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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.

South Sudan Water Resources Profile Overview

South Sudan has abundant water resources, with generally low over-abstraction and water quality risks. Total annual renewable water resources per person are 3,936 m^3, which is higher than the Falkenmark Index[i] threshold for water stress. The total volume of freshwater withdrawn is 4.23 percent of South Sudan's total resource endowment, well below the 25 percent water stress benchmark and slightly lower than the 5.7 percent average in sub-Saharan Africa.[ii] Water resources are not evenly distributed across the country and inter-seasonal variability is high, which leads to extreme flooding and dry season shortages. South Sudan is highly dependent on surface water resources that originate in neighboring countries, which could exacerbate conflicts around water availability if inflows are reduced from upstream sources.

Inadequate permitting and water quality monitoring systems as well as limited data on water resources impede effective integrated water resources management and a comprehensive understanding of risks related to water availability and water quality.

Oil extraction in the central floodplains of Jonglei, Lakes, and Upper Nile has contributed to surface and groundwater quality risks. Pipe leakage and spills have contaminated surface water, while seepage from oil fields have increased salinity and concentrations of heavy metals in groundwater.

Shallow groundwater tables are susceptible to contamination from landfill leaching, sewage, and industrial effluent. Agriculture, animal husbandry, and municipal and industrial effluent have also caused localized surface water contamination.

Climate change will affect rainfall patterns, increase the risk of flooding, and alter river regimes, potentially leading to crop losses and reduced livestock yields.

South Sudan has experienced recurring civil conflicts which have stalled institutional development, especially in the water sector, resulting in inefficient institutions with overlapping responsibilities across ministries. Human and financial resource constraints affect planning, monitoring, and management systems. These governance challenges, paired with widespread poverty, contribute to local water security risks. Government and donor support for integrated water resources management has been a lower priority compared to other sectors, including drinking water, sanitation, and hygiene.

[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

- Seasonal wetlands cover 7.2 percent of the country and play an important role in regulating water flows, recharging groundwater, and providing natural filtration. Approximately half of surface water inflows to the wetlands are lost due to high evaporation.
- The Nile River basin covers 97.5 percent of the country and is divided into three main sub-basins which feed into the Nile River: the Bahr el Jebel, Sobat, and Bahr el Ghazal.
- High rainfall and seasonal flooding are important for groundwater recharge, especially in the central Sudd Basin, which is the largest source of groundwater.

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

The Nile Basin covers 97.5 percent of South Sudan[2] and the Rift Valley Basin covers the remaining 2.5 percent in the southeast near the border with Ethiopia and Kenya. Three major river basins feed into the White Nile, although many of these rivers are highly seasonal.[3] In the south, Bahr el Jebel discharges approximately 30,000 MCM annually into the White Nile and the seasonal Sobat river in the northeast discharges an additional 14,000 MCM per year.[4] Bahr el Ghazal is a seasonal river discharges 12,000 MCM per year into the White Nile. The Sudd wetland is a Ramsar site and its seasonal coverage ranges between 10,000-35,000 km^2, making it one of the largest in the world.5 The White Nile River begins just north of the Sudd wetland where the Bahr el Jebel and Bahr el Ghazal Rivers merge at Lake No.[4] About half of all inflows into the Sudd wetland, and subsequent outflows into the White Nile, are lost due to high rates of evaporation.[2] Wetlands cover approximately 7.2 percent of South Sudan[6] and help regulate flow, recharge groundwater, and provide natural filtration in the Nile River Basin.[4]

Groundwater Resources

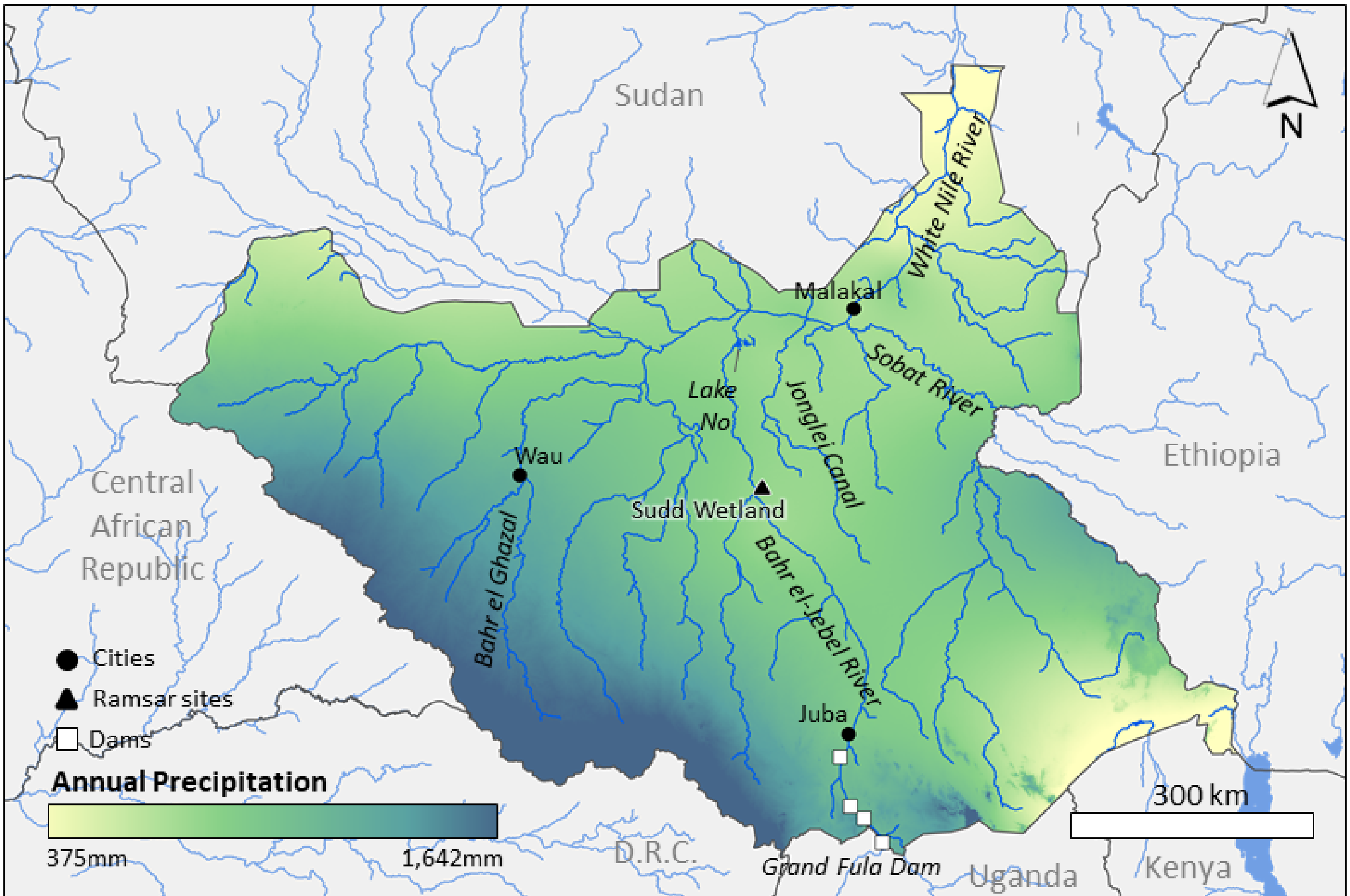
South Sudan has three main aquifer types: unconsolidated, basement, and consolidated.[7] Spanning 365,268 km^2, the Umm Ruwaba unconsolidated geological formation is located within the Sudd Basin and is the largest source of groundwater.[6] Water tables are shallow, ranging between 10-25m, although they can reach over 300m in the central and northern parts of the aquifer.[6,8] Heavy seasonal rainfall and river flooding recharge the Umm Ruwaba aquifer with approximately 341 MCM per year.[5,6] The basement complex covers most of the western border with the Democratic Republic of Congo (DRC) and Central African Republic (CAR).5 The aquifer generally has low productivity and recharge, limited reserves,[9] and the water table is between 4-60m

TABLE 1. WATER RESOURCES DATA

	Year	South Sudan	Sub-Saharan Africa (median)
Long-term average precipitation (mm/year)	2017	900	1,032
Total renewable freshwater resources (TRWR) (MCM/year)	2017	49,500	38,385
Falkenmark Index - TRWR per capita (m3/year)	2017	3,936	2,519
Total renewable surface water (MCM/year)	2017	49,500	36,970
Total renewable groundwater (MCM/year)	2017	4,000	7,470
Total freshwater withdrawal (TFWW) (MCM/year)	2002	658	649
Total dam capacity (MCM)	2015	0	1,777
Dependency ratio (%)	2017	65.79	22.78
Interannual variability	2013	1.50	1.55
Seasonal variability	2013	2.50	3.15
Environmental Flow Requirements (MCM/year)	2017	33,930	18,570
SDG 6.4.2 Water Stress (%)	2002	4.23	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

deep.[7] Aquifer productivity in the consolidated aquifers in the northwest and southeast can be highly variable, although information about the aquifer is generally limited.[7,9]

Surface Water Outlook

KEY TAKEAWAYS

- Domestic use is the main source of demand for surface water, however, livestock watering and fisheries are also important.
- The planned Jonglei canal would reduce water losses and increase water availability for agriculture; however, it would also reduce surface flows through wetland ecosystems.
- Effluent from the oil industry, urban centers, and agriculture contaminate surface waters with heavy metals, fecal bacteria, and chemical fertilizers.

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

Municipal drinking water, agriculture, and animal husbandry are the principal sources of demand for surface water. Surface water demand in South Sudan's largest cities, including Juba, represent a small fraction of total surface water demand.[10] Dependence on surface water for drinking supply is highest (56 percent of the population) in the Upper Nile State in the northeast.[11] Seasonal flooding and oil contamination pose risks to surface quality in the northeast.[5] Agricultural demand for surface water is highest in the northern regions of the Upper Nile state, followed by more limited demand in the east and southwest.[5] Total irrigation potential is approximately 1.5 million ha but only 1.4 percent of all cultivated areas are equipped for irrigation.[2] Animal husbandry, practiced by nearly 70 percent of the population, is another key source of demand for surface water.[13] South Sudan has approximately 38 million livestock, mostly cattle, which require 20-100 liters of water per day.[3]

Surface water is unevenly distributed due to inter-seasonal variability, including flooding and dry season shortages. Wet season flooding is common in the central floodplains, particularly near the Sudd wetland.[8] Increased wet season flows and flooding can triple the size of the wetland.[3] Flooding around the wetland impacts local fishing, displace livestock, and damage croplands.[12] Anticipated increases in year-round irrigation (paired with the impacts of climate change and population growth) may also cause seasonally fluctuating rivers to completely dry up during the dry season.[14] Seasonal fluctuations can lead to competition for water and tension between migrating pastoralists and local communities.[15]

Planned infrastructure projects to help regulate water availability could disrupt surface water flows and impact ecosystems. Infrastructure to divert, capture, and store water is generally limited, however, the government has plans for large dams and canals to regulate surface water flows and support agriculture and hydropower. The proposed capacity for the Grand Fula Dam on the Bahr el Jebel is 890 MW and its reservoir would make water available for irrigation, but construction has stalled due to conflict in 2013.[17] Similarly, once completed, the planned Jonglei Canal between Bahr el Jebel and the White Nile would divert 20 MCM per day around the Sudd wetlands to reduce water losses caused by high evapotranspiration.[2] Construction of the canal commenced in 1978 but it remains incomplete.[6] Diverting water from the wetlands would potentially reduce its size by 7 percent;[18] disrupt local climate regulation, water purification, flood regulation, and groundwater replenishment; harm wildlife; and drive displacement of local populations.[19]

Deforestation, overgrazing, and poor farming practices have increased stream turbidity and siltation. Livestock overgrazing in the south[12] and land clearing for agriculture on steep mountain slopes in the eastern Imatong Mountains have led to high levels of erosion and siltation downstream, including in the Sudd wetlands.[14,15] Water quality samples from the Nile River near Juba also indicate high turbidity.[20] Siltation is one of the main ecological reasons for previously perennial rivers becoming seasonal and has affected rivers along the border with the Central African Republic.[4]

Untreated effluent from industry and municipal waste pose risks to surface water, although comprehensive data is limited. Toxic wastewaters containing salts, metals, and other chemicals from oil production and exploration activities are discharged into surface water in the central floodplains.[8,21] Pipe leakages and spills in the Mala and Tharjat oil fields in the north pose serious risks to human, plant, and animal life near South Sudan's wetlands.[22] Artisanal gold mining is also common in the southeast. Mined gold in South Sudan does not require treatment with mercury or cyanide,[4] however, it could increase siltation over time.[23] Municipal and industrial effluent near Juba have also contaminated surface water with lead, cadmium, aluminum and iron in excess of WHO Drinking Water Guidelines.[10,24]

Human and animal waste drive high rates of microbiological pollution in surface water, especially near urban centers. In Juba, fecal coliforms have been detected in the White Nile River,[20] which has led to high rates of water borne diseases.

Groundwater Outlook

KEY TAKEAWAYS

- Groundwater is the main source of drinking water supply, especially in rural areas. Groundwater abstraction rates are generally low, however, more data and analysis are needed to understand risks to groundwater resources.
- Ambient groundwater quality is influenced by geogenic characteristics, including dissolution of minerals and volcanic rocks. Oil fields have increased the concentration of salts such as chloride, sodium, potassium and sulphate and heavy metals such as lead, barium, and chromium in groundwater. Untreated human waste has also contaminated groundwater with coliform bacteria, particularly near urban centers.

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

Groundwater is the main source of drinking water in rural areas and in key cities like Juba. Boreholes and wells provide an estimated 65 percent of the total water supply.[5] The Ministry of Water Resources and Irrigation, which tracks boreholes, hand-dug wells, and freshwater springs,[25] estimates that 30-50 percent of known water points are non-operational.[5]

While there is significant groundwater potential, more analysis is needed to understand localized

groundwater exploitation risks. Groundwater exploitation is not well managed or regulated by water management entities[26] and there is limited information on abstraction rates and changes in water tables.[13] Communities are generally responsible for their own wells but non-governmental organizations have also played a significant role in borehole drilling and providing access to groundwater in certain areas of the country.[27,28]

Geogenic and anthropogenic contamination pose risks to groundwater quality in some regions. Concentrations of chloride, sodium, magnesium, lead, iron, and cadmium in groundwater have been found to exceed World Health Organization standards and South Sudan Water Quality Guidelines (SSWQGs) for drinking water and irrigation in Eastern Equatoria.[29] The presence of iron and fluoride is likely of geological origin, driven by the dissolution of minerals and volcanic rocks. However, landfill leaching, sewage, and potash fertilizer application may also contribute to elevated iron, lead, and potassium.[29] High groundwater salinity is also an issue in parts of the Umm Ruwaba aquifer,[7,26] especially in the northeast of the basin,[12] and has been attributed to silts and clay, high evapotranspiration, and confined saline groundwater.[30] High salinity in groundwater has also been detected near Juba and Malakal[8] and in various parts of Eastern Equatoria, Jonglei, and Unity, although more analysis is needed to determine the source of salinity.[5,29] Fluoride, iron, manganese, nitrate, chloride, sodium, sulfate, total dissolved solids, antimony, and hardness levels have also exceeded drinking water guideline values in aquifers near Juba.[9,10]

Oil extraction poses serious threats to groundwater quality, especially in the northern state of Unity. There are high concentrations of heavy metals such as lead, barium, and chromium in groundwater near oil fields.[22,31] Groundwater in Unity also shows a high overall salt content and persistently elevated chloride, sodium, potassium and sulphate, likely caused by the seepage of saline water from oil field basins and mud pits.[31,32] Contamination from oil fields has led to higher death of livestock as well as higher incidence of birth defects, miscarriages, infertility, and skin diseases.[33,34,35]

Microbiological contamination also affects groundwater, especially near urban areas. Approximately 66 percent of groundwater sources tested near Juba contained coliform bacteria, likely due to the infiltration of contaminated surface water.[36] Groundwater contamination with coliforms has also been observed in Warrap and Western Equatoria.[12]

Water Resources and Climate

KEY TAKEAWAYS

- South Sudan has been impacted by less overall rainfall, shorter rainy seasons, and more intense rainfall events, leading to desertification and extreme flooding.
- Temperatures have increased by 1°C and will continue to rise by the end of the century. Rising temperatures have already contributed to perennial rivers becoming seasonal and will alter river regimes in the future.

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.

Since the 1970s, precipitation has declined by an average of 10 to 20 percent while variability in the onset, duration, and timing of precipitation has increased. Total annual precipitation is 900 mm with rainfall ranging between 700 mm in the north, northeast, and far southeast to 2,200 mm/year in the south.[2] Most of the country experiences one rainy season from May to October, however, the southern zones of Western and Central Equatoria have two rainy seasons (April-June and August-November).[2] Interannual variability in precipitation variability is also high and can range from 50 percent lower to 50 percent higher from the baseline average.[16] The rainy season has started later and finished earlier[16,39] while the frequency of heavy rainfall events and floods has increased measurably in the last eight decades[39] and is expected to continue to rise.[16]

Since the 1980s, temperatures have increased by more than 1°C and temperatures are expected to increase by at least 2 to 3 degrees by the end of this century. Less rain, warmer temperatures, and more frequent droughts have increased desertification.[16,39] In the last two decades, several perennial rivers have dried up or become seasonal.[38] Increased evapotranspiration and dry periods are also expected to shrink South Sudan's wetlands.[16] Research on the Equatorial Lakes and Bahr El Ghazal sub-basins suggests that a 2°C increase would reduce their average flow by 50 percent.[38,41] Desertification may also continue to impact the northern and southeastern regions as the Sahel shifts southward.[16] The sum total of these climate shifts is expected to leave a large number of South Sudanese exposed to increased food insecurity due to losses in both crop and livestock yields.[16,41]

FIGURE 2: DROUGHT RISK

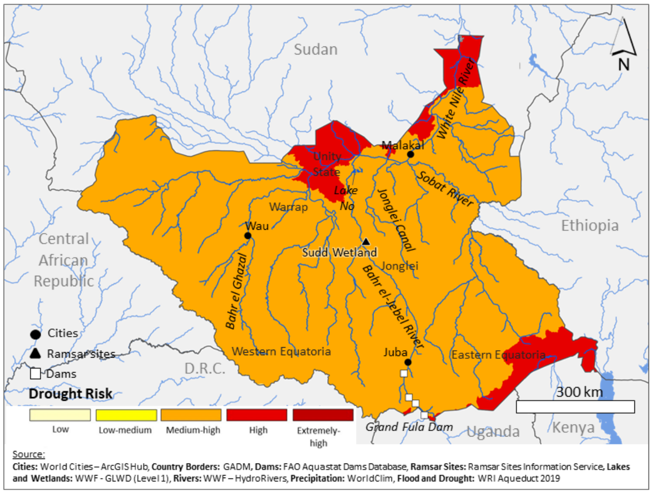
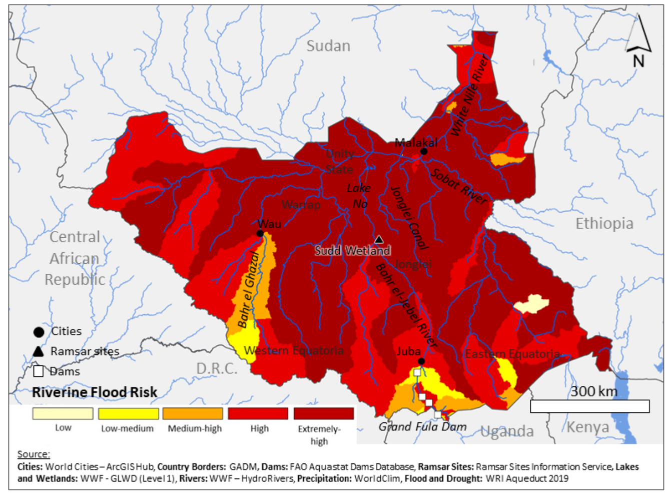


FIGURE 3. RIVERINE FLOOD RISK



Water Policy and Governance

KEY TAKEAWAYS

- As a relatively young country, the water sector is highly fragmented at the national and subnational level and many institutions lack clear roles and responsibilities.
- Limited monitoring and data analytics of water quality and availability impedes development of integrated water resource plans.

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
Southern Sudan Water Policy	2007	Promotes management of water resources through two key principles: 1) water is a shared resource and appropriate legal frameworks shall be established to govern water use and 2) water resources planning shall involve all relevant stakeholders and be undertaken on the basis of natural hydrologic boundaries.
Strategic Framework for Water, Sanitation, and Health	2011	Recommends the establishment of a Water Council, a multi-sectoral advisory board at the national level, and a Water Resources Management Authority to enforce water management and use regulations. The Framework calls for the establishment of Basin Water Boards in each basin with catchment/sub-catchment committees responsible for planning and resolving conflicts.
Water Bill	2013	Provides a legal basis for the National Water Policy. Outlines protection of groundwater and surface water resources from pollution, erosion, and other adverse effects by creating protected zones in catchment areas draining into any water supply facility, lake, reservoir, aquifer, wetland, spring, or other water source. Develops procedures to manage water allocation for different uses, conservation, water quality, water-related disasters, and intersectoral coordination.
National WASH Sector Strategic Framework	2011	Operationalizes and ensures implementation of the National Water Policy, including the priority strategic area of water resources management, and describes the overall governance and development strategy within the water sector.
National Environmental Policy	2012	Outlines sustainable use of natural resources, including guidance relating to water supply and sanitation; forestry; agriculture; fisheries; and wetlands, rivers, and lakes; which all impact water quality, availability, and use.

TABLE 3: 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.
National	Ministry of Water Resources and Irrigation (MWRI)	Responsible for water resource policy, water use planning and regulations, scientific research, setting water use tariffs, protecting wetlands. Advises sub-national entities and builds local WRM capacity. Develops dams, water supply, and irrigation infrastructure.
	Water Council	Multi-stakeholder advisory body, including members from relevant ministries, institutions, the private sector, and civil society.
	Water Resources Management Authority	Regulates the management, development, and use of water resources under the Water Council. Prepare IWRM plan based on sub-national IWRM plans.
	Ministry of Lands, Housing and Physical Planning (MLHPP)	Formulates policy, standards, and regulations on urban planning and urban land management, including urban water supply and sanitation. Responsible for wastewater treatment and disposal.
	Ministry of Environment	Responsible for environmental management policy and enforcement of environmental protection.
	Ministry of Health	Manages water treatment, enforces drinking water quality standards, and coordinates responses to water borne diseases.
	Ministry of Agriculture, Forestry, Cooperative and Rural Development (MAFCRD)	Responsible for planning and distributing water in irrigation schemes.
	Ministry of Foreign Affairs and International Cooperation	Supports management of transboundary water resources.
Sub-national	South Sudan Urban Water Coordination (SSUWC)	Responsible for the production and distribution of improved water supply in urban areas.
	State water and sanitation directorates	Responsible for water resources management at the state level. Administratively accountable to the state-level ministries and formally accountable to MEDIWR.
	Ministries of Agriculture, Animal Resources and Irrigation (MAARIs)	Instituted at the state level with jurisdiction over state natural resources, including water for irrigation.
	Basin Water Boards	Responsible for basin management, including local monitoring and evaluation. Prepares IWRM plans.
	Water Management Committee	Comprised of local stakeholders and provides advisory services to plans and conflict resolution within the basin.
	Water User Associations	Responsible for local service delivery, maintenance, and water management.

Water management responsibilities are distributed across several institutions and entities, but roles and responsibilities are not clear or aligned. Because South Sudan is a relatively new country, institutions are nascent and progress in the water sector has been slow.[42] Despite strong policy frameworks for integrated water resources management, many of the proposed governance structures have yet to be established and operationalized.[43] As of mid-2020, the Water Bill had not been approved by the cabinet or Parliament, nor have the WRMA, Water Council, and Basin Water Boards envisaged in the bill been formed.[44] There is limited coordination and overlapping responsibilities between national and local water management institutions.[5] For example, the Water Policy and WASH Strategic Framework outlined conflicting responsibilities for the MWRI and MLHPP.[45] Sub-nationally, local governments have the legal mandate to manage water resources based on the Local Government Act of 2009 but do not always have the institutional capacity or sufficient funding.[45] Additionally, state-level ministries and state water and sanitation directorates do not yet exist in every state, which complicates local IWRM efforts.[45,46]

The water sector is heavily dependent on donor support, primarily for WASH and emergency response activities. Since 2013, direct funding from the government and development partners has prioritized humanitarian WASH services and emergency infrastructure during the country's protracted conflict.[43] An estimated 85 percent of the water sector's services are provided by international non-governmental organizations such as GIZ and UNICEF.[46] Implementation of long-term, sustainable national and local IWRM is impeded by limited funding and qualified staff responsible for IWRM initiatives.[5] as well as a lack of key equipment, operational systems, and technical capacity for IWRM.[2,45] Governance strengthening measures will be critical for ensuring water security and resilience.

Transboundary governance of the Nile River is a challenge and an opportunity. As South Sudan is located in the middle of the Nile Basin, its role in transboundary management of the basin is critical though a broader framework is needed to assign water rights among riparian countries.[4] South Sudan has benefited from the Nile Basin Initiative's (NBI) technical training for MWRI staff and the piloting of various integrated watershed management projects.[5]

Water Quality Monitoring

Water quality monitoring is generally limited. There are significant information gaps in the understanding of groundwater quality.[3,26] Additionally, only 10 of 113 hydrological stations are operational. Most of the meteorological and hydrological data network was destroyed during the conflict. Only one small water quality laboratory exists within the MWRI.[5] Although the Ministry of Health and MEDIWR currently are responsible for monitoring and setting guidelines for water quality, a "Safe Water Supply and Sanitation Services Regulator" will issue standards and guidelines for water quality once the Water Bill is approved.[49] Overall, the lack of data, monitoring infrastructure, and information management systems makes it difficult to assess water quality and availability.[3]

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