

Ethiopia's Water Resources: A Comprehensive Review of Availability, Utilization, and Management

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Received 29 January 2025;
Accepted 24 December 2025;
Available online 27 December 2025

Abstract: Water is Ethiopia's most critical natural resource, underpinning agriculture, energy, and livelihoods. However, the country faces growing challenges in managing its water resources due to poor spatial and temporal distribution, rapid population growth, climate change, weak institutional frameworks, and transboundary tensions. This review synthesizes evidence on Ethiopia's surface water, groundwater, and rainfall variability across the 12 major river basins. It highlights how rainfall is highly erratic, with increasing frequency of droughts and floods, while groundwater remains underutilized due to limited infrastructure. More than 90% of Ethiopia's water use is allocated to agriculture, yet irrigation potential is far below capacity. Hydropower development has expanded, notably through the Grand Ethiopian Renaissance Dam (GERD), but institutional fragmentation and weak policy enforcement hinder integrated management. Transboundary challenges, particularly in the Nile Basin, add further complexity. The review identifies critical issues, including weak institutional coordination, infrastructure deficits, watershed degradation, and limited data systems. At the same time, opportunities exist in institutional reforms, investment in irrigation and storage infrastructure, conservation-based watershed management, and regional cooperation. To ensure sustainable water security, Ethiopia must adopt integrated water resource management (IWRM), strengthen policies, expand irrigation efficiency, enhance monitoring systems, and foster transboundary cooperation.

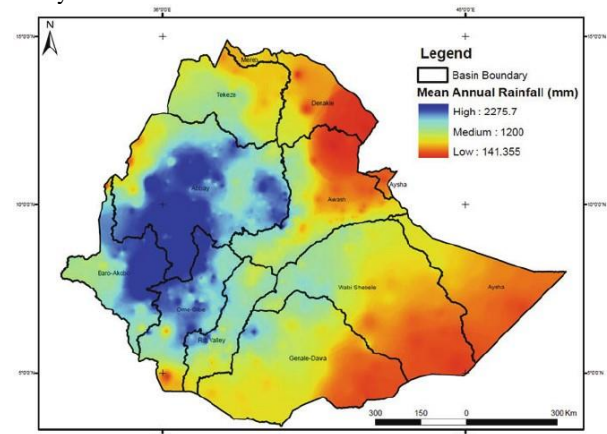
Keywords: Ethiopia; Water resources; Variability; Groundwater; Climate change; Water management; Agriculture; Hydropower; Transboundary; Nile Basin; Integrated Water Resource Management (IWRM).

1. Introduction

Water resources are central to Ethiopia's economy, food security, and social development. Agriculture, which employs more than 70% of the population, consumes over 90% of the country's total water use. Despite an estimated 122 billion cubic meters (BCM) of annual surface runoff and substantial groundwater reserves, Ethiopia faces chronic water scarcity in practice. This paradox arises from high spatial and temporal variability, limited infrastructure, weak institutional coordination, and growing pressures from climate change and population growth.

Ethiopia's climate is characterized by strong rainfall variability, both seasonally and geographically. The highlands receive annual rainfall exceeding 2,000 mm, while lowland and arid regions often receive less than 300 mm. The dependence on the summer "kiremt" rains (June–September) makes the country highly vulnerable to droughts when seasonal rainfall fails. Increasingly, extreme hydrological

events—both droughts and floods—are being observed, with devastating impacts on livelihoods, water supply, and ecosystems.



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Figure 1: Map of Ethiopia's annual rainfall distribution by region

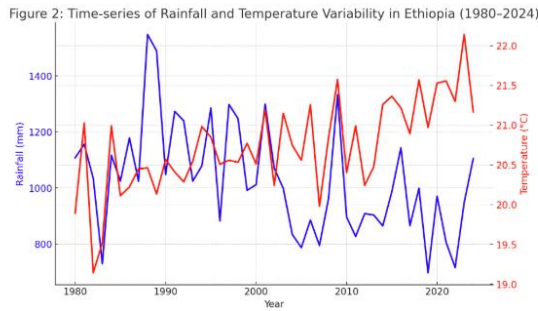


Figure 2: Time-series of rainfall and temperature variability in Ethiopia over recent decades

Ethiopia is divided into 12 major river basins, which together form the backbone of the nation's water resources. These include Transboundary Rivers such as the Abbay (Blue Nile), Baro-Akobo, and Omo-Gibe, which link Ethiopia's water management directly to regional geopolitics. The recent completed of the Grand Ethiopian Renaissance Dam (GERD) on the Abbay River illustrates both the opportunities and tensions associated with transboundary water development.

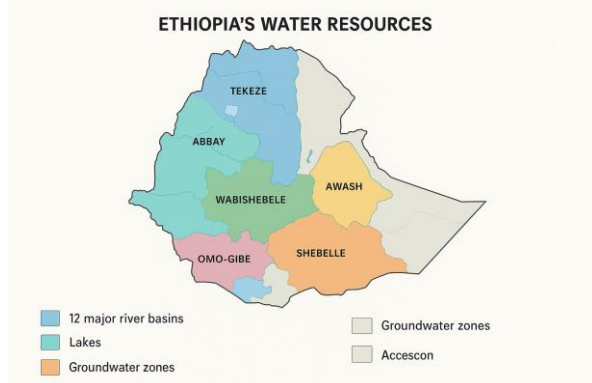


Figure 3: Map of Ethiopia's 12 major river basins with associated lakes and groundwater zones

Institutionally, water governance in Ethiopia has been shaped by the 1999 Water Resources Management Policy and subsequent strategies emphasizing Integrated Water Resource Management (IWRM). However, implementation is constrained by overlapping mandates, limited financial and technical capacity, and weak coordination across ministries and regional governments. These institutional challenges limit Ethiopia's ability to harness its water potential for irrigation expansion, hydropower, and domestic supply.

Table 1: Ethiopia's Water Resources and Utilization

Resource Type	Volume Estimate (BCM/year)	Utilization (BCM/year)	Main Uses (Share %)
Surface water runoff	~122	<5	Agriculture (>90%), Hydropower
Groundwater (renewable)	~30-40	<2	Domestic, small-scale irrigation
Lakes and wetlands	~13	<1	Fisheries, ecosystems

Total	~160+	~6-8	Agriculture 90%, Domestic 7%, Industry 2%, Others 1%
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The purpose of this review is to synthesize available knowledge on Ethiopia's water resources, focusing on availability, utilization, management issues, and opportunities. Special attention is given to climate change impacts, institutional frameworks, and transboundary water challenges, with the aim of informing integrated strategies for sustainable water management.

2. Water Resource Availability in Ethiopia

Ethiopia is endowed with significant freshwater resources, including surface water, groundwater, lakes, and wetlands. Despite this natural wealth, effective utilization remains very low due to infrastructural, institutional, and financial constraints.

2.1 Surface Water Resources

Ethiopia has 12 major river basins with an estimated mean annual surface runoff of about 122 billion cubic meters (BCM). However, the contribution of these basins is highly uneven in space and time. For example, the Abbay (Blue Nile) accounts for nearly 50% of national surface water outflow, while central basins such as the Awash are heavily exploited and often face seasonal scarcity.

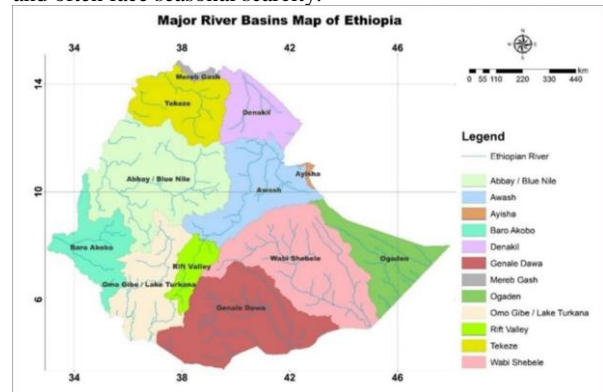


Figure 3: Map of Ethiopia's 12 Major River Basins

Table 2: Surface Water Resources by Basin

Basin	Annual Runoff (BCM)	Key Features/Uses
Abbay (Blue Nile)	~52	Hydropower, irrigation, transboundary flows
Awash	~4.9	Irrigation, domestic, industry (heavily used)
Omo-Gibe	~16.6	Hydropower, irrigation
Baro-Akobo	~23.6	Potential irrigation, wetlands, Nile contribution
Genale-Dawa	~5.8	Irrigation, pastoral use
Wabe-Shebelle	~3.2	Irrigation (Somali region), transboundary
Tekeze	~7.6	Hydropower, irrigation
Mereb	~0.8	Local irrigation, small flow
Afar-Danakil	~0.9	Evaporation-prone, saline water
Rift Valley Lakes	~5.6	Lakes, fisheries, ecosystems
Aycash	~0.1	Small, localized

Ogaden	<0.5	Ephemeral flows
Total	~122	—

2.2 Groundwater Resources

Groundwater is an important but underdeveloped resource, estimated between 30–40 BCM annually. It is particularly vital in drought-prone lowlands where surface water is limited. However, utilization remains below 10% of the potential, largely due to insufficient drilling, pumping infrastructure, and monitoring systems.

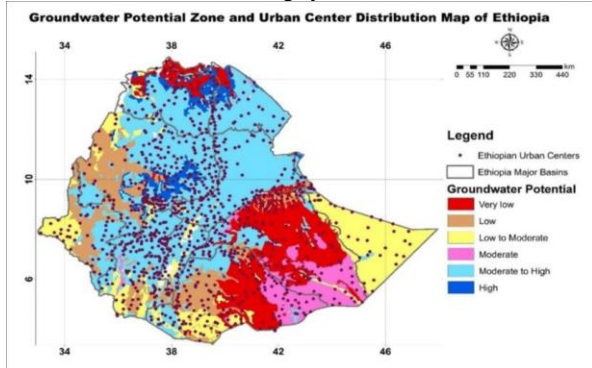


Figure 4: Map of Ethiopia's Groundwater Distribution

2.3 Lakes and Wetlands

Ethiopia has over 12 large natural lakes, primarily in the **Rift Valley system**, with a combined storage of ~13 BCM. These lakes support fisheries, biodiversity, and tourism but are increasingly threatened by pollution, sedimentation, and water abstraction. Wetlands such as those in the **Baron-Akobo basin** provide critical ecosystem services but remain poorly managed.

2.4 Climate and Hydrological Variability

Rainfall is highly seasonal and concentrated in the summer monsoon (kiremt). Variability in rainfall has been increasing, with frequent droughts in 1973–74, 1984–85, 2002–03, 2011, and 2015–16, each causing severe humanitarian crises. Floods have also increased, particularly in the Awash and Baro-Akobo basins, damaging settlements and agriculture.

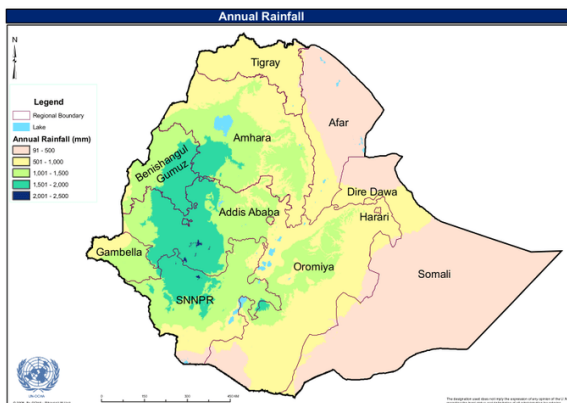


Figure 1: Rainfall Distribution across Ethiopia

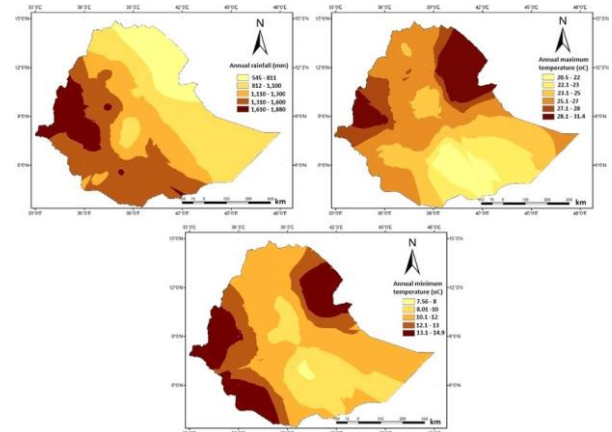


Figure 2: Rainfall and Temperature Variability (1980–2020)

3. Utilization of Water Resources in Ethiopia

Despite Ethiopia's substantial water endowment, actual utilization remains very limited compared to potential. Annual water use is estimated at only 6–8 BCM, which represents less than **10%** of the available renewable water resources. Utilization is uneven across sectors, with agriculture dominating, while domestic, industrial, and hydropower uses remain underdeveloped relative to potential.

3.1 Agricultural Use

Agriculture consumes over 90% of total water withdrawals, mainly for irrigation. However, only about 5–6% of Ethiopia's 5.3 million hectares of irrigable land has been developed. Irrigation schemes range from small-scale community-managed systems to large government-led projects. Constraints include inadequate investment, poor maintenance of schemes, and high evaporation losses in arid zones.

3.2 Domestic and Municipal Use

Water supply coverage has improved in recent years, but access remains limited in rural areas. About 57% of rural households and 97% of urban households have access to improved water sources (MoWE, 2022). However, per capita water consumption remains low (~15–25 liters/day in rural areas vs. WHO minimum standard of 50 liters/day).

3.3 Industrial Use

Industrial water use is small (<2% of total withdrawals), concentrated in food processing, textiles, leather, and emerging manufacturing zones. Industrial abstraction is increasing, but lack of wastewater treatment threatens water quality in rivers and lakes.

3.4 Hydropower Use

Hydropower is Ethiopia's most important non-consumptive use of water. The country has an estimated 45,000 MW of hydropower potential, of which less than 10% is currently harnessed. The Grand Ethiopian Renaissance Dam (GERD), once fully operational, will generate 5,150 MW and provide storage for irrigation and flood regulation.

3.5 Sectoral Water Use Summary

Table 3: Water Utilization by Sector in Ethiopia

Sector	Estimated Use (BCM/year)	Share of Total (%)	Notes
Agriculture	~6.0	~90%	Mainly irrigation (low coverage vs potential)
Domestic	~0.5	~7%	Low per capita

			access, rural–urban disparity
Industry	~0.1	~2%	Emerging, weak wastewater management
Hydropower	Non- consumptive	—	45,000 MW potential, <10% developed
Total	~6.6–7.0	100%	<10% of renewable water resources

4. Water Resource Management Issues in Ethiopia

Despite Ethiopia's significant water potential, multiple challenges constrain effective and equitable utilization. These issues can be grouped into institutional and policy gaps, infrastructure deficiencies, environmental degradation, and transboundary challenges.

4.1 Institutional and Policy Gaps

Water governance in Ethiopia is guided by the **1999 Water Resources Management Policy** and subsequent strategies emphasizing Integrated Water Resource Management (IWRM). However, fragmented mandates across ministries, weak coordination between federal and regional governments, and inadequate financing undermine implementation.

Table 4: Institutional and Policy Challenges in Ethiopia's Water Sector

Challenge	Description	Example
Fragmented institutions	Overlapping mandates across MoWE, MoA, regional bureaus	Irrigation vs. watershed management conflicts
Weak enforcement	Limited capacity to enforce water laws and regulations	Illegal abstractions in A wash Basin
Inadequate financing	Insufficient budget allocation for water	Rural water supply schemes underfunded
Poor data and monitoring systems	Weak hydrological/groundwater monitoring networks	Lack of basin-level data
Limited stakeholder participation	Communities often excluded from planning	Smallholder irrigation projects poorly maintained

4.2 Infrastructure Deficiencies

Ethiopia's water infrastructure remains underdeveloped relative to demand. Only a fraction of irrigation potential is developed, while storage capacity is limited compared to variability in rainfall. For example, per capita storage in Ethiopia is estimated at less than 50 m³, compared to 6,000 m³ in the U.S.A the country also faces limited wastewater treatment capacity, leading to pollution of rivers and lakes.

4.3 Environmental Degradation

Watersheds are deteriorating due to deforestation, overgrazing, and soil erosion. Sedimentation reduces reservoir capacity, while land degradation worsens drought and flood risks. For example, soil erosion in the Ethiopian highlands is

estimated to exceed 20 tons/ha/year, contributing to siltation of dams such as Koka and hydropower reservoirs along the Abbay and Awash rivers

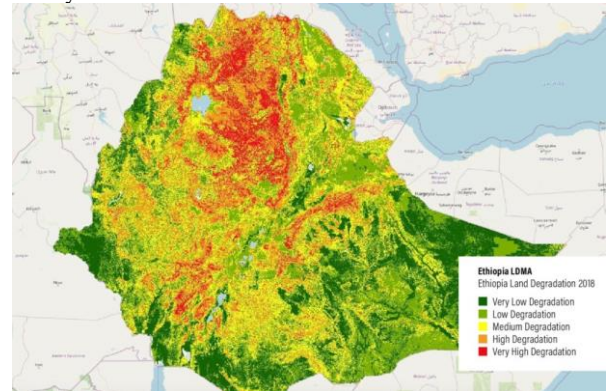


Figure 4: Map showing hotspots and soil erosion trends in Ethiopia

4.4 Transboundary Water Challenges

Ethiopia is the source of major transboundary rivers, notably the Abbay (Blue Nile), Baro-Akobo, and Omo-Gibe. While this provides opportunities for hydropower and irrigation, it also generates regional tensions. The Grand Ethiopian Renaissance Dam (GERD) has sparked negotiations with downstream countries (Sudan and Egypt), highlighting the need for cooperative frameworks.

Table 5: Key Transboundary Water Challenges

Basin/River	Riparian Countries	Issue
Abbay (Blue Nile)	Ethiopia, Sudan, Egypt	GERD filling/operation, water allocation
Baro-Akobo	Ethiopia, South Sudan, Sudan	Wetland management, irrigation development
Omo-Gibe	Ethiopia, Kenya	Flow changes impacting Lake Turkana
Wabe-Shebelle	Ethiopia, Somalia	Irrigation, recurrent drought/floods

5. Opportunities and Strategies for Water Resource Management in Ethiopia

Addressing Ethiopia's water challenges requires context-specific strategies that target institutional, infrastructural, environmental, and transboundary dimensions. Opportunities exist to transform challenges into pathways for sustainable water security.

5.1 Institutional and Policy Reform

Challenges: Fragmented institutions, weak enforcement, poor monitoring, and limited stakeholder participation.

Strategies & Opportunities:

Strengthen Integrated Water Resource Management (IWRM) at basin level through functional River Basin Authorities.

Enhance enforcement of water policies with clear mandates for ministries and regional bureaus.

Expand hydro-meteorological and groundwater monitoring networks with digital platforms for data sharing.

Increase participation of local communities and water user associations in planning and operation of schemes.

Mobilize innovative financing (climate funds, public–private partnerships).

5.2 Infrastructure Development

Challenges: Low irrigation coverage, limited water storage, and weak wastewater treatment.

Strategies & Opportunities:

Invest in multi-purpose dams and reservoirs to increase per capita storage and buffer rainfall variability.

Scale up small- and medium-scale irrigation schemes with efficient technologies (drip, sprinkler).

Promote rainwater harvesting and managed aquifer recharge in arid regions.

Expand wastewater treatment and reuse for industrial and urban water supply.

Integrate hydropower, irrigation, and domestic supply in large infrastructure projects such as GERD.

5.3 Environmental Conservation and Restoration

Challenges: Watershed degradation, soil erosion, deforestation, and sedimentation.

Strategies & Opportunities:

Implement watershed management programs with community participation (e.g., terracing, reforestation).

Promote climate-smart agriculture (CSA) to conserve soil moisture and reduce erosion.

Establish buffer zones around lakes and wetlands to protect ecosystems.

Introduce payment for ecosystem services (PES) to incentivize conservation practices.

Strengthen environmental impact assessments (EIA) and monitoring of large projects.

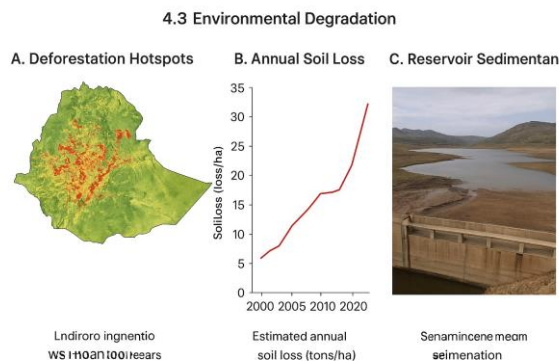


Figure 5: Environmental degradation trends – soil loss, deforestation, reservoir sedimentation

5.4 Transboundary Cooperation

Challenges: Competing demands and regional tensions in shared basins (Nile, Omo, Wabe-Shebelle).

Strategies & Opportunities:

Strengthen the Nile Basin Initiative (NBI) as a platform for dialogue and joint planning.

Develop data-sharing agreements and cooperative frameworks on GERD operation with Egypt and Sudan.

Establish bilateral/multilateral agreements on shared rivers such as the Baro-Akobo and Wabe-Shebelle.

Explore regional energy trade by exporting surplus hydropower to neighboring countries, fostering win-win outcomes.

Encourage joint investment in infrastructure and watershed conservation in shared basins.

6. Conclusion and Recommendations

6.1.conclusion

Ethiopia possesses vast water resources, including 12 major river basins, substantial groundwater reserves, and extensive lakes and wetlands. Yet, despite this natural endowment, utilization remains below 10% of potential, with agriculture consuming over 90% of withdrawals while irrigation development lags far behind. Water availability is further

constrained by high spatial and temporal variability, weak infrastructure, environmental degradation, and governance gaps. Climate change has intensified these challenges, amplifying droughts, floods, and temperature extremes, while Transboundary Rivers such as the Abbay (Blue Nile) link Ethiopia's water security to regional geopolitics.

This review has identified four key issue areas:

Institutional and Policy Gaps – Fragmented mandates, weak enforcement, poor data systems, and limited community participation.

Infrastructure Deficiencies – Low per capita storage, limited irrigation coverage, and inadequate wastewater treatment.

Environmental Degradation – Soil erosion, deforestation, and sedimentation reducing water quality and storage capacity.

Transboundary Challenges – Regional tensions over shared basins, particularly the Nile.

At the same time, Ethiopia has clear opportunities to transform water management into a driver of sustainable growth.

6.2. Recommendations:

Strengthen Governance: Enhance River Basin Authorities, improve enforcement of water laws, and integrate local communities through participatory water user associations.

Invest in Infrastructure: Expand multi-purpose dams, small- and medium-scale irrigation, and urban wastewater treatment. Promote efficient irrigation technologies such as drip and sprinkler systems.

Conserve Watersheds: Scale up reforestation, terracing, and CSA practices to reduce erosion and sedimentation. Introduce incentive schemes such as payment for ecosystem services.

Leverage Technology and Data: Expand hydro-meteorological monitoring networks, remote sensing, and digital platforms for water data sharing.

Foster Regional Cooperation: Strengthen the Nile Basin Initiative, institutionalize data-sharing agreements, and promote regional hydropower trade as a trust-building mechanism.

Mobilize Financing: Utilize climate finance, blended public-private investments, and international development support to close funding gaps.

In conclusion, Ethiopia's water challenges are complex but surmountable. By aligning institutional reforms, infrastructure investment, environmental restoration, and regional cooperation, Ethiopia can move from underutilization and vulnerability to resilience and sustainable water security.

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