increase by 5-10 percent.[39] The 2008 storms affected more than 800,000 people, while Hurricane Tomas (2010), Hurricane Sandy (2012), and Hurricane Matthew (2016) inflicted widespread damage.[11] The Sud, Grande Anse, and Sud-Est Departments have the highest risk of hurricanes[11] and intense storms pose significant risks to Port-au-Prince and Gonaïves.[11,39]

Climate change risks are compounded by high population growth, poverty, environmental degradation, poor infrastructure, and lack of monitoring and response mechanisms.[11,35] Agriculture employs 66 percent of the labor force and accounts for 27 percent of the GDP.[35] Farmers in the Artibonite Basin and Plaine du Cul-de-Sac are vulnerable to flood risks, storm damage, and rising sea levels,[8] which are projected to rise between 0.13 and 0.4 m by 2030.[39] Low resilience and limited resources to respond to natural disasters have exacerbated water accessibility and quality issues. Natural disasters and poor maintenance have rendered more than half of the country's water supply irrigation infrastructure defunct and water quality has declined following storms and earthquakes. For example, a majority of wells were found to be contaminated with fecal coliforms following Hurricane Sandy.[44]

FIGURE 2: DROUGHT RISK

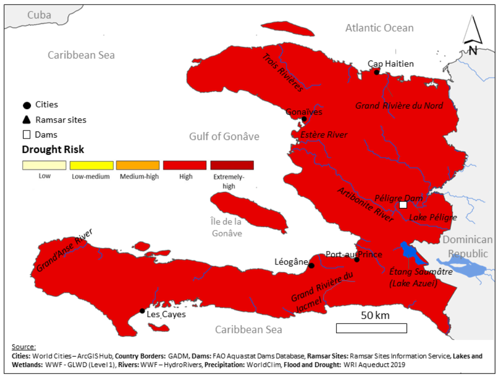
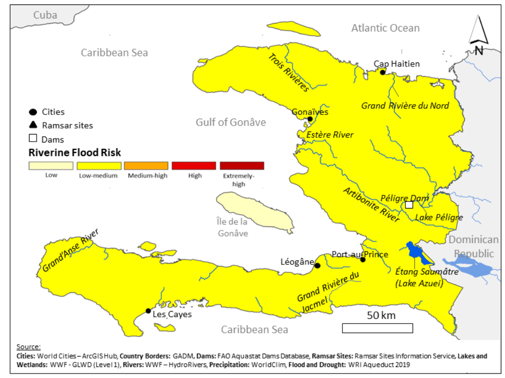


FIGURE 3. RIVERINE FLOOD RISK



Water Policy and Governance

KEY TAKEAWAYS

- Limited funding and understaffing impede integrated water management efforts. Donor support is critical for filling widespread budget gaps.
- Water quality monitoring and regulation responsibilities are distributed to different entities, but lack of financial resources and staff capacity constraints impede effective coordination.

This section provides an overview of key policies, institutions, and management challenges. Key laws, policies, and plans are summarized in Table 2 and the roles and responsibilities of select transboundary, national, and sub-national water management entities are summarized in Table 3.

TABLE 2. KEY LAWS, POLICIES, AND PLANS

Name	Year	Purpose
Framework Water Law	2009	Defines organizational responsibilities for drinking water provision and established a national water management agency.
Environmental Management Decree	2006	Assigns coordination responsibilities to the Ministry of the Environment.
Rural Code	1984	Declares water as property of the state and assigns responsibility for management and construction of water infrastructure to the state.
Ministry of the Environment Environmental Action Plan	1999	Defined a vision for environmental management, including land use and watershed management plans.
Ministry of Agriculture Watershed Management Policy	1999	Requires collectivities to develop micro-watershed plans that can be integrated into watershed plans in higher levels of government.

TABLE 3: WATER RESOURCES MANAGEMENT ENTITIES

Mandate	Institution	Roles and Responsibilities
National	Ministry of Environment (MDE)	Responsible for regulating water quality, monitoring and evaluation, setting water policies, overseeing coordination between ministries, water conservation, and enforcement of regulations.
	Ministry of Agriculture, Natural Resources, and Rural Development (MARNDR)	Manages coordination, studies, construction, and management related to agriculture and irrigation.
	National Directorate of Drinking Water and Sanitation (DINEPA)	Housed within the Ministry of Public Works, Transportation, and Communication. Formed by the 2009 Framework Water Law. Responsible for water supply and sanitation services and infrastructure, policy, sector and donor coordination, and regulation.
Sub-national	Regional Office of Drinking Water and Sanitation (OREPA)	Regional agencies of DINEPA (four total, one in each region), responsible for implementing the water and sanitation strategy. Provide guidance to URDs, CAEPAs, and CPEs.
	Rural development units (URDs)	Supervise and coordinate CAEPAs and CPEs at departmental levels (ten total, one in each department). Focused on water management in rural areas.
	Drinking Water Supply and Sanitation Committees (CAEPAs)	Roughly 650 water user associations with elected members that manage water supply systems in communities with less than 10,000 people.
	Water Point Committees (CPEs)	Manage water supply for populations living less than 500 meters from a water distribution point.
	Communal Water Supply and Sanitation Technician (TEPAC)	Operate with two technicians in 133 communes. Support CAEPAs and CPEs activities, monitoring water quality, evaluation and inventory of water infrastructure, technical support for operation and maintenance, water chlorination, and promotion of sanitation and hygiene behavior change. Coordinate activities during emergencies.

Staffing and technical capacity constraints at all levels and limited coordination across management entities impede effective integrated water resource management. The MDE has a broad mandate to manage water resources, although constraints to human resources and technical staffing impedes its ability to address key challenges in the sector.[42] The TEPACs in each commune have significant water management responsibilities but their staff do not always have the training or capacity to successfully implement their tasks.[10] Poor coordination and conflicting mandates across national and subnational management entities have also impeded water management.[9,26,42] For example, the MARDNR exerts significant influence over watershed management due to the importance of agriculture[2] and DINEPA acts as both the water supply service provider and regulator, posing a conflict of interest.[10] While DINEPA is responsible for permitting drinking water operations, the MDE is responsible for groundwater drilling and water abstraction permits.[26]

Financial constraints compound human resourcing challenges and increase reliance on donor support. Between 2006-2015, the national government only funded one percent of the water sector's budget while staffing constraints further impeded implementation of planned programs. In 2014 and 2015, DINEPA executed 34 percent of its total budget and 22 percent of their expected investments.[26] The water sector also struggles to collect payments for services.[10] For example, 83 percent of water withdrawn in 2012 from the municipal water supply in Port-au-Prince was not billed.[26] International donors played a critical role in filling budget gaps.[10,26] There are over 100 non-governmental organizations funded by bilateral and multilateral donors involved in the water sector[43,44] Some key entities, such as TEPACs and URDs, are 100 percent donor-funded.[10] The largest donors have historically been the Spanish Cooperation for International Cooperation and Development (AECID) and the Inter-American Development Bank (IDB).[10]

Haiti and the Dominican Republic have made limited attempts to coordinate management of the Artibonite Basin.[45,46] A UNDP project from 2010-2015 encouraged the two countries to sign a bilateral agreement. The project enhanced capacity, established initial structures for collaboration, and developed a Strategic Action Plan to guide future management.[47] However, the countries have yet to sign or operationalize the Strategic Action Plan.[41,47]

Water Quality Monitoring

Limited resourcing and poor coordination affect water quality monitoring efforts. The MDE lacks the staff, resources, and capacity to fulfill its key functions in monitoring ambient water quality, enforcing regulations, and managing permits.[24,26,42] Drinking water quality monitoring responsibilities are shared between the

Ministry of Population and Public Health (MSPP) and DINEPA.[26] The MSPP is responsible for national drinking water quality[26] and DINEPA oversees TEPAC efforts to test drinking water quality locally. TEPACs have had preliminary success in measuring chlorine residue in rural piped water through the SISKLOR initiative.[10,26] However, there is limited coordination between MSPP and DINEPA in setting and enforcing regulations.[26] Activities that may degrade surface water quality in Marine Protected Areas are supposed to be regulated, but enforcement is limited due to financial constraints.[5]

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