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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.

Uganda Water Resources Profile Overview

Uganda has abundant water resources, including extensive wetlands, the White Nile River, and major Lakes such as Lake Victoria. Approximately 35 percent of its water resources, however, originate in neighboring countries, which could create water availability or water quality challenges if there is extensive pollution or over-abstraction in upstream regions. Water stress is generally considered moderate and is most acute in dry regions. The ratio of water withdrawals to supply (5.83 percent) is well below the SDG 6.4.2 threshold for water stress.[i] However, per capita water availability (1,402 MCM) is below the Falkenmark threshold water stress, which is due to Uganda's large population.[ii]

Urbanization and agricultural expansion are rapidly degrading extensive wetlands. Over 40 percent of Uganda's wetlands have been lost since 1994, threatening biodiversity and reducing wetland infiltration capacity to protect water quality in lakes. Existing irrigation plans aim to sustain agricultural development in wetlands.

The cattle corridor, which spans several sub-basins, is vulnerable to drought. The region has high rainfall variability but receives low rainfall. The northern and eastern regions are the most susceptible to water stress as perennial surface water is scarce, and valley dams used by cattle often dry up. Climate change will cause more frequent localized droughts in northern and eastern Uganda.

Widespread flooding is common throughout Uganda particularly during El Niño years. The worst impacts are in Kampala and throughout the Lake Victoria and Kyoga Basins. Climate change will increase total rainfall and rainfall intensity and may increase the occurrence of El Niño events.

Untreated industrial and municipal waste, as well as agricultural runoff, cause eutrophication, algal blooms, invasive hyacinth outbreaks, and prolonged anoxic dead zones in parts of Lake Kyoga and Lake Victoria. Artisanal gold mining has polluted surface water with mercury, while industrial pollution contaminate groundwater sources near Kampala with heavy metals.

Water resource management entities struggle to fulfill their mandates due to limited human resources capacity for planning and management, limited data collection and management systems, and budgetary constraints. These factors impede the implementation of catchment management plans, development of key infrastructure, and enforcement of effluent discharge permits.

[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.

WINROCK INTERNATIONAL · TETRA TECH · IUCN · mWater · SEI Stockholm Environment Institute · World Resources Institute · The CEO Water Mandate

Water Resources Availability

KEY TAKEAWAYS

- Uganda has abundant surface water throughout most of the country with the White Nile and Lake Victoria constituting the majority of renewable surface water. Perennial watercourses are scarce in the north and east.
- Most of Uganda's groundwater exists in unproductive hard rock aquifers, although some highly productive sedimentary and alluvial aquifers exist along lake and riverine systems.

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

Uganda has extensive wetlands (9 percent of country) and numerous large lakes, including three of Africa's Great Lakes (Victoria, Albert, and Edward). Lake Victoria is the most important as it outflows to the White Nile River, a key tributary of the Nile River, and connects most of Uganda's major lakes. More than 98 percent[iv] of Uganda is located within the Nile Basin, although Uganda manages its rivers through eight basins: Lake Victoria, Lake Kyoga, Victoria Nile, Lake Albert, Lake Edward, Albert Nile, Achwa, and Kidepo Basins (see Figure 1 and Table 2).[1,2]

Groundwater Resources

Over 90 percent of Uganda is covered by relatively low-yielding hard rock aquifers.[8,9] Aquifer productivity and properties, including total storage, depth, and well yields, vary significantly.[9–11] Borehole yields are generally low[11] and borehole depths are typically less than 80m, but can be as deep as 200m.[10] Sedimentary and alluvial aquifers, which are concentrated around lakes and rivers, and the Albertine Rift Valley, tend to be unconfined and shallow, and generally have the highest yields.10 Average groundwater recharge is estimated at 120 mm/year, and ranges from 1 to 10 percent of precipitation in western and central Uganda, respectively.[10] More research is needed to better understand aquifer characteristics and availability risks.[12,13]

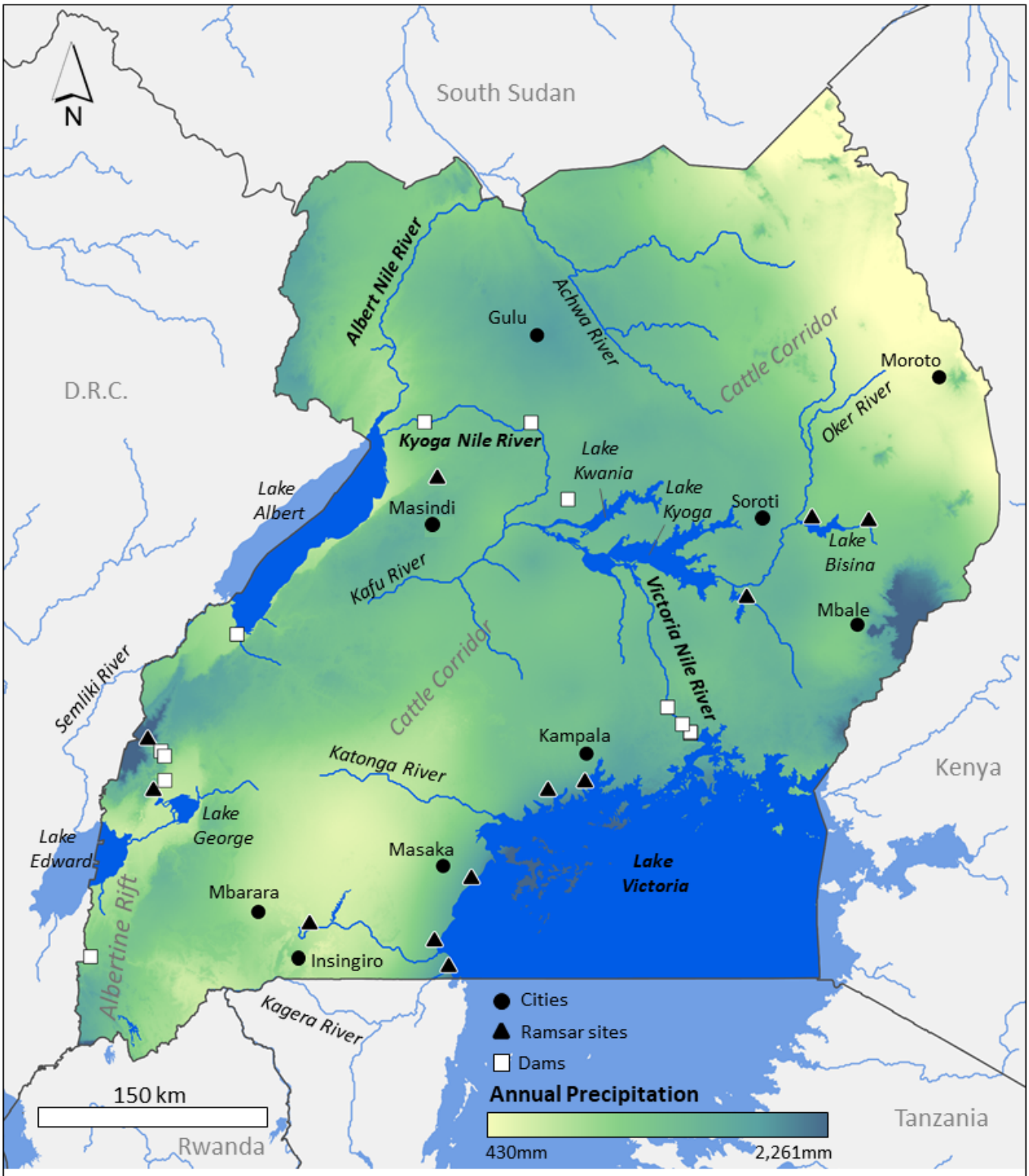
TABLE 1. WATER RESOURCES DATA

	Year	Uganda	Sub-Saharan Africa (median)
Long-term average precipitation (mm/year)	2017	1,180	1,032
Total renewable freshwater resources (TRWR) (MCM/year)	2017	60,100	38,385
Falkenmark Index - TRWR per capita (m3/year)	2017	1,402	2,519
Total renewable surface water (MCM/year)	2017	60,100	36,970
Total renewable groundwater (MCM/year)	2017	29,000	7,470
Total freshwater withdrawal (TFWW) (MCM/year)	2008	637	649
Total dam capacity (MCM)	2015	0.75[iii]	1,777
Dependency ratio (%)	2017	35.11	22.78
Interannual variability	2013	1.7	1.55
Seasonal variability	2013	1.6	3.15
Environmental Flow Requirements (MCM/year)	2017	49,170	18,570
SDG 6.4.2 Water Stress (%)	2008	5.83	5.70

Source: FAO Aquastat

[iii]This figure excludes theoretical storage potential related to the Owen Falls Dam in Uganda, which could be used to increase national storage by raising Lake Victoria's water level.
[iv]A narrow strip of land less than 25km wide and less than 2 percent of Uganda's land area drains eastward to Lake Turkana in Kenya.

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

TABLE 2. OVERVIEW OF UGANDA'S RIVER BASINS

River Basin	Key Lakes	Major Rivers	Basin Highlights
Lake Edward	Edward, George	Mpanga	Includes the Albertine Rift (part of Rift Valley), with important forests, national parks, and extensive biodiversity.[3]
Lake Victoria	Victoria	Kagera, Katonga	Provides 85 percent of Uganda's renewable water supply. Lake outflows are steady across seasons.[1] Direct rainfall over Lake Victoria provides 80 percent of its water.[4] The Kagera River provides 40 percent of overland flow, while the Katonga and Ruizi Rivers only provide 5 to 10 percent.[1,5] The Katonga River can flow in two directions, to Lake Victoria and to Lake George.[6]
Lake Kyoga	Kyoga, Bisina	Victoria Nile (White Nile),	Lake Kyoga Basin covers one quarter of Uganda and has over 40 percent of remaining wetlands. Lake Kyoga is a large but shallow lake.[7]
Victoria Nile	None	Kyoga Nile (White Nile), Kafu	The portion of the White Nile between Lake Kyoga and Lake Albert is called the Kyoga Nile. This stretch of river features the Murchison Falls-Albert Delta Wetland, a key Ramsar site.
Lake Albert	Albert	Semliki River	Lake Edward connects to Lake Albert through the Semliki River, which mostly exists in the Democratic Republic of the Congo (DRC).
Albert Nile	None	Albert Nile (White Nile)	The portion of the White Nile between Lake Albert and the border with South Sudan is called the Albert Nile.
Achwa	None	Achwa, Pager and Agago	The Achwa River is fed by two main seasonal tributaries, the Pager and Agago.
Kidepo	None	None	The Kidepo is Uganda's smallest basin and only seasonal rivers that flow to South Sudan.

Surface Water Outlook

KEY TAKEAWAYS

- Domestic/municipal uses and agriculture account for more than 90 percent of freshwater abstractions, mostly from surface water. Lake Victoria is a critical source of municipal water supply for Kampala and key cities in southwestern Uganda.
- Perennial surface water supplies are scarce in the eastern Karamoja region, and high demand for livestock watering cannot always be met through existing valley dams.
- Municipal, industrial, and agricultural runoff has led to eutrophication and low dissolved oxygen in parts of Lake Victoria, severely impacting fish habitat and aquatic biodiversity. Artisanal mining is also degrading surface water quality.

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

Domestic/municipal uses, agriculture, and industry account for 51, 41, and 8 percent of total freshwater abstractions respectively,[14] with most demand met by surface water.[1] Lake Victoria is an important municipal water source for Kampala,[15] and key cities in southwestern Uganda.[16] Planned oil extraction and refineries near Lake Albert will significantly increase surface water demand.[12] Agriculture is mostly rainfed and only 15,147 hectares (ha) of cropland are under controlled irrigation systems, mostly around Lake Victoria. Additionally, 53,350 ha of uncontrolled wetland irrigation occurs around Lake Kyoga.[1,17]

Surface water in the eastern Karamoja region is seasonal and pastoralists often struggle to secure enough water for their herds. Livestock watering in the semi-arid cattle corridor is the largest source of surface water demand.[1] Water stress is particularly high in Karamoja, which hosts 20 percent of the country's cattle.[18] Perennial surface water supplies are scarce in Karamoja. Excavated "valley dams" are used to store water for livestock. The Kobebe Dam normally provides 2.3 MCM of water storage and is the primary water source for over 5 million livestock. However, the valley dam dried up during droughts in 2014-2015 and 2019.[19]

The government recently announced it will construct 20 new valley dams. Each dam will support an 1,200 cattle for three months during the dry season.[20]

Urbanization and agriculture are destroying critical wetland ecosystems and threatening biodiversity. Uganda has lost over 40 percent of its wetlands since 1994, which now cover only 9 percent of the country.[21] Over 800 km2 of wetlands are lost every year due to encroachment from urbanization and agricultural conversion.[22] Nearly half of the wetlands in the Kyoga Basin have been lost to the cultivation of rice, sugar cane, and maize. Wetlands are also important natural buffers for water quality in lakes, but their continued degradation is harming biodiversity and undermining their capacity to filter water quality.[3,24] Uganda's 2010-2035 Irrigation Master Plan prioritized approximately 253,000 ha of cropland, almost all of which is wetland, for irrigation development.[25] Additionally, the 2018 National Irrigation Policy proposes bringing 1.5 million ha under irrigation by 2040.[26] Continued irrigation development in wetlands will pose continued risks to biodiversity and water quality.

Municipal, industrial, and agricultural runoff is causing eutrophication and reducing oxygen in Lake Victoria. Algal growth in Lake Victoria has increased more than five-fold since the 1960s, threatening aquatic biodiversity.[37] Most sewage is not treated and contaminates waterbodies.[29,30] Kampala's sewerage network only serves 10 percent of the city's population while the rest of the population depend on-site sanitation systems.[28] Over five tons of fecal waste are dumped into Lake Victoria every day,[31] which has led to high biological oxygen demand (BOD) and increased nitrogen levels above ambient water quality standards.[33,34] Breweries, sugar refineries, food processing plants, oil and soap factories, tanneries, dairies, and slaughterhouses also release untreated or poorly treated wastewater into Lake Victoria, elevating BOD. Between 1997 and 1999, water hyacinth covered 180 square kilometers, which depleted oxygen levels and resulted in massive fish die offs.[1] Hypoxic zones have also grown. In the 1960s, hypoxic zones were typically deeper than 60 meters but are now within 30 meters of the surface, constraining fish habitat.[27]

Artisanal gold mining contaminates surface water with mercury. Artisanal mining is a key livelihood for over 200,000 people,[39] and is widespread near the eastern border with Kenya, in the southeastern districts bordering Lake Victoria, and in the southwest near Rwanda.[40] Over 3 tons of mercury are released into the environment annually.[40,41] Mercury pollution is widespread in parts of the Kyoga Basin, reaching over 200 times the WHO guideline value for drinking water in some cases.[42] Mercury concentrations were also elevated in fish tissue, indicating mercury bioaccumulation in the food chain.[42]

Groundwater Outlook

KEY TAKEAWAYS

- Groundwater is the main source of drinking water, which accounts for almost all groundwater abstractions. Projections indicate that groundwater abstraction rates will be highest in the north and east by 2030 but overall groundwater utilization will remain below sustainable yields.
- Pathogenic contamination is widespread in shallow and unprotected wells where the water table is high.
- Fluoride levels are naturally high in the east and west within the Rift Valley. Mining also threatens groundwater quality through the leaching of heavy metals in bedrock aquifers.

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

Risks of groundwater overexploitation are low. Total groundwater withdrawals are less than 4 percent of Uganda's safe yield (5,760 MCM/year[v]).[1] Kaabong and Kotido Districts are most reliant on groundwater for domestic supply and livestock watering, and are projected to abstract half of their sustainable yields by 2030.[1] While risks of groundwater overexploitation are low, concentrated pumping in urban areas may lead to localized depletion.[43]

Inadequate sanitation systems and industrial pollution contaminate springs and shallow wells. A 2019 national survey of over 1,100 groundwater sources in rural areas found that 24 percent of boreholes, 76 percent of shallow wells, and 58 percent of protected springs were contaminated with E. Coli.[35] Pit latrines and livestock watering near unprotected wells are key sources of contamination.[1] Groundwater pollution has been implicated in several outbreaks of infectious disease, including a typhoid fever outbreak in 2015 in Kampala that infected 10,230 people.[45,46] Municipal and industrial waste have also contaminated freshwater springs around Kampala with high concentrations of lead.[47]

[v]Sustainable groundwater yield is an estimated fraction of total renewable groundwater resources at which long term withdrawals can occur without causing negative impacts to the aquifer system.

Fluoride contamination is high in some parts of the Rift Valley, posing risks to human health. Most groundwater sources are within WHO guideline values for drinking water,[48] however, limited testing indicates that fluoride levels around Mbale and Moroto, and in some parts of western Uganda near the Albertine Rift are high.[48] More testing is needed to better understand risks in the Rift Valley.

Mining and the recent discovery of oil and gas resources near Lake Albert threaten groundwater quality. Several large-scale lime, copper, and salt mining companies create localized risks to groundwater quality.[39] A 6.5 billion barrel oil field near Lake Albert, scheduled to begin production in 2022, could also threaten groundwater quality. Oil production, which uses water in cooling systems, for heating and crude washing, and to maintain pressure in oil reservoirs, can leach toxic heavy metals, including cadmium, chromium, lead, arsenic, and mercury.[10,49–51]

Water Resources and Climate

KEY TAKEAWAYS

- Uganda has two wet seasons, but rainfall variability is high in the semi-arid cattle corridor, which covers half the country from southwest to northeast. Projections indicate that the south will become wetter whereas the north and northeast will become drier and more vulnerable to drought.
- Flood risks are high throughout Uganda. Climate change will increase vulnerability to flooding as rainfall intensity increases.

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.

Uganda has two wet seasons, but rainfall variability is high in some parts of the country. Most precipitation is received during a long rainy season (March to May), which is followed by a shorter rainy season (October to December).[56] A semi-arid stretch of land called the cattle corridor covers almost half the country from southwest to northeast. The northeastern zone receives as little as 300-500 mm/year of rainfall and rainfall variability is high.[52,53]

Wet areas in the south will become wetter and drier areas in the north and northeast will become drier and more prone to droughts. Average temperatures will increase between 1.8 and 3.7 °C by the end of the century, while total precipitation will increase 82 to 163 mm/year. Most precipitation gains are expected to occur in the southern and central regions, while the north and northeast is expected to receive less precipitation.[58] Nationally, precipitation gains will exceed losses from increased evaporation and the frequency of severe drought will decrease. However, drier areas in the cattle corridor, particularly in the Karamoja region, will have more frequent droughts.[58,60,61] The Karamoja district has experienced 12 droughts between 1991 and 2011, with the 2010-2011 drought causing $1.2 billion in loss and damages.[58,62]

Flood risks are increasing due to climate change, particularly during El Niño years. Extreme rainfall events are most common during the shorter wet season and during El Niño years.[1,57] Uganda is already prone flash floods. Flooding impacts almost 50,000 people, and causes over $60 million in damages annually, with flood risks being highest in Kampala and the northern and eastern regions.[62] Severe flooding during a 1997-1998 El Niño displaced 150,000 people and a subsequent cholera outbreak killed 500 people and hospitalized 11,000.[32]

FIGURE 2: DROUGHT RISK

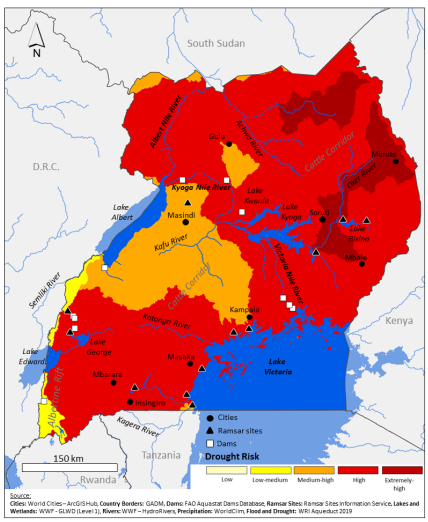
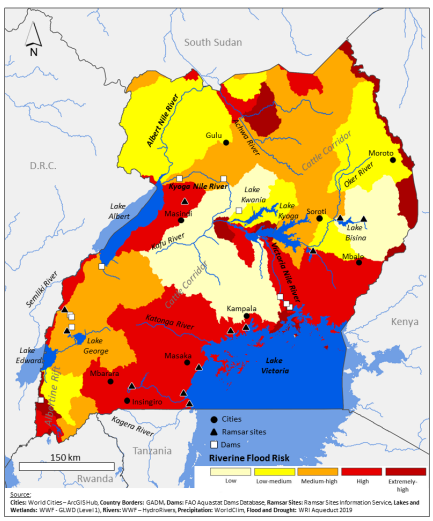


FIGURE 3. RIVERINE FLOOD RISK



Water Policy and Governance

KEY TAKEAWAYS

- Low technical capacity and staffing across the water sector impedes the sector's development and water resources management. Funding constraints limit implementation of activities proposed in Catchment Management Plans and threaten achievement of SDG-aligned 2030 development goals.
- Water user and effluent discharge permitting as well as water quality monitoring are improving but funding constraints remain a challenge.

This section provides an overview of key policies, institutions, and management challenges. Key laws, policies, and plans are summarized in Table 3 and the roles and responsibilities of select transboundary, national, and sub-national water management entities are summarized in Table 4.

TABLE 3. KEY LAWS, POLICIES, AND PLANS

Name	Year	Purpose
Water Act	1997	Defines the water sector's current, largely decentralized, institutional structure. Outlines rights of water users, limits to water use, pollution controls, and the roles and responsibilities of management entities.
National Water Policy	1999	Frames guiding principles and strategies for water resources management, including water supply services, irrigation, transportation, and hydropower generation, among other uses. Establishes an institutional framework for water resources management at the national, district, and local administrative levels.
Strategic Investment Plan for the Water and Environment Sector 2018-2030	2018	National level investment plan for water resources development for 2018 to 2030, outlining the funding requirements for water resources development priorities, which are framed around Uganda's SDG-aligned targets for 2030 and water sector development indicators.

WMZs and the water sector broadly are understaffed. As of 2016, each WMZ only had five out of 19 required staff.[67] The Third National Development Plan (2020-2025) noted that an additional 704 hydrogeology and hydrology specialists were needed nationwide.[68,69] Established in 2018, the national Water Resources Institute (WRI) hosted four trainings in its first year of operation, with 140 participants from the WMZs, local governments, and MWE staff;[35] however, filling the human resources gap will require ongoing efforts by the WRI, universities, and donors.

Funding constraints impede implementation of CMPs and threaten achievements to SDG-aligned 2030 development targets. The Strategic Investment Plan for the Water and Environment Sector 2018-2030 found that the sector will require an average annual budget of nearly USD $2 billion, which is more than four times the FY2019/20 budget, in order to achieve its SDG-aligned 2030 development targets.[35,72] Sector funding has more than doubled from 846 billion UGX in FY2014/15 to 1.82 trillion UGX in FY2019/20, however, water sector investment has remained constant at 3 percent of the national budget over the 2015-2020 timeframe.[73,74] Water resources management objectives receive only a small portion of the total budget, especially for permit compliance and ambient water quality-related objectives.[72] Overall, external funding accounted for over 40 percent of the water sector budget in FY2018/19.[70]

As of mid-2019, 17 CMOs had been formed across four WMZs and 15 CMPs had been finalized.[35] However, implementation of the CMPs has been limited.[35] The MWE targeted a 25 percent increase in the number of water resource management investments implemented from CMPs, but only achieved two percent in FY 2018/19.[70] CMPs are supposed to be funded by national and local governments, financial institutions, international donors, NGOs and CBOs, and the private sector. However, funding is often insufficient and unreliable and government disbursements can be irregular or delayed.[71]

Recent progress has been achieved in water use permitting and enforcement but permitting and enforcement for wastewater discharge has lagged. DWRM and WMZs have made significant progress in identifying unpermitted water users and polluters. In 2018, WMZs identified 794 water users and assisted them in applying for surface water, groundwater, drilling, and wastewater discharge permits, generating UGX 545 million in permit fees.[51,75] The number of permit holders monitored by DWRM staff has increased from 235 in 2011 to 1,339 in 2018.[51] Overall, 79 percent of abstraction permits and 63 percent of wastewater discharge permits are considered compliant.[51]

TABLE 4: WATER RESOURCES MANAGEMENT ENTITIES

Mandate	Institution	Roles and Responsibilities
Transboundary	Nile Basin Initiative (NBI)	International partnership consisting of 11 countries within the Nile Basin, which encompasses the Lake Victoria Basin as part of its upper watershed. Coordinates Basin development through a Council of Ministers, Technical Advisory Committee, and Secretariat.
	Lake Victoria Basin Commission (LVBC)	Transboundary commission under the East African Community, an intergovernmental organization which promotes economic and social development in the region. The LVBC is represented by Kenya, Uganda, Tanzania, Rwanda, and Burundi. Coordinates the water resources management and policy towards economic development goals.
National	Ministry of Water and Environment (MWE)	Plans and coordinates all water and environmental sector activities, with overarching responsibility for setting national policies and standards, regulating water resources, and determining priorities for water resources development.
	Directorate of Water Resources Management (DWRM)	Established in 2007 and housed within MWE. Responsible for developing and maintaining national water laws, policies, and regulations; managing, monitoring, and regulating water resources through permitting; Integrated Water Resources Management (IWRM) activities; and coordinating Uganda's participation in joint management of trans-boundary waters resources.
	Directorate of Water Development (DWD)	Responsible for planning, implementation, and supervision of water and sanitation service delivery and water for production (i.e., irrigation, livestock watering, and industrial uses).
Sub-national	Water Management Zones (WMZs)	There are four WMZs. The Upper Nile manages the Albert Nile, Achwa, and Kidepo Basins. The Kyoga (KWMZ) manages the Victoria Nile and Lake Kyoga Basins. The Lake Albert (AWMZ) manages the Lake Edward and Lake Albert Basins. The Lake Victoria (VWMZ) manages the Lake Victoria basin. WMZs are responsible for water resources monitoring and assessment, water quality testing, water permits assessment, compliance and enforcement, review of environmental impact assessment reports, public outreach, and the development of Catchment Management Plans (CMPs), which further delineate catchments into sub-catchments and micro-catchments.
	Catchment Management Organizations (CMOs)	Implement water resources management at sub-basin level through a stakeholder forum, a management committee, a secretariat, a technical committee, and sub-catchment and micro-catchment committees which engage stakeholders at the local level and steer implementation of catchment management plans.

Water Quality Monitoring

Surface and groundwater is monitored regularly but monitoring efforts are often constrained by lack of funding. DWRM and the WMZs operate a network of surface and groundwater monitoring stations for both hydrometric and water quality data. Uganda's monitoring network reached a peak of 140 stations in 1978 before collapsing during a period of political instability in the 1980s. Since 1994, DWRM has been rebuilding and upgrading its network, but the number of stations remains below the planned 110 surface water and 40 groundwater stations.[10] Currently, DWRM and WMZs operate 65 surface water and 30 ground water hydrological monitoring stations, of which at least 49 (32 surface water and 17 groundwater) have been upgraded to real-time cloud-based data transmission.[35,51] However, data quality has declined since the early 2000s due to insufficient budgets, a lack of routine maintenance, and vandalism.[35,51]

The water quality monitoring network comprises 119 monitoring stations, including both surface and groundwater. However, in 2018 only 80 (67 percent) of the stations were monitored, with the lowest coverage in the Kyoga and Victoria WMZs, due budget constraints.[35] DWRM also collects self-reported hydrological and water quality data from groundwater permit holders, including borehole depth, water strike depths, yields, transmissivity, and chemical parameters.[10] Ambient water samples are commonly tested for pH, electrical conductivity, dissolved oxygen, hardness, major ions, and heavy metals.[76] Water quality testing occurs at the National Water Quality Reference Laboratory (NWQRL) in Entebbe, supported by 4 Regional Water Quality Testing Laboratories (RWQTLs)

in each of the WMZs, and basic laboratories at water treatment plants, industries, and other public and private institutions.[35] The first RWQTL was established in 2015, and all RWQTLs' testing capacity remains limited to basic analysis.[35] Consequently, the NWQRL has tested nearly 70 percent of water quality samples.[35] Hydrometric and water quality data are entered at the WMZ and national level into the centralized Water Information System database, which went online in 2018.

References

(1) MWE. Uganda National Water Resources Assessment; Ministry of Water and Environment, Directorate of Water Resources Management, 2013.
(2) Nayebare, J. G.; Owor, M. M.; Kulabako, R.; Campos, L. C.; Fottrell, E.; Taylor, R. G. WASH Conditions in a Small Town in Uganda: How Safeare on-Site Facilities? Journal of Water, Sanitation and Hygiene for Development 2020, 96–110. https://doi.org/10.2166/washdev.2019.07.
(3) USAID. Uganda Environmental Threats and Opportunities Assessment (ETOA); Washington, D.C., 2015.
(4) Olaka, L. A.; Ogutu, J., O.; Said, M., Y.; Oludhe, C. Article Projected Climatic and Hydrologic Changes to Lake Victoria Basin Rivers under Three RCP Emission Scenarios for 2015–2100 and Impacts on the Water Sector. Water 2019, 11 (1449). https://doi.org/10.3390/w1107144.
(5) FAO. Chapter 6: Review of Existing Information on Irrigation Potential. In Irrigation potential in Africa: A basin approach; Food and Agriculture Organization of the United Nations: Rome, 1997.
(6) Reardon, Erin. Fish in Extreme Environments: Reproduction and Energetics under Hypoxia, McGill University.
(7) Infield, M.; Mafabi, P.; Iyango, L. A.; Barugahare, V.; Ouedraogo, P. Ramsar Advisory Mission Report; Ramsar, 2018.
(8) WRI Aqueduct Beta. Water Risk Atlas www.wri.org/aqueduct.
(9) Aheebwa, J.; Akampurira, S. Country Report on Groundwater Situation, 2019.
(10) MWE. Consolidated Hydrological Year Book for Uganda 1978-2014; Ministry of Water and Environment, 2017.
(11) Tindimugaya, C. Uganda. In Groundwater availability and use in Sub-Saharan Africa: a review of 15 countries; Pavelic, P., Giordano, M., Keraita, B., Vidya Ramesh, Tamma Rao, Eds.; International Water Management Institute: Battaramulla, 2012.
(12) MWE. National Water Resources Strategy; Ministry of Water and Environment, Directorate of Water Resources Management, 2014.
(13) Tindimugaya, C. Groundwater Flow and Storage in Weathered Crystalline Rock Aquifer Systems of Uganda: Evidence from Environmental Tracers and Aquifer Responses to Hydraulic Stress, University of London, 2008.
(14) FAO. AQUASTAT Main Database, Food and Agriculture Organization of the United Nations (FAO).
(15) Chopra, A. Kampala Water Demand Outstrips Supply - NWSC. Daily Monitor. May 13, 2020.
(16) Takouleu, J. M. NWSC and Suez Sign Agreement for €120 Million Water and Sanitation Project. Afrik21. April 29, 2020.
(17) Kabirizi, A. MWE Sector Performance 2018, 2018.
(18) FAO. FAO/GIEWS Livestock and Market Assessment Mission to Karamoja Region, Uganda. Food and Agriculture Organization of the United Nations 2014.
(19) Timberlake, F. M. Valley Dams Offer Half a Hope to Drought-Hit Ugandan Herders. 2018.
(20) State House of Uganda. Government to industrialize Karamoja sub-region, build 20 vally dams https://statehouse.go.ug/media/news/2019/06/12/government-industrialize-karamoja-sub-region-build-20-vally-dams (accessed 2021 -04 -02).
(21) Ocaido, M. P. Report: Uganda's Wetlands face Depletion by 2040 https://kampalapost.com/content/report-ugandas-wetlands-face-depletion-2040 (accessed 2021 -07 -09).
(22) Abet, T. Government names 7 most degraded wetlands https://www.monitor.co.ug/uganda/news/national/government-names-7-most-degraded-wetlands--3343490#:~:text=%E2%80%9CEach%20year%2C%20Uganda%20has%20been,degraded%2C%20according%20to%20the%20report. (accessed 2021 -07 -08).
(23) Nature Uganda. Surveillance of Migratory Birds in Uganda; 2006.
(24) Kayima, J.; Kyakula, M.; Komakech, W.; Echimu, S. A Study of the Degree of Pollution in Nakivubo Channel, Kampala, Uganda. J. Appl. Sci. Environ. Manag. 2010, 12 (2). https://doi.org/10.4314/jasem.v12i2.55540.
(25) MWE. A National Irrigation Master Plan for Uganda (2010-2035); Ministry of Water and Environment, 2011.
(26) Ministry of Water and Environment. National Irrigation Policy. Government of Uganda 2017.
(27) Njiru, J.; Nyamweya, C.; Gichuki, C.; Mugidde, R. Increase in Anoxia in Lake Victoria and Its Effects on the Fishery. In Anoxia; 2012.
(28) International Water Association. Kampala – utility and city partnering up to accelerate success https://iwa-network.org/wp-content/uploads/2017/06/IWA_2017_WSP_Kampala.pdf (accessed 2021 -04 -12).
(29) African Development Bank. P-UG-E00-008 https://www.afdb.org/en/projects-and-operations/p-ug-e00-008 (accessed 2021 -04 -12).
(30) Schoebitz, L.; Bischoff, F.; Lohri, C. R.; Niwagaba, C. B.; Siber, R.; Strande, L. GIS Analytsis and Optimisation of Faecal Sludge Logistics at City-Wide Scale in Kampala, Uganda. Sustainability 2017, 9 (194). https://doi.org/10.3390/su9020194.
(31) The Monitor. Uganda: Vanishing Wetlands Put Country at Risk of Ecological Disasters https://allafrica.com/stories/200908050766.html (accessed 2021 -04 -12).
(32) Uganda Ministry of State for Environment. Initial National Communication to the UNFCC; 2002.
(33) The International Water Association. City Water Stories: Kampala; 2016.
(34) Schoebitz, L.; Niwagaba, C.; Strande, L. Waste Supply and Availability Report - Kampala; 2014.
(35) MWE. Water and Environment Sector Performance Report 2019; Ministry of Water and Environment, 2019.
(36) The National Environment Management Authority. Pilot Integrated Ecosystem Assessment of the Lake Nyoga Catchment Area; Kampala, 2008.
(37) Sayer, C. A.; Máiz-Tomé, L.; Darwall, W. R. T. Freshwater Biodiversity in the Lake Victoria Basin: Guidance for Species Conservation, Site Protection, Climate Resilience and Sustainable Livelihoods, 1st ed.; IUCN, International Union for Conservation of Nature, 2018.
(38) Mugidde, R.; Gichuki, J.; Rutagemwa, D.; Ndawula, L.; Matovu, A. The State of the Fisheries Resources of Lake Victoria and Their Management; 2005.
(39) Uganda Ministry of Foreign Affairs (MOFA). Mining Sector.
(40) Schipper, I.; Haan, E. de; Turyahikayo, S. No Golden Future Use of Child Labour in Gold Mining in Uganda. Stichting Onderzoek Multinationale Ondernemingen (SOMO) 2016.
(41) NEMA. National State of the Environment Report 2012; National Environment Management Authority, 2012.
(42) Omara, T.; Karungi, S.; Kalukusu, R.; Nakabuye, B.; Kagoya, S.; Musau, B. Mercuric Pollution of Surface Water, Superficial Sediments, Nile Tilapia and Yams in Auriferous Areas of Namukombe Stream, Syanyonja, Busia, Uganda. PeerJ 2019, 7, e7919. https://doi.org/10.7717/peerj.7919.
(43) British Geological Survey. Hydrogeology of Uganda. 2020.
(44) Bakyayita, G. K.; Norrstrom, A. C.; Kulabako, R. N. Assessment of Levels, Speciation, and Toxicity of Trace Metal Contaminants in Selected Shallow Groundwater Sources, Surface Runoff, Wastewater, and Surface Water from Designated Streams in Lake Victoria Basin, Uganda. Journal of Environmental and Public Health 2018. https://doi.org/doi.org/10.1155/2019/6734017.

(45) Murphy, J. L.; Kahler, A. M.; Nansubuga, I.; Nanyunja, E. M.; Kaplan, B.; Jothikumar, N.; Routh, J.; Gómez, G. A.; Mintz, E. D.; Hill, V. R. Environmental Survey of Drinking Water Sources in Kampala, Uganda, during a Typhoid Fever Outbreak. Appl. Environ. Microbiol. 2017, 83 (23), e01706-17, e01706-17. https://doi.org/10.1128/AEM.01706-17.
(46) Kabwama, S. N.; Bulage, L.; Nsubuga, F.; Pande, G.; Oguttu, D. W.; Mafigiri, R.; Kihembo, C.; Kwesiga, B.; Masiira, B.; Okullo, A. E.; Kajumbula, H.; Matovu, J.; Makumbi, I.; Wetaka, M.; Kasozi, S.; Kyazze, S.; Dahlke, M.; Hughes, P.; Sendagala, J. N.; Musenero, M.; Nabukenya, I.; Hill, V. R.; Mintz, E.; Routh, J.; Gómez, G.; Bicknese, A.; Zhu, B.-P. A Large and Persistent Outbreak of Typhoid Fever Caused by Consuming Contaminated Water and Street-Vended Beverages: Kampala, Uganda, January – June 2015. BMC Public Health 2017, 17 (1), 23. https://doi.org/10.1186/s12889-016-4002-0.
(47) Bamuwamye, M.; Ogwok, P.; Tumuhairwe, V.; Eragu, R.; Nakisozi, H.; Ogwang, P. E. Human Health Risk Assessment of Heavy Metal s in Kampala (Drinking Water. Journal of Food Research 2017, 6 (4).
(48) Malago, J.; Makoba, E.; Muzuka, A. N. N. Fluoride Levels in Surface and Groundwater in Africa: A Review. American Journal of Water Science and Engineering 2017, 3 (1), 1–17. https://doi.org/10.11648/j.ajwse.20170301.11.
(49) Kwesiga, P. Work on Buliisa Oil Industrial Area Begins. New Vision. August 20, 2017.
(50) Verma, N.; Mukherjee, P. Uganda Expects First Oil Production to Be Delayed to 2022 - Minister. Reuters. February 13, 2019.
(51) MWE. Water and Environment Sector Performance Report 2018; Ministry of Water and Environment, 2018.
(52) Caffrey, P.; Finan, T. Uganda Climate Change Vulnerability Assessment; United States Agency for International Development (USAID), 2013.
(53) Makuma-Massa, H.; Majaliwa, J. G. M.; Isubikalu, P.; Nandozi, C.; Mukwaya, P.; Aribo, L.; Adipala, E. Vegetation Biomass Prediction in the Cattle Corridor of Uganda. African Crop Science Journal 20, 533–5432012.
(54) Owoyesigire, B.; Mpairwe, D.; Ericksen, P.; Peden, D. Trends in Variability and Extremes of Rainfall and Temperature Inthe Cattle Corridor of Uganda. Uganda Journal of Agricultural Sciences 2016, 17 (2), 231–244.
(55) United Nations Office for the Coordination of Humanitarian Affairs. Severe drought affects millions in Eastern Africa https://www.unocha.org/story/severe-drought-affects-millions-eastern-africa (accessed 2021 -07 -09).
(56) USAID. Uganda Climate Vulnerability Profile; 2012.
(57) Relief Web. Uganda CO El Nino, Cholera & Malaria Situation, 10 February 2016 https://reliefweb.int/report/uganda/uganda-co-el-nino-cholera-malaria-situation-10-february-2016 (accessed 2021 -07 -09).
(58) Climate Risk Country Profile: Uganda. World Bank Group 2020.
(59) Nsubuga, F. W. N.; Botai, O. J.; Olwoc, J. M.; Rautenbach, C. J. deW; Bevis, Y.; Adetunji, Abebayo O. The Nature of Rainfall in the Main Drainage Sub-Basins of Uganda. Hydrological Sciences Journal 50 (2). https://doi.org/10.1080/02626667.2013.804188.
(60) Uganda Projections. World Bank Group 2020.
(61) Famine Early Warning Systems Network (FEWSNET). A Climate Trend Analysis of Uganda; Informing Climate Change Adaption Series; USGS and USAID, 2012.
(62) Uganda Vulnerability. World Bank Group.
(63) Moore, S. M.; Azman, A. S.; Zaitchik, B. F.; Mintz, E. D.; Brunkard, J.; Legros, D.; Hill, A.; McKay, H.; Luquero, F. J.; Olson, D.; Lessler, J. El Niño and the Shifting Geography of Cholera in Africa. Proceedings of the National Academy of Sciences of the United States of America 2017, 114 (17), 4436–4441.
(64) Wang, G.; Cai, W.; Gan, B.; Wu, L.; Santoso, A.; Lin, X.; Chen, Z.; McPhaden, M. J. Continued Increase of Extreme El Niño Frequency Long after 1.5 °C Warming Stabilization. Nature Climate Change 2017, 7, 568–572.
(65) Marsham, J. East Africa faces triple crisis of Covid-19, locusts and floods https://www.climatechangenews.com/2020/05/11/east-africa-faces-triple-crisis-covid-19-locusts-floods/ (accessed 2021 -07 -09).
(66) MWE. Catchment Management Organization Procedures Manual; Ministry of Water and Environment, Directorate of Water Resources Management, 2019.
(67) MWE. JWESSP Programme-to-Date Report; Ministry of Water and Environment, 2016.
(68) National Planning Authority. Third National Development Plan 2020/21 - 2024/25; 2020.
(69) MWE. Registered Hydrogeologists and/or Hydrogeological Consultants for Financial Year 2017/2018; Ministry of Water and Environment, Directorate of Water Resources Management.
(70) Amanya, C. Sector Planning, Finance, M&E and Capacity Dev't, 2019.
(71) Ministry of Water and Environment. Albert Nile Catchment Management Plan; Kampala, 2016.
(72) Strzepek, K.; Boehlert, B.; Willwerth, J. Strategic Investment Plan for the Water and Environment Sector, Uganda (2018-2030); Ministry of Water and Environment, 2018.
(73) Water and Environment Sector Performance Report 2015. Ministry of Water and Environment.
(74) Water and Environment Sector Performance Report 2020. Ministry of Water and Environment 2020.
(75) Director of Water Resources Management. Review of Sector Performance Report 2017/2018, 2018.
(76) Owor, M.; Tindimugaya, C.; Brown, L.; Upton, K.; Dochartaigh, B.; Bellwood-Howard, I. Africa Groundwater Atlas: Hydrogeology of Uganda; British Geological Survey, 2018.

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