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.

Ghana Water Resources Profile Overview

Ghana has abundant water resources and is not considered water stressed overall. The total volume of freshwater withdrawn by major economic sectors amounts to 6.3 percent of its total resource endowment, which is lower than the water stress benchmark.[i] Total renewable water resources per person of 1,949 m^3 is also above the Falkenmark Index[ii] threshold for water stress. However, water availability is influenced by management decisions and abstractions from upper-basin countries as almost half of its freshwater originates outside the country.

The Volta Basin covers most of the country and is critical to hydroelectric generation, agriculture, and fisheries. However, water availability for hydropower generation and agriculture is vulnerable to drought and depends on upper basin dam releases and abstractions in Burkina Faso. Flood risks are amplified by uncoordinated floodgate releases from upstream dams. Transboundary cooperation is needed to reconcile basin development plans and address flood mitigation and drought contingencies in the Volta Basin.

Informal gold mining, logging, and the expanding cocoa sector are increasing flood risks, erosion, and sedimentation in the Southwestern and Coastal Basins. Gold mining contaminates municipal water sources with heavy metals, especially in the Pra Basin. Municipal, domestic, and industrial waste also contaminate 60 percent of surface waters and degrade ecosystems and biodiversity, especially downstream of Kumasi and Accra.

Groundwater resources are more limited compared to surface water. Aquifers generally have low productivity, limiting their viability for large-scale agriculture, municipal, and industrial use. Groundwater is used extensively for drinking water and domestic use in rural areas, especially in northern Ghana. Naturally occurring heavy metals are present in gold mining belts in the southwest and the northwest and naturally high fluoride in the north pose risks to public health. Seawater intrusion in coastal aquifers reduces groundwater quality in coastal cities.

Ghana is one of the most flood prone countries in West Africa. Climate change is worsening flooding, particularly in the north, while rising seas threaten coastal wetlands, biodiversity, and communities. Drought frequency and severity are increasing in the Volta Basin, impacting hydroelectric power generation, irrigation water supply, and agricultural and fishery production. Flood risks are worsened by poor urban planning and low enforcement of land use policies and could be alleviated by harnessing green infrastructure for flood management.

The Water Resources Commission lacks funding, sufficient staffing, and technical capacity needed to create and implement basin management plans and establish Basin Secretariats. The water sector's policy and legal framework do not adequately incorporate key government stakeholders and management entities into basin planning processes and address conservation needs, including for forests and wetlands.

[i] 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%.

[ii] 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.

Water Resources Availability

KEY TAKEAWAYS

- Ghana has three main basins that outlet to the Gulf of Guinea. The transboundary Volta Basin covers most of the country and provides the majority of renewable surface water. Rainfall is highest in the southwest while northern Ghana is drier and features semi-arid savannas.
- The Akosombo Dam in southeastern Ghana forms Lake Volta and is one of the world's largest reservoirs.
- Groundwater mostly exists in hard rock aquifers with relatively low productivity.

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

Ghana has three main basins that outlet to the Gulf of Guinea: the Volta, Southwestern, and Coastal Basins. The transboundary Volta Basin contributes almost two-thirds of total runoff,[1] and is divided into the Black Volta, White Volta, Oti River, and Lower Volta Basins. The Black Volta joins the White Volta at the northwestern corner of Lake Volta, which is formed by the Akosombo Dam (147,960 MCM capacity) and is one of the largest artificial reservoirs in the world. The Black Volta is characterized by high seasonal variability, with average wet season flows ten times higher than in the dry season.[2] The White Volta Basin is smaller, however, the River's flow is higher and covers more of Ghana. The White Volta's flows are moderated by Burkina Faso's Bagre Dam and seasonal flows of its tributaries.[3] The Oti River joins the Volta River near Kete Krachi and contributes 40 percent of Lake Volta's annual inflows.[2] The Lower Volta Basin consists of numerous small rivers and Lake Volta.[2,4]

The Southwestern Basin is relatively small but contributes almost one-third of Ghana's total runoff due to high precipitation within the Bia, Tano, Ankobra and Pra Basins.[5] The Coastal Basin contributes six percent of Ghana's total runoff, with the Densu Basin sustaining the Densu Delta, a key Ramsar Site.[6]

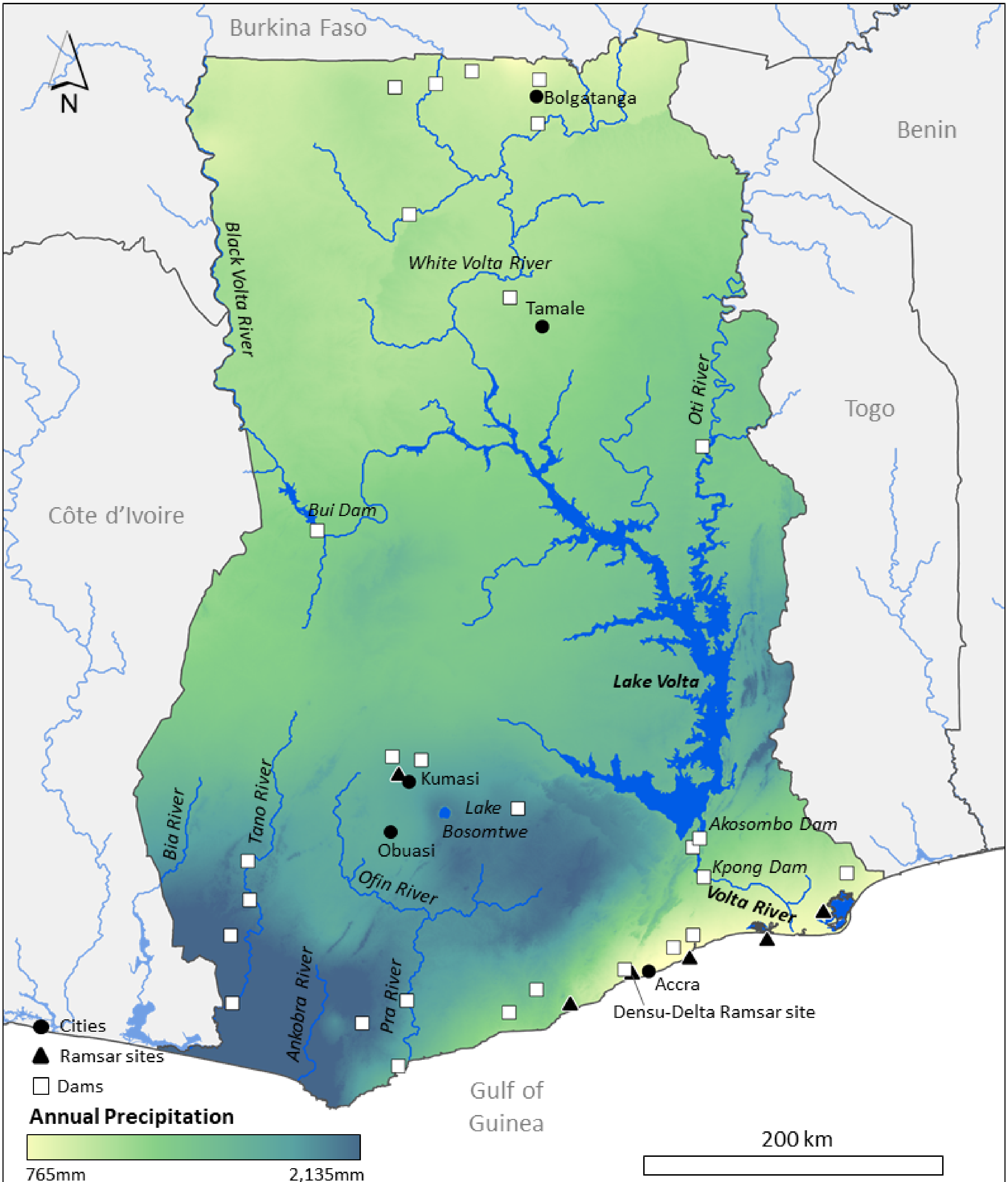
Groundwater Resources

Most groundwater is contained in basement complexes or consolidated sedimentary formations and are not very productive. Basement complexes cover 54 percent of the country, mostly in the west, south central, and the north. Consolidated sedimentary formations are present in most of the Volta Basin. Aquifer depth is shallow (10-60 meters) while well yields are generally low. More productive limestone aquifers exist along the southeastern and southwestern coasts at greater depths (120-300 meters) with high average well yields, but these systems only underlie one percent of the country. Groundwater recharge is generally low and highly variable, ranging from 1.5 to 19 percent of rainfall, with higher rates in the upper Volta Basin.[1]

TABLE 1. WATER RESOURCES DATA	Year	Ghana	Sub-Saharan Africa (median)
Long-term average precipitation (mm/year)	2017	1,187	1,032
Total renewable freshwater resources (TRWR) (MCM/year)	2017	56,200	38,385
Falkenmark Index - TRWR per capita (m3/year)	2017	1,949	2,519
Total renewable surface water (MCM/year)	2017	54,900	36,970
Total renewable groundwater (MCM/year)	2017	26,300	7,470
Total freshwater withdrawal (TFWW) (MCM/year)	2000	982	649
Total dam capacity (MCM)	2015	148,500	1,777
Dependency ratio (%)	2017	46.09	22.78
Interannual variability	2013	1.4	1.55
Seasonal variability	2013	3	3.15
Environmental Flow Requirements (MCM/year)	2017	33,260	18,570
SDG 6.4.2 Water Stress (%)	2000	6.31	5.70

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

Surface Water Outlook

KEY TAKEAWAYS

- Irrigation in the Volta Basin is the largest source of surface water withdrawals, although non-consumptive uses from Lake Volta are critical to the economy, including hydropower generation and inland fisheries.
- Wet season flood risks and hydroelectric generation on Lake Volta are impacted by water management decisions and discharges from upstream dams in Burkina Faso.
- Informal gold mining and logging, as well as expanding cocoa production degrade watersheds throughout the Southwestern and Coastal Basins, creating high wet season turbidity which can disrupt municipal water treatment. Gold mining contaminates rivers in the Southwestern Basin with toxic heavy metals.
- Municipal, industrial, and domestic waste contaminate rivers throughout the Coastal and Southwestern Basin and degrade ecosystems and biodiversity in key wetlands.

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

The agricultural sector is the largest water user (73 percent of total withdrawals), followed by municipal/ domestic (20 percent), and industry (7 percent). Most withdrawals are from surface water. Most agriculture is rainfed and only 30,900 hectares irrigated nationwide, less than 2 percent of its total irrigation potential.[7] Large public irrigation systems in the Volta Basin and small reservoirs and dugouts in the north are the main mechanisms of abstraction and use of surface water for livestock watering and small-scale irrigation.[2]

The Investing for Food and Jobs Initiative prioritizes investments for rehabilitation and expansion of large public irrigation systems, and calls for allocating 10 percent of the national budget to support agriculture.[8] However, the percent of cultivated land under irrigation is projected to be 3.5 percent by 2023.[9] The recently completed "One Village – One Dam" program constructed dug-out reservoirs for villages across northern Ghana,[10] but reports indicate that many of these reservoirs cannot be used for irrigation and are empty in the dry season.[11–13] The Volta Basin also has important non-consumptive uses, including transportation, tourism, aquaculture, and hydropower generation through the Akosombo, Bui, and Kpong Dams.[14,15] Notably, around 40 percent of Ghana's electrical production is from hydropower.[16]

Poor coordination and management of upstream dams in Burkina Faso can lead to heavy flooding in Ghana's Volta Basin. Uncoordinated releases from Bagre Dam have flooded riparian communities along the White Volta River.[15] In 2018, around 100,000 people were displaced by floods caused by heavy rainfall and releases from Bagre Dam.[19,20] The transboundary Volta Basin Authority's mandate encompasses flood forecasting and coordination among member states, although its effectiveness is hampered by inadequate hydrological forecasting and modeling, poor coordination and communication between basin states, and a lack of effective early warning systems for floods.[21]

Catchments in the Southwestern and Coastal Basins are severely degraded by informal logging and surface mining for gold, as well as the expansion of cocoa production. These cause sedimentation, increase flood risks, reduce water quality, and threaten biodiversity and communities.[22] Recent estimates suggest that up to 70 percent of total timber production is from informal logging.[23] Ghana is also one of the largest gold producers globally and over one-third of the country's total production comes from small-scale, open pit mining called galamsey,[24] which degrades seven times more area than large-scale mining. Galamsey-driven deforestation doubled from 2015 – 2018[24] and it is estimated that restoring land and waterways degraded by galamsey will cost a total of $250 million for the Western Region alone.[25] Large-scale open-pit mining is also common in the southwest, including more than 10 large-scale mines in the Ankobra Basin.[24]

Ghana produces one-fifth of global cocoa and recent investments may double national output.[26] Ghana lost eight percent of remaining primary forest (2002- 2019), mostly from cocoa expansion.[29] Between 2017 and 2018, Ghana's deforestation rate of primary forests increased by 60 percent, faster than any country in the world. Agricultural encroachment (mostly from cocoa) degrades 30 to 60 percent of forests in reserves and the degraded area has increased tenfold since 2010.[30]

Heavy metals, mainly from small-scale gold mining, pollute rivers and key drinking water sources throughout the Southwestern Basin. Heavy metal pollution from gold mining has been observed in Southwestern Basin's Tano and Ankobrah Basins, but is worst in the Pra Basin where gold mining is concentrated.[31] Gold mining has led to water service disruptions in several towns due to extreme contamination of surface water.[14,35,36] Arsenic levels near Prestea (Pra Basin) have also been detected at nearly 800 times the WHO guideline limit for drinking water, most likely from gold mining.[34]

Untreated industrial, municipal, and domestic waste deplete oxygen levels in rivers while high turbidity in the wet season can disrupt water treatment and service delivery. Approximately 60 percent of surface water is polluted nationwide[14] and is most severe in the Southwestern and Coastal Basins, especially downstream of Kumasi and Accra.[37,38] Municipal and industrial effluent has led to high concentrations of fecal coliforms and "dead zones" from deoxygenation in the Subin River in Kumasi.[35] High turbidity in the Pra basin has significantly increased water treatment costs and left some plants inoperable for several months each year.[35] The lower Volta River also has high chromium levels that likely derive from industrial and municipal pollution.[39]

Agricultural and urban runoff harms biodiversity in Ghana's Ramsar sites and 80 wetlands. Anthropogenic pollution has caused significant biodiversity losses in southern lagoons such as Korle, Kpeshie, and Sakumo.[40] Upstream agriculture and wastewater pollution from Takoradi has led to critically low dissolved oxygen and decimated fish populations in the Essei Lagoon.[41,42] Similarly, biodiversity in Lake Bosomtwe has suffered from high sedimentation from upstream deforestation, as well as eutrophication from nearby agriculture, leading to large declines in fish populations.[43]

Groundwater Outlook

KEY TAKEAWAYS

- Almost all groundwater abstractions are for drinking water and domestic use, primarily in rural areas. Dependence on groundwater is significantly higher in northern Ghana.
- Nationally, the risk of over abstraction of groundwater is low, although in some cases, significant fluctuations in the water table due to drought and seasonal recharge, which may worsen with climate change, hinder accessibility.
- Groundwater quality is generally good throughout Ghana, but gold mining belts in the north and southwest are contaminated by heavy metals, and naturally high fluoride contaminates drinking water in northern Ghana, posing health risks.
- Localized risks in urban areas from poor sanitation systems, over-abstraction, and sea level rise in coastal cities like Accra also affect groundwater availability and quality.

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

Groundwater is widely used for community-level drinking water supply as it is more reliable, particularly in periods of drought, and often does not require much treatment. Approximately 41 percent of the population depend on groundwater for household use, although this rate is much higher in rural areas (59 percent) than in urban areas (16 percent). Groundwater dependency is highest in northern Ghana due to low seasonal availability of surface water. Groundwater abstraction for irrigation and animal husbandry occur primarily in the northern Volta Basin, and for industry in the south around Accra, but these abstractions are nominal compared to domestic use.[1,45]

Groundwater availability and risks stem from poor regulation and enforcement, a lack of reliable data, drought, and reduced recharge from climate change. Recent estimates on renewable groundwater supply and withdrawals indicate that total withdrawals are very low compared to renewable supply. However, localized depletion often occurs as most wells are clustered and unregulated. The Water Resources Commission monitors groundwater levels in 70 wells nationwide, although technical issues reduce the consistency and quality of data.[46,47] Inter-annual groundwater levels are relatively stable although seasonal fluctuations can range one to seven meters, indicating a high dependency on seasonal rainfall for recharge and potential vulnerability to drought.[46] Models suggest that climate change impacts such as higher evaporation rates, reduced rainfall, and drought will reduce groundwater recharge significantly in several basins.[37,38,48]

Groundwater quality is generally acceptable for most uses, although naturally occurring heavy metals and fluoride are high in gold mining belts in the north and southwest. Heavy metals such as lead, arsenic, and cadmium have been found above WHO guideline values for drinking water, especially in the southwest[49,50] and in northern Ghana, where contamination is most severe and widespread.[51] Much of this contamination may be natural and is often associated with gold deposits.[51,52] Similarly, high arsenic concentrations have been found around key gold mining zones around Obuasi (Pra Basin) and Bolgatanga (White Volta Basin), well in excess of WHO guideline values for drinking water.[52] Naturally occurring fluoride is also present and in excess of WHO guideline values in deeper boreholes.[53] One study concluded that 20 percent of sampled wells in the Northeastern Region exceeded WHO guideline values for fluoride.[54] Improved groundwater quality monitoring is needed, particularly in gold mining zones, to better assess risks to public health.

Shallow groundwater is increasingly susceptible to pollution from inadequate sanitation systems in cities, and from sea level rise and over pumping in coastal aquifers. Only one-third of wastewater is safely disposed of in Accra, while sewerage systems only receive 10 percent of all wastewater. As of 2014, poor maintenance limited Accra's wastewater treatment plants to one-fifth their design capacity.[55] Shallow groundwater is widely contaminated by sources such as bathhouses, landfills, latrines and septic tanks, and animal waste from pigs and poultry.[56] There are over 45,000 hand dug wells in Ghana and only half are suitable for drinking due to water quality problems from high turbidity, nitrates, and fecal coliforms.[53,57] Salinity is a growing problem in coastal aquifers due to seawater intrusion. In the greater Accra region, high salinity has limited the use of boreholes for drinking and irrigation in small farming communities. In the Densu Basin, salinity is likely caused by seawater intrusion as result of concentrated abstractions.[38]

Water Resources and Climate

KEY TAKEAWAYS

- Climate change is reducing precipitation, increasing temperatures, and increasing evaporation rates in the Volta Basin, creating widespread risks to water availability across northern Ghana.
- Warmer temperatures are reducing the productivity of coastal and inland fisheries (Lake Volta) and impacting agriculture in northern Ghana.
- Ghana is one of the most flood prone countries in West Africa. Climate change will increase the intensity and frequency of flooding due to sea level rise and higher precipitation intensity. Urban slums and riverine communities in northern Ghana are particularly vulnerable to flood risks.

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.

Declining rainfall and higher evapotranspiration will reduce water availability in the transboundary Volta Basin and increase vulnerability to drought. Northern Ghana is semi-arid and experiences one rainy season (May-September) while southern Ghana has two rainy seasons (April-July, and September-November). Mean annual rainfall is approximately 1,200 mm however total annual rainfall ranges between 1100 mm/year in the north to 2,100 mm/year in the southwest.[58] Climate change is expected to raise average annual temperatures by 1.7-3.5 °C by the end of the century. While the impact on total precipitation is uncertain, higher temperatures will increase evaporation and cause water losses.[59] Climate change impacts on upper Volta Basin countries, particularly Burkina Faso, will also impact water resources in Ghana.

Declining rainfall and higher evapotranspiration rates in Burkina Faso could reduce the Volta River's annual flow by 24 percent by 2050 and 45 percent by 2100.[60,61] Poor governance and low adaptive capacity increase the vulnerability of affected populations in northern Ghana.[58,62,63] Reductions in water availability may increase tensions with neighboring Burkina Faso as it pursues further development of its water resources.[58]

Higher temperatures and increasing water stress in the Volta Basin threaten hydropower generation and inland aquaculture at Lake Volta, as well as agriculture across northern Ghana. Hydropower generated at the Akosombo Dam is highly sensitive to changes in Lake Volta's water level.[64] Most shortfalls in hydroelectric power generation derive from rainfall variability, which disrupt industry and cause economic losses of several hundred million dollars.[65,66] Over the past few decades, drought has caused national hydroelectric production to fall to 33 percent of capacity in some cases.[67] Ghana's fisheries are also considered highly vulnerable to climate change, and inland fisheries in Lake Volta have been declining due to increasing temperatures.[17]

Growing water demand in the Volta Basin's uppermost states will worsen impacts of drought and strain water supply across northern Ghana.[60] Without adaptive practices, higher temperatures and drought will reduce agricultural production and viable farmland, especially in the northern cocoa-growing regions. Some estimates suggest that over one-third of Ghana is vulnerable to desertification,[68] which degrades 20,000 hectares per year in the north.[69]

Flood risks are increasing with climate change, particularly in urban areas and riverine communities in northern Ghana. Sea level rise is reducing freshwater availability and harming coastal wetlands. Between 1988 and 2010, Ghana experienced 15 major floods that displaced hundreds of thousands of people.[70] In 2010, 700,000 people were displaced after heavy rainfall destroyed a dam and in 2015 flash flooding in Accra killed more than 150 people and caused over $100 million in damage.[71] Precipitation is becoming more variable and intense, which is increasing flood severity and impact.[58,72] Coastal populations, which comprise one-quarter of the population and include five major cities, will become more exposed to flooding.[73,74] Sea level has already risen by over 60mm, and may rise an additional 75-190mm by 2100.[58] Rising sea levels will increase erosion and shoreline loss along the coasts and in wetlands,[58] and increase salinity in coastal aquifers.[73] Mangrove restoration programs have been shown to prevent coastal erosion and reduce impacts from coastal storms, although programs should also focus on improved governance.[75]

FIGURE 2: DROUGHT RISK

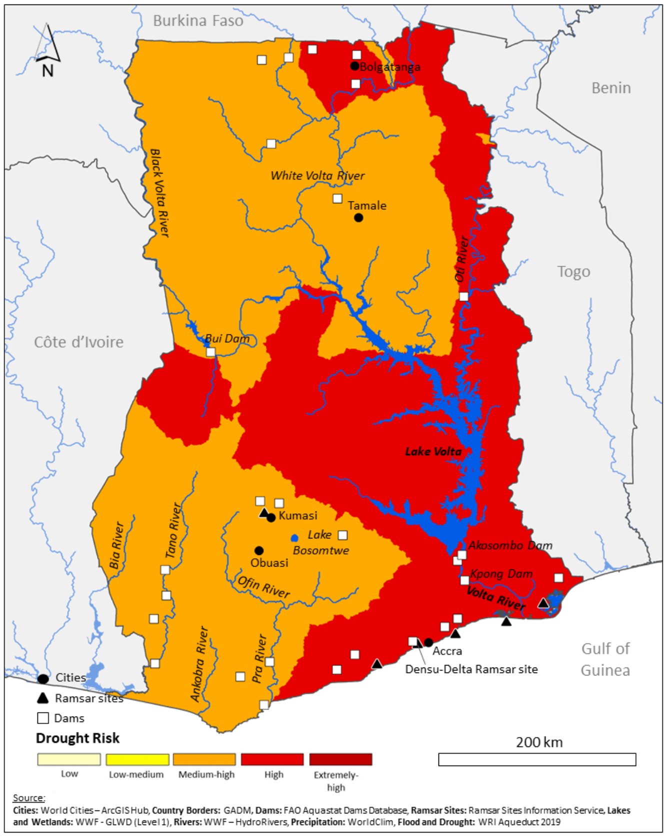
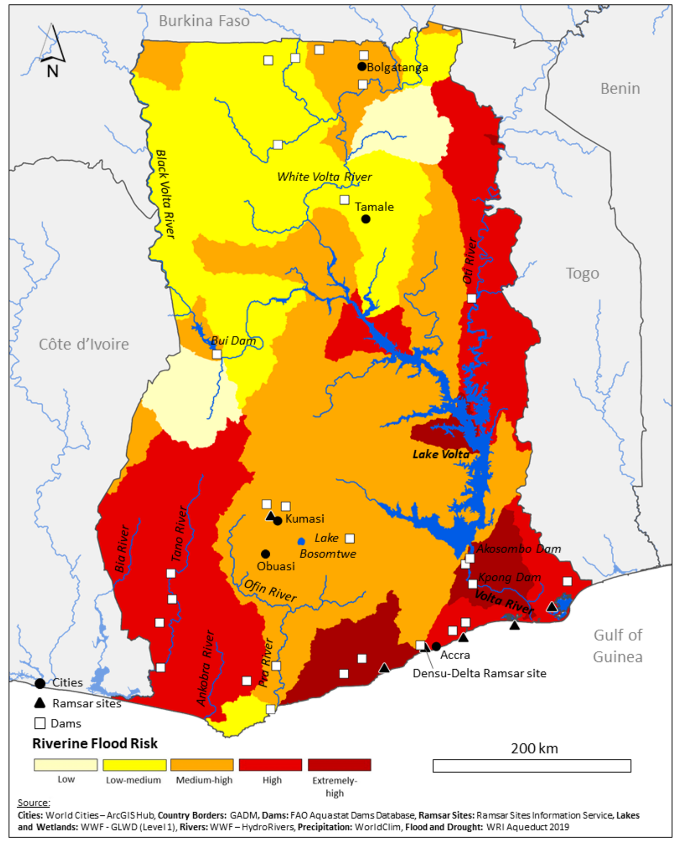


FIGURE 3. RIVERINE FLOOD RISK



Water Policy and Governance

KEY TAKEAWAYS

- Low levels of staffing, funding, technical capacity, and data constraints impede basin management, slows the establishment of new Basin Secretariats, and affects the ability of water management entities to address risks from agriculture, mining, and deforestation.
- Limited stakeholder engagement and institutional collaboration in basin planning and water management impedes the regulation and conservation of wetlands, riparian corridors, forests, and groundwater.
- Groundwater quality is not monitored, and surface water quality monitoring systems are not systematized across basins. Limited water quality monitoring increases uncertainty about the extent of pollution and impacts on ecosystems, biodiversity, and communities.

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
2012-2025 Water Sector Strategic Development Plan (WSSDP)	2014	Implementation framework for National Water Policy, focused water and sanitation services delivery and cross cutting issues concerning Integrated Water Resources Management (IWRM).
Riparian Buffer Zone Policy	2013	Mandates demarcation of protected zones around surface water to protect water quality, reduce sedimentation, and mitigate flood impacts.
National IWRM Plan	2012	Outlines water resources challenges identified through stakeholder and expert consultation and proposes IWRM policy objectives and outcomes.
National Water Policy	2007	Recognizes water as a social need with economic value and emphasizes IWRM, participatory decision-making, and transboundary cooperation, among other issues.
Water Resources Commission Act	1996	Established the Water Resources Commission as the lead entity in charge of water resources management, policy, and regulations.

TABLE 3: WATER RESOURCES MANAGEMENT ENTITIES

Mandate	Institution	Roles and Responsibilities
Transboundary	Volta Basin Authority (VBA)	Operational since 2009, the VBA is represented by 6 member states, including Benin, Burkina Faso, Cote d'Ivôire, Ghana, Mali, and Togo.
National	Ministry of Sanitation and Water Resources (MSWR)	Formulates policies, coordinates the water sector, and operates programs for the sustainable management of public lands, river basins and coastal areas. The Water Directorate leads water resources management and drinking water supply and oversees key agencies, including the Water Resources Commission, the Ghana Water Company Limited (GWCL), and the Community Water and Sanitation Agency (CWSA). The Hydrological Services Department (HSD) is responsible for monitoring and managing river flow gauging stations.
	Water Resources Commission (WRC)	The WRC regulates and manages surface and groundwater use and coordinates IWRM actors at basin and sub-basin levels.77 Coordinates transboundary basin development, manages permitting, and leads public awareness campaigns and conservation efforts.77 The WRC is accountable to the MSWR's Water Directorate and governed by a board of key sectoral entities.76 Establishes and manages Basin IWRM Plans and Secretariats (basin offices).
	EPA	Responsible for permitting and compliance monitoring of wastewater.
	Water Research Institute (WRI)	Under the Council for Scientific and Industrial Research, the WRI supports policy development, manages water quality laboratories, and conducts research on surface and groundwater availability and quality, and climate change impacts.
	Public Utilities Regulatory Commission (PURC)	Independent regulatory authority that monitors urban drinking water quality and urban water service providers.
Sub-national	Basin Secretariat	Basin Secretariats fulfill the WRC's mandates at the basin level and function as WRC branch offices. They currently exist in several basins, including the Densu, White Volta, Black Volta, Ankobra, Pra, and Tano Basins.
	Basin Boards	Responsible for water resources management at the state level. Administratively accountable to the state-level ministries and formally accountable to MEDIWR.
	Sub-Basin Committees	Fulfill similar roles as the Basin Boards but at the sub-basin level.

Understaffing, low technical capacity, limited funding, and hydrological and water quality data constraints hinder basin planning and management. Government funding for the WRC has amounted to only 3 percent of total funding in recent years. Total allocations to the WRC declined between 1997 to 2009 and disbursements are often late.[35] Resource constraints have delayed the establishment of new Basin Secretariats and IWRM Plans. The 2012 National IWRM Plan set a target of updating six existing IWRM Basin Plans and developing six new plans within 10 years. However, as of 2018, only seven IWRM Basin Plans have undergone development, revision, and implementation.[77,78] Resource constraints also affect the WRC's ability to monitor and manage water use permits[77] and data on surface and groundwater availability and quality.[76] Limited technical resources also impede the development and use of flood and drought monitoring and early warning systems.[76] Research on climate change impacts on water resources, such as droughts and floods, are not adequately incorporated into national mitigation strategies.[76]

Limited stakeholder engagement and institutional collaboration in basin planning and water management impedes the regulation and conservation of wetlands, riparian corridors, forests, and groundwater. Implementation of the National Water Policy does not engage the Ministry of Lands and Natural Resources, the Lands Commission, the Minerals Commission, or traditional authorities.[79] Communities also struggle to systematically participate in IWRM planning and decision-making processes and local customs around land and water rights are not always aligned with legal frameworks.[14] The lack of community involvement in basin development is compounded by the lack of Basin Secretariats and Basin Boards. Further, the National Water Policy lacks clear strategies for protecting forests and wetlands, and clear timelines and targets for policy monitoring, evaluation, and revision.[79] There is no legal framework for the WRC to manage groundwater abstraction rates[80] and enforcement of existing regulations and permits is weak.[76] Sector regulations concerning dam safety and effluent discharge from domestic and industrial users need to be strengthened as well.[14] Draft regulations are being developed to enforce key provisions of the Riparian Buffer Zone Policy, although additional legislation is needed to address land ownership and acquisition processes required to establish buffer zones.[77]

Water Quality Monitoring

Systematic groundwater quality monitoring does not occur and a broader framework for water quality monitoring is lacking. The MSWR's Water Directorate oversees the WRC, which is responsible for bulk water quality monitoring. The CWSA supports water quality monitoring for rural drinking water sources, while the PURC monitors drinking water quality for urban providers. These monitoring efforts are supplemented by crosscutting surface and groundwater quality research from the WRI. While the WRC has routinely monitored surface water quality since 2005, systematic groundwater quality monitoring does not occur.[77,80] The WRC monitors basic physio-chemical parameters for surface water in all of its three basins through 32 river monitoring stations and nine reservoir/lake stations.[77] However, parameters such as dissolved oxygen and microbial indicators are not monitored.[77,81] Further, the WRC lacks a national water quality monitoring framework. PURC lacks the equipment and logistical capacity to independently monitor urban drinking water quality, and instead relies on the GWCL to support this mandate.[82]

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