Cooperation in International Waters in Africa

CIWA Climate Resilience & Mitigation Assessment

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HOSTED BY WORLD BANK GROUP Water

CIWA

Credit list

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Abbreviations

AFD	French Development Agency
AfDB	African Development Bank
ASA	Advisory Services and Analytics
BETF	Bank-executed trust fund
CIWA	Cooperation in International Waters in Africa
CRIP	Climate Resilience Investment Plan
DBA	Dam break analysis
DPF	Development policy financing
DRC	Democratic Republic of the Congo
DSS	Decision support system
ENTRO	Eastern Nile Technical Regional office
ESIA	Environmental and social impact assessment
FY	Fiscal year
GBV	Gender-based violence
GRID	Green, resilient, and inclusive development
HoA	Horn of Africa
IGES	Institute for Global Environmental Strategies
IsDB	Islamic Development Bank
Km	Kilometers
GHG	Greenhouse gas
G-RES Tool	GHG Reservoir Tool
HES	Hydroelectric scheme
ICRR	Implementation Completion and Results Report
IDA	International Development Association
IGAD	Intergovernmental Authority on Development
IPF	Investment project financing
KDRP	Kariba Dam Rehabilitation Project
MDB	Multilateral development bank
MDTF	Multi-Donor Trust Fund
MW	Megawatt
MWh	Megawatt hour
MSIOA	Multi-Sector Investment Opportunity Analysis
NBA	Niger Basin Authority
NBI	Nile Basin Initiative
NBS	Nature-based solutions
NCCR	Nile Cooperation for Climate Resilience
NCORE	Nile Cooperation for Results
OKACOM	Permanent Okavango River Basin Water Commission
PAD	Project Appraisal Document
PIDACC	Program for Development and Adaptation to Climate Change
PforR	Program-for-results
RCRP	Regional Climate Resilience Program for Eastern and Southern Africa
RECLIMA	Resilience and Water Security in Angola
RETF	Recipient-executed trust fund
SADC	Southern Africa Development Community
SADC-GMI	SADC Groundwater Management Institute
SADRI	Southern Africa Drought Resilience Initiative
SSA	Sub-Saharan Africa
TA	Technical assistance
$tCO_2e(q)$	(metric) Tons of carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States dollar
WRM	Water resources management
WSS	Water supply and sanitation
ZAMCOM	Zambezi Watercourse Commission
ZRA	Zambezi River Authority
ZRB	Zambezi River Basin

Executive Summary

Since its inception, the Cooperation in International Waters in Africa (CIWA) Trust Fund has brought climate change and resilience considerations to the forefront of its work. CIWA is well aligned with the World Bank's Climate Change Action Plan 2021-2025 and Action Plan on Adaptation and Resilience, which prioritize mainstreaming climate change actions and addressing climate change resiliency. Cooperative transboundary water resources management is imperative for a peaceful and climate-resilient planet and people.

For this assessment, CIWA conducted a stocktaking of its operations and their influence on climate mitigation and resilience outcomes, identified CIWA's comparative advantage, highlighted its niche, and determined if there are missed opportunities for future consideration. This report summarizes CIWA's impact and cumulative results to date for climate mitigation and resilience.

The stocktaking shows that CIWA has significantly contributed to enhancing climate change resilience and mitigation in transboundary water resource management and development in most, if not all, basins and regions where it works in Sub-Saharan Africa (SSA). Climate resilience has been a core objective of many of its strategies and projects. CIWA facilitated regional climate change scenario planning and included climate risk assessments in the planning and development of water infrastructure. CIWA also supported studies and projects that target water sectors with high vulnerability or adaptation potential such as groundwater, flood and drought management, and agricultural water use. Through collaboration with the World Bank's Environment and other Global Practices and international NGOs, CIWA connects climate change to other regional and global challenges such as gender equity, poverty reduction, biodiversity, migration, and fragility in its work.

The stocktaking and analysis found these key results:

- The predominant mechanism that CIWA contributes to climate change mitigation is through its influence on six major hydropower investments: four mobilized and two potential. Mobilized hydropower investments resulted in greenhouse gas (GHG) mitigation of 23,770 ktCO_2eq/year and average production of 25,000 GWh additional energy per year. The four mobilized hydroelectric dams provide seven percent of Africa's power.[1] If or when implemented, the two potential hydropower dams (Luapula and Batoka) will add an additional 14,092 GWh of electricity with 14,029 ktCO_2eq/year of GHG emissions savings.

- On a much smaller scale, multiple CIWA operations also contribute to GHG mitigation through implementation of solar-powered pumps for groundwater use.

- CIWA has influenced the design of additional potential investments that would lead to GHG mitigation (through hydropower, solar-powered pumps, and watershed management) when they are eventually realized, including potential investments from Nile, Niger, Cubango-Okavango River Basin operations.

- The most prevalent climate resilience actions supported by CIWA operations relate to (i) promotion of regional cooperation on flood risk reduction, (ii) provision of water resources management (WRM) training and expertise to river basin organizations (RBOs) to improve the climate resilience of water systems, and (iii) support for the supply side of water management by expanding supplies, reducing water losses, and/or improving cooperation on shared water resources.

- CIWA also contributes to climate resilience through influencing investments in flood protection, water quality, and water supply. Sanitation, including wastewater management and wastewater collection, transportation, treatment, and disposal is the least represented water sub-sector in CIWA's portfolio, with only one occurrence, which was to be expected considering that CIWA focuses on water resources management.

CIWA has contributed to i) influencing investments that are now delivering a significant fraction of SSA's hydroelectric power, ii) delivering core information and institutional inputs that are requisite for climate change adaptation and resilience, and iii) expanding its portfolio to previously lightly-touched sectors that are linked to climate resilience and mitigation such as water quality; dam safety; nature-based storage solutions; groundwater management and sustainable use; and biodiversity, ecosystem services, and conservation. These sectors are critical for resilience to extreme weather but have only minor mitigation benefits that are not linked to the energy sector (e.g., through watershed management). CIWA's active and pipeline projects include multipurpose dams, and future mitigation investments will likely focus on smaller investments such as in carbon sequestration through climate-smart watershed management and rehabilitation plans, solar-pumped groundwater investments, and wetlands and biodiversity protection. CIWA's current portfolio embraces its strong track record of climate resilience through improving regional water resource management and planning while leaning into the trajectory on increased flood and drought risk management, dam safety, and water quality actions.

[1] Total electricity produced in Africa is148,422 GWh (IEA 2022)

Background

Climate Change is an Existential Threat to Sub-Saharan Africa

Sub-Saharan Africa is one of the most vulnerable regions to climate change effects but only a minor contributor to global GHG emissions. Africa is already experiencing climate change impacts and includes regions that will experience the most devastating consequences of projected climate trends. Many SSA regions are warming at a faster rate than the global average and facing an above-average sea-level rise.[2]

In 2022, Nigeria lost more than 600 people and farmlands to the worst flooding in a decade following heavy rain and Cameroon's release of water from Lagdo Dam. As this report was being finalized, the Lagdo Dam was again undergoing controlled releases of up to 1,000m³ per second that is drenching farms and threatening lives and livelihoods. The controlled releases are to mitigate the flooding that would occur if the carrying capacity of the Benue River system were exceeded.

Exacerbated by the El Niño weather pattern, heavy rains and flooding have claimed hundreds of lives and displaced 1 million people across the region, including in Ethiopia, Kenya, Somalia, and Tanzania. In Tanzania, torrential rains wreaked havoc from January to May 2024. Over those months, recurring floods transformed roadways into rivers, submerged entire homes, and killed or injured hundreds. In addition to the impact on human lives, the destruction of more than 51,000 homes and 76,700 hectares (189,000 acres) of farmland has adversely affected more than 200,000 people across the country. The lack of a well-coordinated disaster plan in Tanzania contributes to delayed responses that ultimately lead to a higher death toll. Those floods are a symptom of the larger-scale devastation unfolding across East Africa since the region's seasonal rains began in October 2023. Many of those countries are also grappling with severe public health emergencies caused by the floods. In Somalia, floods have created a breeding ground for bacterial diseases that have in turn resulted in a surge in cholera outbreaks across the country. In Kenya and Tanzania, floods have caused extensive agricultural damage, leading to economic losses and increasing the risk of food insecurity.

Southern Africa is experiencing its worst drought in more than a century, exacerbated by the El Niño effect and the consequences of climate change.[3] The 2023 rainy season (November-April) recorded below-average rainfalls, heatwaves, and an overall temperature increase. Crops and livestock suffered major losses due to the ongoing drought and related water shortages, fueling food insecurity and economic hardship. The Southern Africa Development Community (SADC) estimates that 68 million people, or 17 percent of the region's population, need aid.[4] Malawi, Zambia, and Zimbabwe declared a state of disaster in 2024. The effects of the drought are acutely felt along the Zambezi River Basin and its dam reservoirs, whose historically low levels could hamper hydropower operations.

Drought can lead to adverse effects to ecological systems, industrial production, agriculture, and water availability and quality. Recent analysis from the World Bank shows that each moderate-to-severe drought, on average, reduces the gross domestic product (GDP) growth rate in SADC countries by a quarter percentage point.[5] In May 2024, the SADC Secretariat released a Regional Humanitarian Appeal in response to the El Niño-induced droughts. Seventeen percent of the region's population need food assistance and humanitarian aid. Widespread harvest failures and livestock deaths mean a shortfall in agriculture production and farm incomes in a region where 70 percent of people's livelihoods depend on rain-fed agriculture.

In 2020 in the Horn of Africa, locust upsurges occurred, where over 23 million already food-insecure people were living, many already affected by violent conflict and droughts. Intense locust outbreaks are linked to climate change and the increased frequency of extreme weather events.[6] Outbreaks coincided with cyclone Mekunu from 2018, and warmer weather combined with heavy rains at the end of 2019. Large swarms were born at the start of 2020 in Ethiopia and Somalia and spread rapidly to Kenya, Uganda, Sudan, and other countries.[7] It was estimated that by the time the swarms receded in 2021, they had damaged hundreds of thousands of hectares of crops in Ethiopia and Kenya. Eighty-four percent of farms in Puntland, Somalia were affected by desert locusts, destroying 61 percent of fruit and vegetables. The World Bank has allocated US$500 million to support countries affected by the desert locusts.[8]

A refugee in Sudan. ©Claudiad / Getty

[2] IPCC, Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II, and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115, doi: 10.59327/IPCC/AR6-9789291691647
[3] https://www.usaid.gov/sites/default/files/2024-06/2024-06-11_USG_Southern_Africa_Regional_Drought_Fact_Sheet_1.pdf
[4] https://www.reuters.com/world/africa/nearly-68-million-suffering-drought-southern-africa-says-regional-bloc-2024-08-17/
[5] Zaveri et al., 2023. https://openknowledge.worldbank.org/server/api/core/bitstreams/8b8659c6-8087-46f2-907e-0d69a0a89d56/content
[6] 2020. https://media.un.org/unifeed/en/asset/d252/d2529915 Accessed September 2024
[7] Antoaneta Roussi 2020. https://www.nature.com/articles/d41586-020-00725-x
[8] https://www.worldbank.org/en/news/press-release/2020/05/21/world-bank-announces-500-million-to-fight-locusts-preserve-food-security-and-protect-livelihoods

World Bank projections indicate that climate change will push an additional 68-to-135 million people globally into extreme poverty by 2030, and the majority are expected to be women, elderly, and youth.[9] Research by the Intergovernmental Panel on Climate Change (IPCC) predicts increases in flooding severity and extreme weather events over the coming decades. Exposure and vulnerability to climate change in Africa is multi-dimensional, with socioeconomic, political, and environmental factors intersecting. Persistent gender gaps exacerbate women's exposure to shocks and limit their ability to adapt.[10] Women's significantly lower labor force participation and wages, their high representation in the agriculture and informal sectors, limited land ownership, unequal access to off-farm work opportunities, restricted access to credit, higher workload caring for family members and fulfilling domestic roles, and other restrictive social norms in many countries reduce their ability to mitigate the negative impacts of climate change.[11] Engagement with international waters in Africa requires a series of complementary processes that support economic, political, and social collaborations that consider all relevant uses for water. Rural communities, particularly in countries that are experiencing fragility, conflict, and violence (FCV), are especially vulnerable to water-related climate shocks. Rampant poverty, limited resources and infrastructure, inadequate information, and weak institutions constrain people's ability to adapt and build resilience to climate stressors.

Climate change affects water resources in Africa in six main ways. It increases aridity, the frequency and intensity of droughts, the frequency and intensity of floods, seasonal variability, swings between wet and dry periods, and higher temperatures causing more evaporation. Heavy precipitation and flooding can transport large volumes of water with untreated contaminants into waterbodies, overload water supply systems, and increase the potential spread of water-borne diseases. Greater frequency and severity of extreme heat can significantly increase evapotranspiration and heighten water supply demands, while increasing stress on limited water resources. These can cause disruptions to water facilities, storage, and infrastructure. Variability in the hydrological cycle transcends borders, which is felt acutely in Africa, where over 60 transboundary river basins account for 90 percent of total surface water and 40 percent of the continent is situated on aquifers supporting more than one country.[12]

Water is central to Africa's social and economic climate change-resilient development. Sustainable development, use, and management of water resources underpins the performance of key economic sectors. With nine percent of the world's freshwater resources and 11 percent of the global population, SSA is not considered water-poor by global standards. However, it is estimated that less than 10 percent of SSA's cultivated land is irrigated, the rest being rain-fed and highly vulnerable to climate variability and change.[13] Water supplies for rural and urban populations are central for social development, human health, and industrial development, and yet only 58 percent of Africans have access to safe drinking water. An even smaller percentage (25.6 percent as of 2022) has access to safely managed sanitation services. SSA's growing water insecurity is increasingly recognized as a binding constraint to its economic growth and development.

This is due to high levels of hydro-climatic variability, coupled with inadequate and lagging investments in water resources infrastructure (along with aging infrastructure), a lack of financial and human resources and sustainable institutions for managing and developing water resources, and disparate legislative frameworks. Increasing water demand and growing competition between water-dependent sectors, in addition to pollution from point and non-point sources, contribute to the degradation of water resources and further exacerbate water insecurity. Climate change will likely increase the vulnerability of the linked economies and peoples of Africa, who rely on shared water resources. With nine of every 10 natural disasters being water-related, the physical effects of climate change are largely experienced through heightened variability in the hydrological cycle. Changing weather patterns are causing more intense and prolonged floods and droughts across the continent, with some countries experiencing both too much and too little water almost simultaneously.

Cooperation in International Waters in Africa

Acknowledging the importance of cooperation and challenges related to international waters in Africa, the World Bank established the Cooperation in International Waters in Africa Multi-Donor Trust Fund in 2011. CIWA promotes cooperation in shared water resources to catalyze and improve the quality of institutions, information, and investments that will result in sustainable, climate-resilient growth and poverty reduction. It is important to understand how CIWA works to recognize how CIWA contributes to the results described in this assessment. CIWA engages in i) sustained engagements in priority basins through support for foundational elements required for cooperative planning and operation of infrastructure and information systems such as data, agreements, institutions, investment planning, and operations; ii) discrete engagements in additional basins where an opportunity arises for CIWA to unlock cooperative potential and improve the quality of investments; and iii) knowledge management through the production, collection, and dissemination of information to demonstrate the benefits and evidence base for cooperation. CIWA's activities are aligned with the World Bank's Water Global Practice's analytical programs, technical assistance, lending projects, and operational support at the national, river basin, and regional levels. CIWA prioritizes client-driven collaboration with RBOs and regional economic communities (RECs), national ministries, and community-based organizations and actively works for harmonized coordination with multilateral and bilateral partners. CIWA's portfolio is dominated by recipient-executed projects, often with RBOs as implementing agencies, however, many operations are World Bank-executed. CIWA operations focus on delivering results in the three Is (Information, Institutions, and Investments) through four crosscutting pathways (climate resilience, gender equality and social inclusion, support to FCV situations, and biodiversity and conservation).

[9] Jafino, B.A.; Walsh, B.J.; Rozenberg, J.; Hallegatte, S. Revised Estimates of the Impact of Climate Change on Extreme Poverty by 2030 (English). Policy Research working paper, no. WPS 9417, COVID-19 (Coronavirus) Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/706751601388457990/Revised-Estimates-of-the-Impact-of-Climate-Change-on-Extreme-Poverty-by-2030
[10] IPCC. Climate Change 2022: Impacts, Adaptation and Vulnerability. 2022. https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/
[11] Fruttero, A., Halim, D., Broccolini, C., Coelho, B., Gninafon, H., and Muller, N. Gendered Impacts of Climate Change: Evidence from Weather Shocks (English). Policy Research working paper; no. WPS 10442 Washington, D.C.: World Bank Group. http://documents.worldbank.org/curated/en/099342305102324997/IDU0ba259bd2039ca04fa20b87a0893bb487e014
[12] McCracken, M. and Wolf, A.T. Updating the register of international river basins of the world. International Journal of Water Resources Development. 2019. Also see: https://transboundarywaters.ceoas.oregonstate.edu/international-river-basin-register
[13] Farmer-led Irrigation Development Guide – A what, why and how to for intervention design. World Bank. 2021

CIWA and Climate Change

Transboundary water resources management is a global public good that depends on access to safe, reliable water and resilience to extreme weather. Climate vulnerability crosses geopolitical divides, emphasizing the need for transboundary cooperation.[14] Of the approximately 300 internationally shared river basins worldwide, more than 60 are shared among 44 countries in Sub-Saharan Africa. All mainland SSA countries share at least one international freshwater body. While it is widely acknowledged that managing international waters has created opportunities for fostering regional economic and political integration through cooperative development, the added complexity of cooperative WRM and development can also lead to tension and suboptimal utilization of shared public goods. Climate change is a conflict multiplier, and water scarcity during droughts has been a direct source of small-scale violent conflicts between pastoralists and others throughout SSA.

CIWA interventions linked to climate resilience are designed as part of river basin planning frameworks and aligned with regional climate change strategies. CIWA supports Sub-Saharan governments, RBOs, and other partners to unlock the potential for sustainable, climate-resilient growth through cooperative water resources management and development. CIWA's work is highly aligned with both World Bank and regional partner strategies for climate change resilience (such as the Intergovernmental Authority on Development [IGAD]'s Regional Strategy 2021-2025, the SADC Climate Change Strategy and Action Plan 2020-2023, and the African Union Climate Change and Resilient Development Strategy and Action Plan 2022-2032). CIWA grants directly influence the design of regional operations that contribute to addressing climate change, and in 2024 CIWA began requiring all recipient-executed projects to satisfy the World Bank's approach to the Paris Agreement, a treaty that was adopted in 2015 at the United Nations Climate Change Conference (COP21) in Paris. World Bank financing operations are assessed for Paris treaty alignment, and method guidance notes have been developed to streamline the process for all financing instruments used by the Bank.[15] Climate risks are transboundary in nature, both from potential impacts due to climate change and responses to climate change,[16] therefore, efforts to support sustainable resilience must anticipate the cross-boundary impacts, consequences, and needs. Broadly, CIWA contributes to climate change mitigation and resilience by delivering knowledge and institution-strengthening activities for improved regional capacity to initiate the design and planning of climate-resilient regional water investments (that are then implemented through other projects).

CIWA considers investments to be influenced when it has provided means to unlock future investments and/or influence the progress of a project. Influenced investments are captured under the program's development objectives, with Objective 1 capturing the value of influenced investments and Objective 2 capturing the number of direct beneficiaries from these influenced investments. There are two types of influenced investments:

- Mobilized investments, which refer to all planned and actual investment financing that is incorporated into a formal and public or verifiable financial planning process.
- Potential investments,[17] which refer to projects that will likely or potentially be advanced to finance investments.

CIWA has influenced investments through facilitation of investment dialogue, project scoping or identification, contribution to an analysis enabling project preparation (feasibility studies, pre-feasibility studies, diagnostics, and environmental and social impact assessments [ESIAs], transaction negotiations, and development of investments plans). While CIWA focuses on studies and institutions that inform and plan investments, it is not an investment program. Through these actions, CIWA has influenced investments that are implemented both by the World Bank and external partners. However, the potential of CIWA activities to influence investments can be greater than regional and country capacities to implement them, indicating that CIWA needs to ensure that there is both willingness and capacity in the region to leverage investment opportunities cultivated by its work. CIWA also strengthens regional institutions while providing targeted support to strengthen national institutional capacity to enable countries' engagement in regional cooperation. Together, these have contributed to enabling transboundary water cooperation in challenging environments by creating spaces and knowledge to inform discussions on investments.

In several regions, CIWA has contributed to the strategic identification of prioritized regional investments, some of which have been mobilized. This is notably the case in the Nile River Basin, where CIWA contributed to the development of the Nile Equatorial Lakes Investment Program, which prioritized 28 investments based on agreed country criteria and the Nile Basin Initiative (NBI)'s regional data services. The same is true for the Zambezi River Basin, where CIWA contributed to the development of the Zambezi Strategic Plan, which prioritizes 23 transboundary investments and 80 national investments. In some basins, CIWA has strengthened the institutional capacities of RBOs to carry out their investment functions. For example, following CIWA technical support, both IGAD and the Zambezi River Authority (ZRA) have, for the first time, managed water resources management investment feasibility studies and ESIAs. Table 3 and Annex 4 provide lists of CIWA-influenced mitigation and resilience investments. Notably, these lists are underestimates, as some CIWA-influenced investment plans, such as the Niger Climate Resilience Investment Plan (CRIP), point to large sets of potential investments that are yet to be fully identified.

To inform its engagement in African international waters, CIWA undertook this strategic assessment of the scope of climate resilience and mitigation in its cumulative portfolio to identify opportunities, value proposition, and risks. Since its inception, CIWA has prioritized and implemented work to address the consequences and causes of climate change in transboundary water management and development and regional water security more broadly, however, it lacked a systematic view of its climate resilience and mitigation work. In FY23, CIWA's Advisory Committee agreed to seek—and was granted—an extension of the CIWA Trust Fund until 2031 and endorsed a new CIWA operation pipeline. The new pipeline and CIWA 2.0 approach will implement the lessons learned from this assessment. It is anticipated that this assessment will inform the new CIWA pipeline and that future mid-term evaluations will build on this analysis.

[14] Birkmann J., et.al., 2021 Regional clusters of vulnerability show the need for transboundary cooperation. Environ. Res. Lett. 16 094052
[15] World Bank Paris Alignment Method for: (i) Development Policy Financing; (ii) Investment Project Financing; (iii) Program for Results
[16] Simpson et al., A framework for complex climate change risk assessment. Volume 4, Issue 4, 23 April 2021.
[17] A potential investment influenced by CIWA is only counted toward results once a feasibility or pre-feasibility study is completed, estimates the value and number of expected beneficiaries, and is endorsed by a governing body such as a relevant Council of Ministers.

CIWA Climate Resilience and Mitigation Assessment

This cumulative stocktaking assessment of CIWA operations, their influence, and comparative advantage on climate mitigation and resilience outcomes aims to highlight CIWA's cross-cutting pathways to impact[18] in the three Is and determine if there are missed opportunities for future consideration.

For this analysis, both types of CIWA operations – Bank-executed Trust Funds (BETFs) and Recipient-executed Trust Funds (RETFs) – from 2011 to date were classified according to climate change resilience or mitigation measures. The classification was done using component descriptions in project papers and documentation of any investments deemed to have been influenced by a CIWA operation (the same investments tracked in CIWA's FY23 Annual Report). Six of 47 operations were excluded from this analysis because they produced a single knowledge product or were part of programmatic strategic studies that are not directly tied to development activities, and therefore did not count toward contributing to resilience or mitigation in this methodology. Annex 1 lists all operations deemed to include climate change measures. Investments were verified by key informant interviews to verify the role of the CIWA operation.

Climate Mitigation Assessment Methodology

A baseline approach was adopted to evaluate the amount of GHG emissions mitigated through CIWA-influenced investments. Accordingly, the volume of GHG emissions mitigated (for existing hydropower plants) and expected to be mitigated (for potential hydropower plants), expressed in tons of CO_2 equivalent (tCO_2eq/year), corresponds to the amount of GHGs that would have been emitted annually if the electricity generated by the hydropower plant would have been instead produced by other electricity providers on the grid (coal-burning plants). Emissions mitigation figures were obtained by multiplying the amount of electricity generated by the hydropower project with the grid emissions factor, which corresponds to the amount of CO_2 emissions associated with each unit of electricity provided by the electricity system (sourced from the Institute for Global Environmental Strategies).[19] This method is in line with the International Financial Institution Approach to GHG Accounting for Energy Efficiency Projects of the United Nations Framework Convention on Climate Change (UNFCCC).[20] While this holds for planned projects (greenfield), in the case of existing plants undergoing rehabilitation (brownfield) through a CIWA-influenced project, the additional electricity generated after rehabilitation was used to determine the additional GHG emissions reduced. Most of the power plants in the CIWA-influenced projects are related to a dam and/or multi-purpose reservoir as part of an integrated activity.

Although hydropower plants contribute to mitigating GHG emissions, when a reservoir is created upstream of a dam, organic matter contained in the flooded soil decomposes and emits GHGs, mainly carbon dioxide and methane. The amount of GHGs emitted varies and is influenced by factors such as dam location, climate, and type of vegetation. For an accurate calculation of reservoir emissions, the GHG Reservoir (G-RES) tool could be used, although this is data-intensive with several data points required for each dam system. G-res global estimates from the literature[21] for reservoir per-area greenhouse gas fluxes range from 115 to 145,472 g CO_2 eq./m²/yr. The highest value of 145,472 g CO_2 eq./m²/yr was used since this corresponds to reservoirs situated toward the Equator, which can be approximated to being the case of the dam systems influenced by CIWA. This allows for a first estimate as shown in Table 1. For the case of run-of-river hydropower plants, we consider there to be no reservoir and therefore zero emissions, as is the case for the existing Rusumo Falls plant and the planned Nsongezi and Luapula hydropower plants.

The following assumptions were made when calculating GHG mitigation from the hydropower projects influenced by CIWA:

1. A conservative estimate of reservoir GHG emissions based on global per-area greenhouse gas flux estimates from G-res tool was used[22] rather than a zero-emission approach, particularly given that one of the projects of the analysis involves one of the world's largest artificial lakes (Lake Kariba; area of 5,500km²). Four of the hydropower plants influenced by CIWA, including on Lake Kariba, have associated reservoirs, while the remaining two (Rusumo Falls and Nsongezi) are run-of-river and therefore do not involve the creation of an upstream reservoir. For future analysis, a more precise calculation of reservoir GHG emissions for each CIWA-influenced project could be undertaken.

2. Project emissions are considered zero (e.g., emissions during preparation, construction, and operation have not been included).

3. Leakage emissions are considered negligible.[23]

4. In countries with regionally interconnected grids, the emissions factor of the regional grid is used. This provides a standardized baseline for values of the CO_2 emissions factors for the interconnected electricity system. In the case of Zambia, for example, the Southern African Power Pool Grid emissions factor is used. For projects in countries that are not interconnected, the grid emissions factor of the country is applied.

[18] The four pathways are through actions in gender equality and social inclusion, climate resilience, biodiversity and conservation, and support to FCV-affected situations.
[19] Institute for Global Environmental Strategies. 2024. List of Grid Emission Factors, version 11.4. Available at: https://pub.iges.or.jp/pub/iges-list-grid-emission-factors. Note that the grid emission factors data provided in this source are extracted from the UNFCCC website.
[20] UNFCCC. 2023. IFI Approach to GHG Accounting for Energy Efficiency Projects Version 3.0 https://unfccc.int/sites/default/files/resource/Energy%20Efficiency_GHG%20accounting%20approach.pdf
[21] Harrison, J. A., Prairie, Y. T., Mercier-Blais, S., & Soued, C. (2021). Year 2020 global distribution and pathways of reservoir methane and carbon dioxide emissions according to the greenhouse gas from reservoirs (G-res) model. Global Biogeochemical Cycles, 35(6). e2020GB006888. https://doi.org/10.1029/2020gb006888
[22] G-res estimates of reservoir per area greenhouse gas fluxes ranging from 115 to 145.472 g CO_2 eq. m-2 y-1). Given that the higher values were observed for reservoirs with geographic locations around the equator, the upper value of the range (145.452 $gCO_2eq/m2$) was used, since the location of the reservoirs in our study are located closer rather than further to the Equator.
[23] Projected GHG emissions from construction, other upstream and downstream activities, leakage, and the rebound effect can be excluded as per the International Financial Institution Framework for a Harmonized Approach to Greenhouse Gas Accounting, unless these are deemed as significant and assessed in the project appraisal.

Analysis and Results

For the quantitative analysis, the investment and projects considered include greenfield hydropower plants and rehabilitation of existing dams. A distinction is made between potential investments—that is, investment opportunities explored by feasibility studies or ESIAs sponsored by CIWA but not yet realized—and mobilized investments.

The analysis covers the Kariba Dam The analysis covers the Kariba Rehabilitation, Kandadji Dam, Batoka Hydroelectric Scheme, Nsongezi Hydropower project, Rusumo Falls Hydroelectric Scheme, and Luapula Transfer. Table 1 summarizes the main characteristics of these hydropower plants, the amount of GHG mitigation expected, and how CIWA influenced these potential and mobilized investments.

Table 1: CIWA-influenced hydropower projects.

Characteristics	Batoka Gorge	Kariba Dam Rehabilitation	Luapula Transfer	Kandadji Dam	Rusumo Falls Hydro	Nsongezi Dam
Countries Benefiting	Zambia, Zimbabwe	Zambia, Zimbabwe	Zambia, DRC	Niger, Nigeria	Burundi, Rwanda, Tanzania	Uganda, Tanzania
Greenfield / Rehabilitation	Greenfield	Rehabilitation	Greenfield	Greenfield	Greenfield	Greenfield
Potential / Mobilized	Potential	Mobilized	Potential	Mobilized	Mobilized	Mobilized
Installed capacity (MW)	2,400	2,130[24]	789	130	80	39
Reservoir area (km^2)	23	5,500	0	2.28	0	0
Electricity generated annually (MWh/year)	10,215,000	10,035,000	3,877,000	225,000	448,000	273,312
Grid Emissions Factor (tCO_2eq/MWh)	0.996	0.996	0.9958	0.578	0.767	0.274
GHG emissions from reservoir ($tCO_2eq/year$)	3,345	799,986	0	332	0	0
Mitigated CO_2 per year ($tCO_2eq/year$)	10,168,752	9,192,867	3,860,717	129,718	343,616	74,887
CIWA's influence	Analyzed financial implications of the investment, facilitated negotiations to review findings and encourage renewal of the project, additional engineering studies, and investment preparation.	Produced studies on rehabilitation of the dam that led to the decision to invest in safety and reliability improvements.	Explored potential cooperative legal and institutional arrangements for a future Luapula River Authority.	Supported analytical study of resettlement best practices.	Supported NBI to convene stakeholders for mobilization, planning, and creation of the resettlement action plans.	Conducted pre-feasibility of project profile and coordinated resource mobilization, institutional support, and facilitation of stakeholder engagement

Note: Kariba Dam refers to consolidated hydropower capacity (e.g., both Kariba North and South); Kandadji refers to the completed dam (including after rehabilitation, e.g., elevation increases from 224 to 228m) and hydropower project. The electricity generated and associated GHGs mitigated corresponds to only the additional electricity generated following this rehabilitation; Luapula, Rusumo Falls and Nsongezi are run-of-river hydropower plants.

[24] Of the 2,130MW installed, 1,080 is for Kariba North (in Zambia), and 1,050 MW for Kariba South (in Zimbabwe). The only extension in capacity occurring during CIWA operations is the 300MW Kariba South Extension (which together with the existing 750MW add up to the 1,050MW). However, given that the rehabilitation work was related to dam safety and not the additional 300MW, we have used a "no dam" scenario rather than focusing on the additional capacity. The mitigated GHG is therefore for the entire 2,130MW, given that the work influences the entire dam, and consequently the two associated hydropower plants.

Table 2: Evolution of annual electricity generated by Kariba South Hydropower station.

Year	2023	2022	2021	2020	2019	2018	2017	2015	2014
Kariba South supply (GWh)/year	3,496.91	5,757.10	5,813.74	3,707	4,095.6	5,377.30	3,850.00	4,938	5,403

Source: ©ZERA (Zimbabwe Energy Regulatory Authority) Annual reports

Annual electricity generation figures correspond to maximum operation or are based on estimates using the installed capacity. The corresponding GHG mitigation estimates should therefore be aligned to where the dam is producing during optimal conditions, which might not necessarily be the case in reality.

An example is the Kariba South hydropower station, where the impact of longer dry seasons is exacerbated by the effects of climate change. Table 2 shows that despite an additional 300MW commissioned in 2018 (Kariba South Extension), the total electricity generated in 2023 was only about 65 percent of what was generated in 2014 prior to the extension, highlighting the significance of climate change on water levels.

As detailed in Table 3, CIWA has influenced six major hydropower investments that could result in the avoidance of up to 23.8 $MTCO_2e$ annually.

From this total, around 14 $MTCO_2e$ are potential investments, in Luapula River Basin and Batoka Gorge on the Zambezi River. Mobilized greenfield hydropower investments contribute to the avoidance of 0.6 $MTCO_2e$ from Kandadji Dam, Rusumo Falls Hydro, and Nsongezi Dam. Another 9.2 $MTCO_2e$ are mitigated through mobilized investments in the rehabilitation of the Kariba Dam, which will address key structural issues to ensure safe operations.

The cumulative installed maximum capacity of mobilized and potential CIWA-influenced hydropower investments totals 5.568 GW, which corresponds to around 13 percent of Africa's overall hydropower capacity (42 GW).[25]

Table 3: Mitigation potential of CIWA operation-influenced investments (tCO_2eq)

	Potential investment	Mobilized investments
Hydropower greenfield	15,678,186 tCO_2eq	418,503 tCO_2eq
Hydropower rehabilitation	0 tCO_2eq	10,374,333 tCO_2eq

Regional Rusumo Falls Hydroelectric Dam, Rusumo, Tanzanian-Rwanda border. ©NBI

Further potential mitigation investments were identified but not included in the current analysis as they have either not had a feasibility study or not been fully identified. These investments are found under the Nile Cooperation for Results (NCORE) project (including both additional financings), Niger CRIP, and the Cubango-Okavango Resilient Livelihoods Enhancement Program. Further information and data collection will be needed to include these projects. For example, in the case of Cubango-Okavango, the investments relate to 28 potential hydropower projects that have been identified, and although the expected cumulative annual electricity to be generated from these projects is available, individual data on installed capacity and electricity generated for each project has not been disclosed yet. Table 3 highlights the mitigation investments identified among the 41 CIWA-influenced projects analyzed. Only those that are also in Table 1 have been studied sufficiently to be included in the calculations. As investments shown in Table 4 become mobilized, future analyses can add them to Table 1 calculations.

[25] International Hydropower Association, Africa Region Profile https://www.hydropower.org/region-profiles/africa

Table 4: CIWA-influenced Investments with GHG-reducing Benefits

No.	Mitigation Investment	Project Title
1	Batoka Gorge HES*	• Zambezi River Basin Development project (P133380) • Zambezi River Basin Management project (P143546)
2	Kariba Dam Rehabilitation*	
3	Nsongezi HP Project *	• Nile Cooperation for Results project (P130694)
4	Power Expansion Plan and Regional Integration Plan of South Sudan into Regional Electricity Grid	
5	Regional Rusumo Falls Hydroelectric Project *	
6	Kabuyanda, Uganda: hydropower 0.1 MW	• Additional financing for Nile Cooperation for Results (P147218)
7	Lerekwe and Sio-Sanga, Kenya: hydropower 0.05 MW and 0.1 MW; storage 6.2 MCM and 5.8 MW	
8	Mara Valley, Tanzania: hydropower of 6 MW; storage: 30MCM	
9	Ngono Valley, Tanzania: hydropower of 14.5 GWh/yr	
10	Ruvyironza, Burundi: hydropower of 22 MW; storage 372.6 MCM	
11	Muvumba Irrigation Development and Watershed Management project. A proposed 3MW multipurpose dam in Eastern Rwanda.	
12	Installation and interconnection of thousands of megawatts of power	• Second additional financing for the Nile Cooperation for Results project (P162304)
13	Kandadji Dam*	• Niger River Basin Management Project (P149714)
14	Niger CRIP (172 priority actions focusing on knowledge and institutions and climate vulnerability)	
15	Luapula Hydro Power Project (HPP)*	• Luapula River Basin Development (P162810)
16	28 potential hydropower projects identified for development within the Cubango Okavango basin	• Cubango-Okavango Resilient Livelihoods Enhancement Program (P167308)

Note: Projects marked with * have been included in the GHG mitigation analysis conducted in this study.

The Niger Basin CRIP primarily contains measures for adaptation and resilience and includes some mitigation measures as co-benefits, such as in agroforestry and hydropower. Further analysis of the CRIP will be required since the plan includes 172 priority actions totaling an estimated US$2.27 billion. A first bundle of 50 actions has been mobilized with financing from the African Development Bank, while the Niger Basin Authority is seeking financing for the remaining 122 actions.

Transboundary Water Pathways for Improved Climate Mitigation

If fully and properly harnessed, hydropower can easily close the electricity access gap and meet Africa's climate mitigation goals. At the crossroads of water and energy, hydropower is well positioned to help the continent toward its goal of achieving universal access to electricity, adapting to climate change, and mitigating its effects. Per capita electricity consumption remains much lower in Africa than the global average, with 43 percent of the continent's population lacking access to electricity. Africa's hydropower potential remains largely untapped.[26] However, the overexploitation of rivers would also be detrimental to regional water security, biodiversity, and socioeconomic development. Hydropower presents both positive and negative socioeconomic and environmental externalities, which should be carefully balanced.

Operations support mitigation efforts if, compared to a baseline situation or other counterfactual, the activities lead to a reduction, limitation, or storage of GHG emissions or increase their removal from the atmosphere. Interventions in sanitation (capturing GHGs generated by treatment and replacing fossil fuel energy supply with clean sources), water supply, irrigation (replacing fossil fuel energy supply with clean sources), and hydroelectricity have great potential for achieving GHG emissions reductions. CIWA's climate mitigation efforts have mostly been delivered by influencing hydropower infrastructure investments. CIWA's footprint in the other subsectors is small but examples include influencing solar-powered groundwater investments in the Horn of Africa (HoA) borderlands and SADC region and identifying investments for solar-powered irrigation schemes. While the actions are important for communities and countries, the actual GHG mitigation influenced by these CIWA operations is marginal compared to the net reduction from hydropower.

CIWA supported studies and other analytical work that informed the identification and preparation of hydropower investments. For example, in the Niger River Basin, technical water and safeguard information provided by CIWA influenced member states in choosing an alternative site for the Fomi Dam (see Box 1). In the Luapula River Basin, CIWA supported analytical and advisory work on the legal and institutional framework, which informed the development of potential hydropower investments in Zambia and the Democratic Republic of the Congo (DRC). CIWA-facilitated studies and negotiations influenced two major investments in the Upper Zambezi River: the Kariba Dam Rehabilitation Project, which is being implemented by the Zambezi River Authority with World Bank financing, and the Batoka Gorge Hydroelectric Scheme (HES), a proposed dam at the border of Zambia and Zimbabwe upstream of Kariba.

In the Niger Basin, CIWA supported analytical studies on resettlement best practices around the Kandadji Dam, which is being built in Niger. In the Nile River Basin, CIWA used its convening role with the NBI to bring Burundi, Rwanda, and Tanzania together around the Rusumo Falls Hydroelectric Project, which is now completed, by supporting the implementation and mapping of the resettlement plan. Further, CIWA conducted pre-feasibility studies and provided support for resource mobilization and stakeholder engagement in the preparation of the Nsongezi Dam project in Uganda and Tanzania.

Box 1: Fomi Dam Multipurpose Hydropower project (Niger River Basin)

The choice of location of the planned Fomi Dam exemplifies the balancing act between positive and negative social and environmental impacts of large hydropower projects. The Fomi Dam was one of three priority infrastructure investment projects designated by Niger Basin Authority (NBA) member states in their 2007 Shared Vision and Sustainable Development Action Plan. The rural population of the Niger River Basin is particularly vulnerable to food and water insecurity and conflicts. In this context, multi-purpose dams can improve energy security while also improving water storage for irrigation and consumption and mitigating flood and drought risk. On the other hand, hydropower projects can spur regional and transboundary risks through river fragmentation and disruption of natural water flows. Riverbanks are often inhabited and heavily used for livelihoods, and the areas flooded by human-made reservoirs often lead to population displacements and loss of agricultural land.

As part of its engagement with the NBA, CIWA supported technical capacity building of the organization, regional dialogue, and technical studies for the preparation of potential hydropower projects. This included feasibility studies and an environmental and social impact assessment (completed in December 2017) to evaluate whether the proposed site for the Fomi Dam was suitable for investment. An ESIA can contribute to a project's impacts related to climate mitigation and resilience in multiple ways by helping identify and quantify potential GHG emissions associated with a project and providing information to design mitigation strategies. An ESIA can recommend mitigation measures to reduce a project's negative environmental impact, such as by proposing cleaner technologies or improving energy efficiency. The Potential Adverse Impacts assessment identifies ways in which the project can minimize negative impacts on biodiversity and ecosystems, hydrology, water quality, soil erosion, microclimate modification, and other issues, which all have the potential to reduce people's and the environment's climate resilience. The Niger Basin Support Program delivered a study on advanced modeling of ecosystem services in the Niger Inner Delta to inform upstream development and investment choices, including the potential impact on flow regimes of different operational conditions of new dams.

[26] IHA, 2024. Region Profiles Africa https://www.hydropower.org/region-profiles/africa

The studies revealed that the socioeconomic benefits derived from building the Fomi Dam in the designated site would be far outweighed by adverse social and environmental impacts. The dam construction in the original site would have displaced 60,000 people in two towns that have hospitals and schools. The project attempted to balance climate mitigation benefits from hydropower against losses of biodiversity and livelihoods. Members of the Fomi Inter-ministerial Committee agreed to find a different site with fewer adverse impacts. An alternative site, which will mean the relocation of 12,000 people, was found (CIWA was not involved in identifying the new site).

Ultimately, these activities illustrate the potential pros and cons of large dam investments; the benefits of producing electricity through hydropower did not accrue, however, people and ecosystems were spared disproportionate negative externalities.

No CIWA operation or activity directly implements significant GHG emissions reduction. Rather, almost all climate mitigation results are linked to CIWA's influence on downstream or concurrent lending projects. As shown in Table 1, climate mitigation influenced by CIWA operations included four mobilized and two potential hydroelectric stations. The cumulative installed capacity of mobilized CIWA-influenced hydropower investments amounts to 2,379 MW, which corresponds to about 5.66 percent of Africa's overall hydropower capacity (42 GW). These are the most readily quantifiable of CIWA's activities; CIWA also has operations and influenced projects that incorporated solar-powered pumps for groundwater extraction or irrigation, but these are generally on a very small scale and not quantified for this report (see Table 3).[27] The active BETF, Untapping Resilience: Groundwater Management and Learning in the Horn of Africa's Borderlands, is on track to support larger investments in groundwater solar pumps across the HoA borderlands through the World Bank's HoA Groundwater for Resilience program. CIWA's other mitigation activities include influencing potential investments in grid interconnection expansion supporting accounting and management of biodiversity, wetlands, and ecosystem services, and potential investments in watershed management and rehabilitation.

Cattle grazing beside the Sélingué reservoir, Mali. ©Marisa Goulden / International Alert

[27] Operations include Sustainable Groundwater Management in SADC Member States Phase 1 and 2, Sahel Groundwater Initiative, and Untapping Resilience.

Box 2: Kandadji Hydropower project (Niger River Basin)

The Kandadji Dam is an example of a CIWA-influenced hydropower project with major development objectives around increased power generation, irrigation, and job creation and significant GHG mitigation benefits. Niger has one of the lowest electrification rates in the world, at 10 percent of the population (less than 1 percent in rural areas), which cripples advances in human and economic development. An estimated 1 million people will directly benefit from the project. It is strategic to the development of Niger and the region. Upon completion and at maximum capacity, the Kandadji Dam will increase Niger's national electricity production by over 50 percent. The cross-border nature of the project also involves cooperation with neighboring Mali, into which the 2.28 km2 reservoir will extend. The project is being financed by World Bank and other development partners including the African Development Bank (AfDB), the Islamic Development Bank (IsDB), and the French Development Agency (AFD).

The dam will provide not only climate-positive energy generation, but also facilitate better basin management will enhance environmental flows in the dry season, reliable municipal water supply for Niamey, and irrigate up to 45,000 hectares of land. The dam's 130 MW hydropower plant component will allow for GHG mitigation estimated at 381,840 tCO_2eq per year. This accounts for the final and second phase of the project involving a second elevation to 228m and an average annual generation of 660 GWh of electricity.

In 2018, CIWA supported the Kandadji hydropower project through an analysis of resettlement practices.[28] The completed resettlement program for 9,000 people at the dam site and the planned reconstruction of Ayorou and resettlement programs for 50,000 people in the reservoir area represent important, multi-faceted development opportunities for impoverished local communities, including new roads, electricity, drinking water, schools, clinics, markets, and other community infrastructure and services; 8,000 hectares of irrigated perimeters for displaced farmers; over 10,000 new houses; extensive agricultural and non-agricultural livelihood restoration programs, including training and employment opportunities related to construction of new resettlement sites; improved employment opportunities, including jobs for women and youth; and improved water infrastructure that will lead to better health and education outcomes, contributing to increased human capital.

The ESIA identified multiple opportunities to minimize harms and even improve the environmental impacts that affect climate resilience such as establishment of the Kandadji National Nature Reserve and Hippopotamus Sanctuary, building locks or fish ladders for fish migration, controlling the proliferation of invasive aquatic plants, and other actions to regenerate ecosystems for local fauna and flora.

A fully functional grievance redress mechanism is in place to address concerns raised by the project, however, it is currently paused because of the July 2023 coup.[29]

Climate Resilience Assessment Methodology

The climate resilience analysis included two lines of assessment: i) mapping the CIWA portfolio against a list of climate adaptation indicators[30] and ii) a qualitative mapping and description of CIWA-influenced climate adaptation investments.

The climate adaptation indicator analysis reviewed individual components of 41 operations. CIWA-influenced operations were systematically analyzed, starting with key sources including Project Appraisal Documents (PADs), Implementation Status and Results Reports, and Implementation Completion and Results Reports. Project components that explicitly included climate resilience actions were matched with one or more types of resilience indicators (listed in Table 4). If some elements of a component were found to be linked to climate resilience, those were also matched with one or more climate adaptation action indicators from the list.

Project components were qualitatively analyzed and matched to adaptation activities included in the World Bank's Climate Change Adaptation and Mitigation Co-benefits Tracking: Guidance Note for the Water Sector (Version 4).[31] CIWA activities that increase resilience of the project (and the infrastructure created by the project) or of the communities benefitting from the project were included. The Guidance Note groups adaptation activities into five categories: (i) sanitation and wastewater management; (ii) water supply; (iii) flood protection; (iv) wastewater collection, transportation, treatment, and disposal; and (v) general water, sanitation, and flood protection and miscellaneous. Table 5 shows the Guidance Note's list of potential adaptation activities/indicators and their categories (Box 2.1 in the Guidance note). This assessment used this list but added additional adaptation activities that were identified by CIWA — (vi) dam safety and (vii) drought risk management—to reflect the focus of CIWA operations on these climate adaptation sectors. These are indicated in Table 5.

Kandadji Dam site, northwest of Niamey, Niger. ©World Bank

[28] Kandadji Niger Basin Water Resources Program. Brief. June 2020. https://www.worldbank.org/en/country/niger/brief/kandadji-project.
[29] Afrik21, 2023, Niger: Following the coup, CGGC Suspends Construction of the Kandadji Dam. https://www.afrik21.africa/en/niger-following-the-coup-cggc-suspends-construction-of-the-kandadji-dam
[30] Typology of Activities with Climate Co-Benefits by World Bank Sector. https://www.worldbank.org/content/dam/Worldbank/document/Typology.pdf
[31] https://worldbankgroup.sharepoint.com/sites/WBWaterpractice/Knowledge%20Base/Forms/AllItems.aspx?id=%2Fsites%2FWBWaterpractice%2FKnowledge%20Base%2FAdaptation%20and%20Mitigation%20Co%2DBenefits%20Water%20Sector%20Guidance%20version%204%2Epdf&parent=%2Fsi

Table 5: Climate adaptation indicators pertaining to the water sector[32]

Sector	Climate adaptation indicators
1. Sanitation and wastewater management	1.1 Incorporate changes in design of wastewater/fecal sludge management systems to better cope with extreme weather events (by reducing potential water contamination and the likelihood of component and system failures)
2. Water supply	2.1 Support demand-side management based on water-saving and water-pricing policies to maintain climate-resilient water supplies (by reducing water consumption and increasing water-use efficiency) 2.2 Support supply-side management by expanding supplies (e.g., through diversification of water sources), reducing water losses, and/or improving cooperation on shared water resources 2.3 Relocate well fields away from floodplains or raise well heads 2.4 Improve watershed management planning and regulation of water abstraction 2.5 Install water-recycling equipment to improve water security 2.6 Optimize water infrastructure design based on climate and hydrological models
3. Flood protection	3.1 Retain or reestablish mangrove forests and wetlands as protection against floods 3.2 Improve flood resilience of infrastructure (e.g., bridges, water supply, community infrastructure) 3.3 Promote regional cooperation on flood-risk reduction 3.4 Construct or strengthen polders, dikes, and embankments to protect against increasing flood risks 3.5 Reinforce the coastline physically (with new/rehabilitated structures) or naturally (with vegetation) 3.6 Incorporate climate-related aspects in design standards for drainage systems
4. Wastewater collection, transportation, treatment, and disposal	4.1 Incorporate changes in design of wastewater treatment and disposal systems in response to extreme weather and flood events 4.2 Protect wastewater infrastructure against increasing flood risk 4.3 Treat wastewater and conserve/reuse (waste)water to respond to declining water supplies
5. General water, sanitation, and flood protection	5.1 Develop water monitoring and information systems 5.2 Train RBOs to apply WRM techniques to make water systems climate-resilient* 5.3 Develop and implement equitable arrangements for sharing water resources between competing demands (agriculture, hydropower, industry, and household) 5.4 Incorporate climate-related factors (e.g., changes in precipitation, temperature, runoff, evapotranspiration) in hydromet forecasts, total/seasonal water availability, and water demand and storage planning 5.5 Incorporate climate-related factors (e.g., changes in precipitation, temperature, runoff, evapotranspiration) in hydromet forecasts, total/seasonal water availability, and water demand and storage planning 5.6 Incorporate climate-related water cycle changes into national and transboundary water basin planning 5.7 Provide supplemental irrigation, multi-cropping systems, drip irrigation, leveling, and other approaches and technologies that reduce the risk of large crop failures 5.8 Establish core protected areas and buffer zones to safeguard biodiversity and ensure the sustainable use of water to meet livelihood needs during drought 5.9 Fill in climate change-related data gaps that hinder policy formulation and implementation 5.10 Design and implement conjunctive management strategies for groundwater and surface water that incorporate climate-related water cycle changes
6. Dam safety**	6.1 Improved physical safety of dams to better withstand floods and provide increase supply during droughts.
7. Drought risk management**	7.1 Drought risk management and development of regional efforts on drought resilience 7.2 Introduction of digital solutions and innovative financial instruments such as drought insurance 7.3 Modernization of the management of strategic food reserves for improving resilience to droughts

Source: World Bank, 2021 Climate Change Adaptation and Mitigation Co-benefits Tracking: Guidance Note for the Water Sector (Version 4)

* Indicator 5.2 was modified from "local water boards" to RBOs to reflect CIWA's focus of activity on the regional and transboundary instead of local level.
** The Sectoral Groupings and Indicators on dam safety and drought risk management were added to the original list to account for CIWA engagement in these areas and their relevance to climate resilience.

[32] The Guidance Note's organization of potential climate adaptation activities has undergone previous revision, and it is notable that additional regroupings and edits may be sensible, however, this assessment aimed to utilize a core framework that future work can be built from, and therefore, as few changes as possible were made to the original list.

For some closed projects, components expressed in the PAD were either modified or did not reach full completion at project closure. Likewise, characterization of components from the PAD or Concept Note could lead to an overestimate since components that are only partially implemented or dropped altogether do not achieve expected results. Therefore, the best source of data was taken from Implementation Completion and Results Reports, however these exist only for completed recipient-executed operations. Additional data was taken from Activity Completion Reports, for closed Bank-executed operations. Future analyses could improve the precision of current results once all operations are completed and their results documented.

In the second line of assessment, CIWA-influenced investments were analyzed for their climate adaptation benefits. CIWA operations were screened for components that specifically facilitated the identification or preparation of new investments. This can include facilitation of investment dialogue, the development of investment plans, or the financing of project preparation studies (e.g., feasibility studies, ESIAs). The identified influenced investments were matched against the list of adaptation activities from Table 5.

Decision Theater as part of the Nile Cooperation for Climate Resilience project at the Nile Basin Initiative Secretariat in Entebbe, Uganda. ©CIWA / World Bank

Climate Adaptation Indicator Mapping Analysis and Results

A total of 179 CIWA project components were matched with the 30 climate adaptation indicators from Table 5. Annex 3 illustrates the distribution of climate adaptation indicators across CIWA project activities. Annex 4 shows alignment of the adaptation indicators with the CIWA-influenced investments that have significant adaptation benefits.

Overall, the World Bank Water Global Practice climate co-benefits typology for adaptation actions matched CIWA where expected: to date, CIWA has not had significant work in sectors related to drainage, reforestation, management of strategic food reserves, sanitation systems, coastline protection, and others, however, it has a large share of activities related to water monitoring and information systems, filling in climate change-related data gaps, building WRM capacity, and contributing to regional water management and development planning. As noted above, WRM training of local water boards was changed to RBOs to reflect CIWA's focus on the regional and transboundary levels instead of local level.

The sectoral groupings of flood protection; general water, sanitation, and flood protection; and water supply are well represented throughout CIWA project components. Sanitation and wastewater management and wastewater collection, transportation, treatment, and disposal are the least represented grouping with one and zero occurrences, respectively, which was to be expected considering that CIWA is primarily active in WRM.

The most prevalent climate adaptation actions supported by CIWA operations relate to promotion of regional cooperation on flood risk reduction; provision of WRM training and expertise to improve the climate resilience of water systems; and support for supply-side water management by expanding supplies, reducing water losses, and/or improving cooperation on shared water resources. About half of CIWA operations included provision of missing climate-related data, watershed management planning improvement and regulation of water abstraction, and development of water monitoring and information systems. Dam safety has so far been the focus of three components of CIWA operations—this is perhaps a thematic area where CIWA could expand its attention, not least in the context of the recent devastating floods in Eastern Africa. Drought risk management indicators have exclusively been matched with components of CIWA's Southern Africa Drought Resilience Initiative (SADRI)—this is another area where CIWA could scale up.

Finally, only one indicator (5.2 provide WRM training and expertise to RBOs to improve climate-resilience of water systems) captured the climate resilience potential of transboundary water resources management and cooperation. In future studies, it might be worthwhile to investigate this dimension further. This could be achieved by an in-depth climate-proofing analysis of water treaties and charters of CIWA-supported river basins. An evaluation could shed light on the degree to which RBO strategic documents not only consider current hydrological regimes, but also future climatic scenarios and possible resilience measures.

CIWA activities have concentrated on a clear subset of dimensions of climate resilience. In the future, CIWA activities could be further diversified to account for important emerging aspects of climate resilience in the water sector such as nature-based solutions for flood protection or the optimization of water infrastructure design based on climate and hydrological models.

A complete compilation of CIWA's cumulative climate change resilience actions are out of scope of this report, but the reader is referred to the many examples in this report, Annexes 3 and 4, and CIWA Annual Reports. Notable highlights include:

- In FY23, CIWA contributed to the Country Climate and Development Reports for the G5 Sahel region,[33] which estimated that climate shocks could force as many as 13.5 million more Sahelians into poverty by 2050 if urgent climate adaptation measures are not taken.
- CIWA has contributed to resilience in the Eastern Nile by developing a flood early-warning system that is used by the Eastern Nile Technical Regional Office (ENTRO) to generate and disseminate flood forecasts to member countries. In Sudan, CIWA responded to devastation caused by floods with technical support on flood damage assessment and development of a recovery plan. This included supporting the Emergency Operations Center, carrying out a post-disaster needs assessment, and identifying medium- to long-term support to improve flood resilience.
- In the Niger Basin, CIWA supported environmental impact assessment studies as a mechanism for limiting the Fomi Dam project's detrimental environmental effects (see Box 1). The CIWA-financed CRIP was developed to mobilize and coordinate investments in climate resilience. The Niger Inner Delta modeling effort implemented by the NBA with CIWA support helps basin stakeholders better understand how projected changes in the climate could impact flooded areas and social systems that rely on the wetlands.
- Climate change was central to the Lake Chad Development and Climate Resilience Action Plan, which identified investments that could support regional development and strengthen resilience to climate change. CIWA's current Lake Chad Basin operation includes a thematic note on Water and the Climate-Conflict trap.[34]
- CIWA has positioned and crafted its support at the intersection of climate change, resilience, and FCV-related challenges, given historic conflicts in the HoA. CIWA is contributing to resilience by incorporating robust designs in investment proposals in the Untapping Resilience BETF.
- In Southern Africa, much of CIWA's support to SADC countries has been through two projects implemented by the SADC-Groundwater Management Institute (GMI) to develop capacity and knowledge for inclusive groundwater management and use at community, national, and transboundary levels, which is critical for addressing an increasingly drought-prone region. The SADRI technical assistance worked with countries, cities, and the SADC to adopt a unified approach to drought risk assessment under three sectoral pillars—cities, energy systems, and livelihoods and food security.

CIWA-Influenced Climate Resilience Investments

Table 6 highlights Investments that included climate resilience benefits, distinguishing between mobilized and potential investments. See Annex 4 for the full list of CIWA-influenced resilience investments.

Table 6: Number of resilience investments identified in CIWA-influenced operations

Sector	CIWA Operation	No. of Resilience investments	
		Mobilized	Potential
Nile	Nile Cooperation for Results	6	9
	Additional financing for Nile Cooperation for Results	1	5
Cubango-Okavango	Cubango-Okavango Resilient Livelihoods Enhancement Program	0	3
Transboundary aquifers in the SADC region	Sustainable Groundwater Management in SADC Member States Phase 1	12	0
	Sustainable Groundwater Management in SADC Member States Phase 2	11	0

[33] https://www.worldbank.org/en/news/infographic/2022/09/19/g5-sahel-region-country-climate-and-development-report
[34] https://blogs.worldbank.org/en/water/water-security-way-out-conflict-climate-risk-trap-lake-chad-basin

It is notable that of the larger adaptation investments influenced by CIWA in the Nile and Cubango-Okavango regions[35] only about one-third are mobilized (seven mobilized of 21 total).[36] It is possible to justify the hypothesis that those without large grey infrastructure seem to be less likely to be mobilized. However, large-scale watershed rehabilitation and management are critical to derisking the effects of climate change, especially for flash flooding and droughts. Future work should consider how to elevate these as priorities. There is an important and growing climate finance gap in vulnerable contexts, and climate resilience/adaptation finance is not sufficiently targeted to the most FCV-affected countries.[37] CIWA provides important support in the most vulnerable contexts, including FCV settings, to focus on resilience building and addressing this gap, when many other funding sources do not.

CIWA-influenced climate resilience investments in the Nile Basin primarily focus on expanding irrigation and constructing multi-purpose dams for hydropower, agriculture, and multiuse water supply. NCORE and its additional financing supported riparian countries in the identification of a pipeline of priority investments to improve water, energy, and food security in a coordinated manner. Twenty-one investments identified were matched with climate resilience measures. Of the 21 resilience investments, seven have been mobilized, five of which are multi-purpose water resources development projects, in Kocholia and Sio-Sango (Kenya), Kabuyanda (Uganda), Angololo (Kenya and Uganda), and Nyimur (Uganda and South Sudan). The Regional Hydromet investment has focused on establishing a regional hydrological monitoring system to provide reliable information for water resources management. One example of the Nile Basin Discourse's (NBD) support was helping communities in the Lakes Edward and Albert Integrated Fisheries and Water Resources Management Project build government capacity in the DRC and Uganda to harmonize fisheries regulations, monitor the system, and provide equitable oversight.[38]

The NCORE project contributed the largest share of potential and mobilized adaptation investments of regional significance. The combination of Nile projects (NCORE, the NBD RETF, NCCR, and Nile Basin Support Program) influenced a total of 21 investments classified as significantly related to climate resilience. One example is the feasibility study for the Kabuyanda Multipurpose Water Resources Development Project in Uganda. This CIWA-influenced investment successfully mobilized World Bank International Development Association (IDA) financing for its realization. This investment, which improves farmers' access to irrigation and establishes management arrangements for irrigation service delivery, supports supply-side management by expanding supplies (e.g., through diversification of water sources, reducing water losses, and/or improving cooperation on shared water resources). Upon completion, the investment will expand climate-smart irrigation by 4,500 ha.

The three investments in the Cubango-Okavango each consisted of bundles of investments identified by the Cubango-Okavango Resilient Livelihoods Enhancement Program, based on a previous Multi-Sector Investment Opportunity Analysis (MSIOA) conducted by CIWA. Potential investments included the review of a series of irrigation schemes in Angola and Namibia, urban water supply upgrading and extension, and water abstraction and transfer schemes.

The Sustainable Groundwater Management in the SADC Member States (Phase 1 and 2) supported SADC-GMI with a joint strategic action program to support small-scale investments in local aquifers. Twenty-three local investments were designed—12 in Phase 1 and 11 in Phase 2. These small projects usually followed one or more of the following objectives: improving groundwater data collection monitoring systems, identifying and characterizing local aquifers, rehabilitating or drilling new boreholes, and installing solar-powered pumps. Projects were identified in a large subset of SADC countries (Angola, Botswana, DRC, Eswatini, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Zambia, and Zimbabwe).

The Niger CRIP is treated separately from those in Table 6 because of the large package of investments, many of which are not yet fully identified. CIWA facilitated extensive consultations between the NBA and its nine riparian countries to enhance climate resilience and reduce poverty. The CRIP was endorsed by heads of states of the nine countries at COP21 in Paris in 2016. Of 246 actions originally identified, the NBA selected a subset of 172 priority climate adaptation investments. A first bundle of 50 activities (not with CIWA), for a total of US$274 million, has secured funding from the AfDB, Green Climate Fund, and the European Union (under the Program for Development and Adaptation to Climate Change [PIDACC]).[39] The PIDACC projects reinforce the resilience of the Niger River's ecosystems and agropastoral communities through sustainable resources management. The remaining package of 122 CRIP actions, totaling US$1.99 billion, are under consideration for support by the World Bank.

CIWA influenced 38 investments in climate change resilience. These include 23 mobilized small-scale investments directly implemented by the Sustainable Groundwater Management in SADC Member States projects (each costing about US$150,000) in 12 SADC countries. However, these 38 investments do not include the 172 priority climate resilience investments selected by the Niger CRIP. CIWA's future work with the NBA will lead to identifying and preparing some of these actions.

[35] SADC region investments are mobilized but they are very small at ~$200,000 each. Certainly, these are impactful, but they are inherently different.
[36] These investments are further described in Annex 4.
[37] United Nations Environment Program (2021) Adaptation Gap Report 2021: The gathering storm–Adapting to climate change in a post-pandemic world. Nairobi.
[38] Implementation Completion and Results Report (ICR) Document - Engaging Civil Society for Social and Climate Resilience in the Nile.- P132448.
https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099700006172227110/p1324480813fb70608f71033fa872da9fd?_gl=1*4zeoww*_gcl_au*ODYwMDIyNDM1LjE3MjY2NzI5OTE.
[39] MapAfrica: Mali-Integrated Program for Development and Adaptation to Climate Change in the Basin of Niger (PIDACC)
https://mapafrica.afdb.org/en/projects/46002-P-Z1-C00-068

Pathways for Improved Climate Resilience

Sustainable water management is central to building the resilience of societies and ecosystems and to reducing carbon emissions. In the water sector, activities to improve water resources management or development are often synonymous with climate resilience by improving resilience to the impacts of climate change such as flood and drought risk management, enhancing efficiency in water uses such as irrigation, reusing wastewater, harnessing groundwater, improving carbon storage, and protecting natural buffers. When water storage, supply, use, and quality are sustainable, reliable, and sufficient, then people and ecosystems are more resilient to the effects of climate change. For example, improved WRM and development also contributes to mitigating climate change itself by protecting ecosystems and reducing carbon emissions from water and sanitation transportation and treatment.

In the Nile River Basin, Horn of Africa, Zambezi River Basin, and Lake Chad Basin, CIWA supported the design of hydrometeorological monitoring systems and/or generation of hydromet data through remote sensing to enhance water resource management through better data on basin water availability and use. In the Nile and Zambezi River Basins, CIWA supported the establishment and/or maintenance of decision-support systems (DSSs) that have been used by RBOs to provide information services to its member countries and, in some cases, inform the identification of investments. In Southern Africa and the Nile River Basin, CIWA supported the development of information systems on floods and droughts (in the Nile River Basin) and groundwater (in Southern Africa) shared with member countries through integrated knowledge portals. In addition, in Southern Africa, SADRI supported the development of drought resilience profiles for SADC member states and a regional profile that captures commonalities and key opportunities across the 16 countries while also providing information that supports the identification of regional drought risk management investment opportunities, including in ecosystem services and biodiversity.

Needs Assessment Workshop for the development of Decision-Support Tools for Optimization of Zambezi Dam Operations (under the CIWA-funded Southern Africa Drought Resilience Initiative (SADRI). ©SADRI / World Bank

The outflows into the Zambezi river from the hydroelectric power stations either side. ©GavinD / iStock

Case Study – Kariba Dam Rehabilitation Project

Context

The Zambezi River Basin (ZRB) is the fourth largest watershed on the African continent, spanning eight countries in Southern Africa: Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe. It provides important ecosystem services and livelihoods to more than 38 million people and is essential for regional hydropower production and food and water security. The Zambezi's hydrological cycle is influenced by strong climatic and seasonal variations. Periodic droughts and floods exacerbated by climate change are having devastating impacts on the region. Climate models and future projections for the basin indicate that relative impacts can be quite different across the whole Zambezi River Basin, the greatest impacts being in the Lake Malawi/Nyasa sub-system.[40] According to the Zambezi Watercourse Commission Secretariat, most climate models agree that the basin will be warmer and drier, on average, with more consecutive days without precipitation.[41]

The large dams built along the Zambezi River are a pillar of the region's energy and water security. They also help regulate water flows by providing water storage capacity during drier periods and flood protection during wetter periods. The Kariba Dam and HES is the largest hydropower installation on the Zambezi in terms of installed capacity. It was constructed between 1956 and 1959, creating the Kariba Lake in the process, the world's largest artificial lake by volume. Located at the border between Zambia and Zimbabwe, the Kariba Dam HES is jointly operated and maintained by the two countries under the ZRA. Electricity is generated via two underground hydropower stations located on the north bank in Zambia and the south bank in Zimbabwe, with a combined installed capacity of 2,130 MW. This installation is crucial for the power generation of the two countries and regional economic development. The power stations account for 37 and 42 percent of Zambia and Zimbabwe's total generation capacity, respectively.

After more than 50 years of operation, the Kariba Dam required a series of time-sensitive rehabilitation works to prevent further degradation of the structure that could potentially lead to dam failure. In the first 20 years following dam construction, sustained heavy spillage episodes resulted in erosion of the bedrock immediately downstream of the dam foundation, presenting a risk to the stability and safety of the dam wall. Moreover, the sluice gates that make up the spillway were distorted over the years from a chemical reaction in the concrete, which could prevent effective management of the reservoir level in case of flood. Given the large storage volume of Kariba Lake (181 km3), a dam failure would result in catastrophic flooding in the region, with an estimated 3 million people living in the potential impact area.

[40] Hughs and Farinosi. 2020. Journal of Hydrology: Regional Studies. (32) 100763
[41] https://www.zambezicommission.org/sites/default/files/publication_downloads/factsheet_zamcom.pdf

CIWA's influence

From its inception in 2011, CIWA selected the Zambezi as one of its priority basins of engagement. CIWA rolled out a series of three grants as part of its ZRB programmatic approach: the Bank-executed Zambezi River Basin Support Program and the two recipient-executed Zambezi River Development and Zambezi River Management projects. Table 8 provides an overview of CIWA's programmatic approach in the ZRB.

Table 6: Number of resilience investments identified in CIWA-influenced operations

CIWA Operations in the ZRB	Implementing Agency	Project Development Objective
ZRB Support Program	World Bank (Analytical activity)	To facilitate sustainable, climate-resilient cooperative management and development of water resources within the ZRB through evidence-based analytical work and technical assistance
ZRB Development Project	Zambezi River Authority	To advance preparation of the Batoka Gorge HES and strengthen cooperative development within the Zambezi River Basin
ZRB Management Project	Zambezi Watercourse Commission (ZAMCOM)	To strengthen cooperative management and development within the Zambezi River Basin to facilitate sustainable, climate-resilient growth.

Through these three operations, CIWA facilitated a dialogue platform for riparian countries and international financiers to discuss the crucial rehabilitation of the Kariba Dam. In particular, the Zambezi River Development Project paved the way for the subsequent World Bank Kariba Dam Rehabilitation Project (KDRP). CIWA facilitated the KDRP via three avenues:

1. ZRA became a client of the World Bank for the first time through the Zambezi River Development Project, leading to better regional integration.
2. While the Zambezi River Development Project mainly focused on the preparation of the Batoka Gorge HES upstream of Kariba, it also emphasized improving regional cooperation and dam security. The Zambezi River Development Project financed a dam break analysis to evaluate the potential socioeconomic and environmental consequences of a dam failure in the basin. The dam break analysis was later delegated to KDRP and became a component of the Bank-financed operation.
3. Upstream engagement from the CIWA team supported Zambia and Zimbabwe to resolve a long-term debt dispute over the Kariba complex, which created momentum for further cooperation in this critical infrastructure rehabilitation operation. CIWA played an instrumental role in building trust between Zambia and Zimbabwe, helping overcome political differences by encouraging a shift toward technical dialogue.

Combined, these CIWA-facilitated outcomes helped create the conditions for the complex arrangements of the KDRP.

The Kariba Dam Rehabilitation Project

The Kariba Dam Rehabilitation Project identified three main rehabilitation works necessary for the continued safe operation of the Kariba complex:

- The design, fabrication, and installation of an emergency spillway gate and a new gantry to prevent uncontrolled loss of water in the event of floodgate failure.
- The refurbishment of the upstream emergency gate and stop-beam guides and replacement of secondary concrete to secure their smooth operation.
- The reshaping of the plunge pool downstream of the dam to limit scouring and erosion that could potentially undermine the dam foundations and lead to dam failure.

Additionally, the CIWA-financed dam break analysis was removed from the Zambezi River Development Project and added as a component of the KDRP, to be exclusively financed by a grant from Sweden.

The KDRP started in February 2015 and is set to be completed in 2025. The ESIA identified direct socioeconomic, physical, and biophysical impacts of the project and proposed mitigation measures.[42]

[42] Kariba Dam Rehabilitation Project, Environmental and Social Impact Assessment https://www.zambezira.org/kdrp/sites/default/files/utf-8%27%27KDRP%20Revised%20and%20Updated%20ESIA%20and%20ESMP%20-%20Oct.%202020.pdf

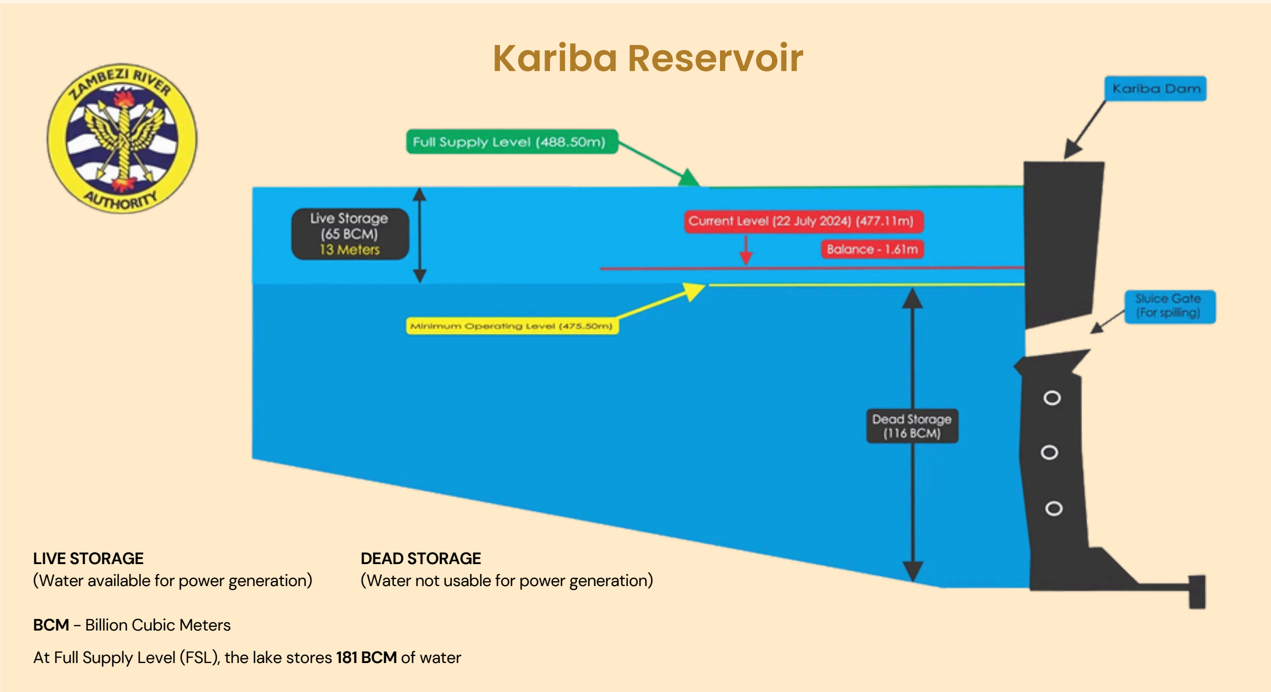
Overall, KDRP's social and environmental risks linked to climate adaptation had smaller impacts and were easier to mitigate than a large-scale infrastructure project because rehabilitation did not necessitate flooding new large areas, nor did it substantially alter the downstream flow of the Zambezi River. Among the biophysical risks identified, increased sediment load (earth- and rock-moving activities) and spillage of construction materials and hydrocarbon from construction machinery might negatively impact water quality. This risk was deemed highest during the dry season when flows are the lowest. Reduced water quality also causes a localized threat to aquatic life if sediments and hazardous substances are spilled in the river. This risk was mitigated through a sediment-trapping system and monitored through water-quality monitoring downstream. The risk of land loss for waste disposal is mitigated by designing a disused quarry for rock waste. Other solid waste produced on site is to be collected, separated, and recycled. The ESIA also identified a risk of fish deaths from dredging, blasting, and dewatering. Fish trapped within the dewatered area will be removed via gill and seine netting and released downstream.

Climate benefits

Climate resilience benefits are multiple, starting with reduced disaster risk and improved flood protection. Upon completion of the rehabilitation works on the Kariba Dam, it is projected that 3 million people will benefit from reduced risk of dam breaks and avoided flooding. An estimated US$8 billion in assets will be better protected from extreme flooding, including water infrastructure. The overall energy security of the region will be enhanced, thanks to rehabilitation of the most critical power plants in Zambia and Zimbabwe. Access to climate-resilient electricity can build resilience during climate shocks as well.

Concerns in the region have shifted since 2001 to droughts, rendering increased water storage critical. Rather than an excess of water, it is the lack thereof that now worries riparian countries. Southern Africa has been grappling with recurrent droughts, the latest of which reached historic levels in 2024.[43] Climate change is expected to increase droughts both in frequency and duration. Plants die during extreme droughts, leaving soil exposed and more vulnerable to erosion from rainfall. Extreme floods remain an eventuality that is being addressed by renovation works and the lessons learned from the dam break analysis. Meanwhile, the Kariba Reservoir is currently at its lowest historical level. In August 2024, storage levels stood between 9-10 percent, down from 28 percent one year earlier.[44] As shown in Figure 1, the current water level is dangerously close to the minimum level at which Kariba HES can operate.

The decreasing water table can be attributed to two main factors. First, rainfed inflows from the Upper Zambezi have been particularly low because of the prolonged drought. Second, outflows have been on the rise from electricity shortages, even more so since additional generating capacity was installed on Kariba South in 2017. Although the expansion was designed for peaking, power shortages in the region are making it politically difficult for Zambia and Zimbabwe not to use the additional capacity. In Zimbabwe, electricity demand exceeds the country's current production from hydropower and coal-fired power plants, and per capita electricity consumption has almost halved over the past decade.[45] In Zambia, 95 percent of power capacity is sourced from hydropower, and according to climate projections, drought-related losses in hydropower generation will increase.[46]



Kariba reservoir level as of July 22, 2024 (https://www.zambezira.org/hydrology/lake-levels). ©Zambezi River Authority

[43] NASA Earth Observatory, Severe Drought in Southern Africa https://earthobservatory.nasa.gov/images/152711/severe-drought-in-southern-africa
[44] Zambezi River Authority, Lake Kariba Weekly Levels in Meters https://www.zambezira.org/hydrology/lake-levels
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[46] CIWA, Zambia Drought Resilience Profile https://www.ciwaprogram.org/wp-content/uploads/Zambia_July-2021-non-editable.pdf

Meanwhile, Kariba Lake provides an invaluable source of water storage for human use, fisheries, and agriculture, which is critically important to mitigate the effects of the drought in the region. The dam also allows for flow regulation throughout the year, ensuring downstream water flow during moderately dry times.

Going forward, the improvement of cooperation between Zambia and Zimbabwe through the ZRA might be one of the most important long-term benefits achieved by CIWA. Cooperation on international waters contributes to climate resilience, as countries coordinate their responses to the changing climate and better manage shared resources to make their populations more resilient. Considering the ongoing impacts of droughts, the Kariba Dam has helped spearhead cooperation and discussion between Zambia, Zimbabwe, and the respective power utilities in terms of optimizing available water resources. CIWA support to the ZRA also included the financing of a feasibility study and ESIA for the Batoka Gorge HES. This potential joint project upstream of Kariba would contribute to improving electricity access, reducing blackouts, and improving regional energy security.

Earthworks on the banks of the Zambezi River, Zambia. ©Arne Hoel

Conclusions & Lessons for CIWA

Cumulative evidence suggests that CIWA delivers core support to SSA people in realizing sustainable, inclusive, climate-resilient growth by addressing constraints to cooperative management and development in transboundary waters. CIWA is in a rare position to link partnerships with regional organizations, national ministries, and civil society actors with the World Bank's technical and operational support to deliver impacts for mitigating and adapting to climate change through sustainable and equitable water resources development. This evidence shows that CIWA primarily contributes to climate change mitigation through influencing investments in hydropower, and resilience through strengthening information services, policies, and capacity building. Recently strengthened efforts toward work on regional ecosystems and biodiversity, investment diversification, and shifts into other water sectors (e.g., water quality) are now scaled up in the CIWA 2.0 pipeline.

An important aspect of transboundary climate resilience will be for member states to have accurate data on which to establish water agreements but also to climate-proof agreements so that they are useful through climate-change scenarios. CIWA focuses on helping partners strengthen information availability and information systems for both surface and groundwater and has contributed to multiple regional water agreements or policies (Table 9). However, the current client demand for assistance assistance in supporting transboundary water agreements themselves has waned,[47] and those previously supported may not all be sufficiently climate-proofed. This is a key area for CIWA's future work, which is not yet explicit in the pipeline.

There are significant political barriers to cooperation in some basins, however, in much of SSA, CIWA's only limitations are its resources to implement projects. Transboundary water cooperation often makes progress and then takes a step back. Fortunately, many CIWA donors have been a consistent driving force for its work and willing to make a long-term commitment to address water security. CIWA will only be able to deliver its mandate by crowding in new and bigger fund flows from donors that see the true value in regional approaches to achieving water security and climate resilience.

Table 9: Strategies, Policies, Plans, and Institutional Frameworks Influenced by CIWA

Name	Status
Annex 2 of the Niger Basin's Water Charter	Adopted but not yet implemented
Climate Change Policy, Environment and Social Policy, Anti-Corruption Policy, Information Technology Policy, and Gender Policy	Active
DRC and Uganda fishery legislation	Active
Lake Chad Development and Climate Resilience Action Plan	Implementation of some components
LVBC and NELSAP-CU institutional frameworks and policies on water quality	Active
NBA institutional audit	Under-implemented
Policy, Legal, and Institutional Development for Groundwater Management in the SADC Member States (GMI-PLI): Regional Gap Analysis and Action Plan Report	Not yet implemented
Somalia National Water Resource Strategy 2021-2025	Active
Strategic Plan for the Zambezi Watercourse 2018-2040	Implementation of some components
Volta Water Charter	Active
Water law and policies across the Zambezi River	Active

[47] The 2023 SDG indicator 6.5.2 report shows that in Africa only 29 percent of transboundary river basins have agreements, but these cover most of the largest basins.

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Annex 1: CIWA-Influenced Projects Covered in the Climate Assessment

No.	Project ID	Project
1	P147218	Additional Financing for Nile Cooperation for Results
2	P133380	AFCC2/RI-Zambezi River Basin Development Project
3	P151921	Africa-wide Hydromet Services Facilitation—TA
4	P167308	Cubango-Okavango Resilient Livelihoods Enhancement Program
5	P132448	Engaging Civil Society for Social and Climate Resilience in the Nile Basin
6	P172554	Great Lakes Water Quality
7	P169078	Horn of Africa Groundwater Initiative
8	P149931	Improved Access to Capacity Building and Knowledge Exchange
9	P149868	Improving Public Access to Basin Data
10	P173152	Improving Water Resources Management in West and Central Sahel
11	P144568	Lake Chad Dialogue
12	P176378	Lake Chad Transboundary Water Security
13	P144228	Lesotho Highlands Botswana Water Transfer Study Project
14	P162810	Luapula River Basin Development
15	P177477/ TF0B8090	Mainstreaming Climate and Non-climatic Resilience in Water Resources and Service Delivery/Prioritizing Resilient Transboundary Infrastructure in Southern Africa
16	P148889	Niger Basin Support Program
17	P149714	Niger River Basin Management Project
18	P172848	Nile Cooperation for Climate Resilience
19	P130694	Nile Cooperation for Results Project
20	P156765	Nile Basin Support Program
21	P150383	Okavango Multi-Sector Investment Opportunity Analysis

22	P175105	Sahel Groundwater Initiative
23	P162304	Second Additional Financing for the Nile Cooperation for Results Project
24	P167749	Somalia—Support to a Transboundary Water Resources Management
25	P180611	South Sudan Transboundary Waters Support Program
26	P173077	Southern Africa Drought Resilience Initiative—SADRI Umbrella
27	P174856	Southern Africa Drought Resilient Energy Systems—SADRI Grant
28	P174871	Southern Africa Drought Resilient Energy Systems—SADRI Grant
29	P174871	Southern Africa Drought-Resilient Livelihoods and Food Security—SADRI Grant
30	P172358	Strengthening Resilience in the Horn of Africa
31	TFOC4064	Strengthening Transboundary Basin Organizations through Program Development and Capacity Building in Africa ASA
32	P127086	Sustainable Groundwater Management in SADC Member States
33	P175355	Sustainable Groundwater Management in SADC Member States Project Phase 2
34	P178786	Untapping Resilience: Groundwater Management and Learning in the Horn of Africa's Borderlands
35	P147202/ P149969	Volta River Basin Institutional Development Project
36	P149969	Volta River Basin Strategic Action Plan Implementation Project
37	P132564	Volta River Basin Support Program
38	P176348	Water Data Revolution: Closing the data gap for transboundary water in Africa
39	P181092/ TFOC2624	Water Security and Climate Resilience in Southern Africa
40	P143546	Zambezi River Basin Management Project (ZAMCOM)
41	P143186	Zambezi River Basin Support Program 1

Annex 2: Mitigation Calculations for Main Hydropower Plant Projects

Kariba Dam Rehabilitation:

The figure for electricity generated is from 2015. This could be an underestimate from increased installation capacity since 2015, however, it could also be an overestimate if we consider the effects of diminishing water levels in reservoirs from climate change, which has reduced generation output below optimum. More recent data on electricity generation would be needed for a better estimate.

Kandadji Dam:

The calculated mitigated GHG emissions estimates are based on electricity generated from phase 2 completion.

Nsongezi Dam:

Annual electricity generation is not available and was estimated knowing the installed capacity and assuming a capacity factor of 80 percent (based on what is commonly between 50 percent and 80 percent for such hydropower plants).

Rusumo Falls Hydroelectric Station:

The grid emission factors for Rwanda were used. The power plant is located at Rusumo Falls on the border of Rwanda and Tanzania.

Luapula Hydroelectric Station:

Annual electricity generation is not available and was estimated knowing the installed capacity and assuming a capacity factor of 80 percent (based on what is commonly between 50 percent and 80 percent for such hydropower plants).

Annex 3: Climate Resilience Analysis of CIWA Project Components with Climate Adaptation Indicators

Sectoral Grouping	Climate Adaptation Indicators	CIWA project components matched
1. Sanitation wastewater management	1.1 Incorporate changes in design of wastewater treatment and disposal systems in response to extreme weather and flood events	1
2. Water supply	2.1 Support demand-side management based on water-saving and water-pricing policies to maintain climate-resilient water supplies (by reducing water consumption and increasing water-use efficiency)	1
	2.2 Support supply-side management by expanding supplies (e.g., through diversification of water sources), reducing water losses, and/or improving cooperation on shared water resources	22
	2.3 Relocate well fields away from floodplains or raise well heads	0
	2.4 Improve watershed management planning and regulation of water abstraction	15
	2.5 Install water-recycling equipment to improve water security	0
	2.6 Optimize water infrastructure design based on climate and hydrological models	3
3. Flood protection	3.1 Retain or reestablish mangrove forests and wetlands as protection against floods	2
	3.2 Improve resilience of infrastructure (e.g., bridges, water supply, community infrastructure) to floods	3
	3.3 Promote regional cooperation on flood risk reduction	29
	3.4 Construct or strengthen polders, dikes, and embankments to protect against increasing flood risks	0
	3.5 Reinforce the coastline physically (with new/rehabilitated structures) or naturally (with vegetation)	0
	3.6 Incorporate climate-related aspects in design standards for drainage systems	0
4. Wastewater collection, transportation, treatment, and disposal	4.1 Incorporate changes in design of wastewater treatment and disposal systems in response to extreme weather and flood events	0
	4.2 Protect wastewater infrastructure against increasing flood risk	0
	4.3 Treat wastewater and conservation/reuse of (waste)water to respond to declining water supplies	0

5. General water, sanitation, and flood protection and Miscellaneous	5.1 Develop water monitoring and information systems	14
	5.2 Provide WRM training and expertise to RBOs to improve climate-resilience of water systems	28
	5.3 Develop and implement equitable arrangements for sharing water resources between competing demands (agriculture, hydropower, industry, and household)	7
	5.4 Incorporate climate-related factors (e.g., changes in precipitation, temperature, runoff, evapotranspiration) in hydromet forecasts, total/seasonal water availability, and water demand and storage planning	9
	5.5 Incorporate climate-related water cycle changes into national and transboundary water basin planning	6
	5.6 Design and implement conjunctive management strategies for groundwater and surface water that incorporate climate-related water cycle changes	5
	5.7 Provide supplemental irrigation, multi-cropping systems, drip irrigation, leveling, and other approaches and technologies that reduce the risk of large crop failures	5
	5.8 Establish core protected areas and buffer zones to safeguard biodiversity and ensure the sustainable use of water to meet livelihoods needs during droughts	2
	5.9 Fill in climate change-related data gaps that hinder policy formulation and implementation	20
6. Dam safety	6.1 Improved physical safety of irrigation dams will secure food production systems, improve the climate resilience of the hydraulic infrastructure network including dams, and reduce the risk of inundation downstream due to dam failure	3
7. Drought risk management	7.1 Drought risk management and development of regional efforts on drought resilience	2
	7.2 Introduction of digital solutions and innovative financial instruments such as drought insurance	1
	7.3 Modernization of the management of strategic food reserves for improving resilience to droughts	1

Annex 4: CIWA-Influenced Investments with Climate Resilience Benefits

Sectoral Grouping	Climate Adaptation Indicators	CIWA project components matched	Adaptation Indicator matched	Status of investment
Additional Financing for Nile Cooperation for Results	Kabuyanda, Uganda	Irrigating 4,300 ha; hydropower 0.1 MW	Indicator 2.2	Mobilized
Additional Financing for Nile Cooperation for Results	Lerekwe and Sio-Sanga, Kenya	Irrigating 3,500 ha; hydropower 0.05 MW and 0.1 MW; storage 6.2 MCM and 5.8 MW	Indicator 2.2	Potential
Additional Financing for Nile Cooperation for Results	Mara Valley, Tanzania	Irrigating 8340 ha; hydropower of 6 MW; storage: 30MCM	Indicator 2.2	Potential
Additional Financing for Nile Cooperation for Results	Ngono Valley, Tanzania	Irrigating 11,342 ha; hydropower of 14.5 GWh/yr	Indicator 2.2	Potential
Additional Financing for Nile Cooperation for Results	Ruvyironza, Burundi	Irrigating 14,674 ha; hydropower of 22 MW; storage 372.6 MCM	Indicator 2.2	Potential
Additional Financing for Nile Cooperation for Results	Muvumba Irrigation Development and Watershed Management project, Rwanda	Irrigating 13,000 ha, hydropower 3 MW, water supply to 188,000 people	Indicator 2.2	Potential
Cubango-Okavango Resilient Livelihoods Enhancement Program	Irrigation development, Angola and Namibia	11 irrigation schemes, an estimated 279,500 hectares planned for development. Another 16 schemes have been identified in Namibia, with an estimated 23,200 hectares to be developed.	Indicator 5.7	Potential
Cubango-Okavango Resilient Livelihoods Enhancement Program	Urban water supply	The restoration of design capacities and the accommodation of future growth to 2040 (the planning horizon of the MSIOA study) result in projected abstractions for urban water use within the basin of between 27.1 million cubic meters per year and 38.5 million cubic meters per year.	Indicator 2.2	Potential
Nile Cooperation for Results Project	Chemoga-Yeda Integrated Watershed Management, Ethiopia	189,212 ha watershed management project; 533,811 expected beneficiaries.	Indicator 2.4	Potential

Nile Cooperation for Results Project	Fincha Integrated Watershed Management, Ethiopia	186,405 ha watershed management project; 456,981 expected beneficiaries.	Indicator 2.4	Potential
Nile Cooperation for Results Project	Lelaitich Sub-catchment Management Plan (SCMP)	Supported the development of Catchment Management Plans in Mara sub-basin	Indicator 2.4	Potential
Nile Cooperation for Results Project	Middle Malakisi/Toloso SCMP	Supported the development of Catchment Management Plans in Mara sub-basin; 138,397 expected beneficiaries.	Indicator 2.4	Potential
Nile Cooperation for Results Project	Ol Chorro Lemek SCMP	Supported the development of Catchment Management Plans in Mara sub-basin; 14,148 expected beneficiaries.	Indicator 2.4	Potential
Nile Cooperation for Results Project	Restoration of the Kerib lands in Gedarif State along the Upper Atbara River-Sudan	Reducing soil erosion in 181,607 ha wetlands management plan in Eastern Sudan; 66,614 expected beneficiaries.	Indicator 2.4	Potential
Nile Cooperation for Results Project	Regional Hydromet	Establishing and operationalizing a regional hydrological monitoring system to provide more reliable data and information for water resources management.	Indicator 5.4	Potential
Nile Cooperation for Results Project	LEAF Project	Strengthening the legal, policy, institutional, and regulatory framework for sustainable management of natural resources and protection of the environment	Indicator 5.4	Potential
Nile Cooperation for Results Project	Kocholia Multipurpose Water Resources Development Project	Irrigating 4,000 ha; hydropower 0.1 MW; storage 66.9 MCM	Indicator 2.2	Potential
Nile Cooperation for Results Project	Nyimur Multipurpose Water Resources Development Project	Irrigating 6,000 ha	Indicator 2.2	Potential
Nile Cooperation for Results Project	Shared Angololo Multipurpose Water Resources Development Project	Irrigating 2,500 ha, storage 13MCM	Indicator 2.2	Potential
Nile Cooperation for Results Project	Sio-Sango Multipurpose Water Resources Development Project	Irrigating 1790 ha; 28,398 expected beneficiaries	Indicator 2.2	Potential
Nile Cooperation for Results Project	Akanyaru Multipurpose Water Resources Development Project	Irrigating 12,474 ha, supplying water to 614,200 people	Indicator 2.2	Potential

Nile Cooperation for Results Project	Integrated Fisheries and Water Resources Management of Jebel-Awlia-Renk-Malakal Project	The project involves water supply and fisheries management along a 629 km length of the Jebel Awelia reservoir, two-thirds of which are in Sudan and one-third is in South Sudan. NELSAP completed project identification and is mobilizing funds for Transboundary Diagnostic Analysis and Feasibility Studies for the project.	Indicator 2.2	Potential
Nile Cooperation for Results Project	Water Harvesting in the gash Delta, Kassala-Sudan	274,978 expected beneficiaries	Indicator 2.2	Potential
Nile Cooperation for Results Project	Integration of Groundwater Resource Data Management System, Botswana	Integrating the National Geoscience Information system (NIGIS) database model with the HydroGeo Analyst (HGA), load all the data from NIGIS (Water modules) into HGA, and develop a web-based application to access the HGA customized solution.	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Expansion of a National Groundwater Monitoring Network, Lesotho	Expanding the existing groundwater monitoring network to form a comprehensive nationwide network for the support and guidance of groundwater management activities in Lesotho.	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Review and Update of the Hydrogeological Map, Namibia	Updating the Hydrogeological Map of Namibia (completed in 2001), through the updating of recent project findings and newly available data from GROWAS II.	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Groundwater Management in the Kimbiji Aquifer System, Tanzania	Drilling five wells for monitoring of water levels in the recommended area spread out across the predicted drawdown areas between the two wells fields to supplement existing observation wells.	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Groundwater monitoring network system in Greater Harare, Zimbabwe	Characterizing the aquifer system and setting up a groundwater monitoring network system in Greater Harare.	Indicator 5.9	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Monitoring and Management of Groundwater Supply in the Municipality of Caimbambo, Angola	Generating data and information about the occurrence of groundwater to increase water availability for human supply and productive activities.	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Groundwater Monitoring and Installation of Solar-Powered Pumps at Selected Localities, Eswatini	Reactivating a groundwater monitoring system that from climate change and drought was converted into the water supply system.	Indicator 2.2	Mobilized

Sustainable Groundwater Management in SADC Member States Phase 1	Water Supply project in Chimbiya, Dedza District, Malawi	Exploring deep aquifers by drilling a 100m deep borehole, equipping the borehole with a motorized electric pump, delivering the water to 10 communal-style distribution points around the community, culminating in supplying water to approximately 15,000 people in Chimbiya.	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Transformation of a dispersed Source in Water Supply System and Promotion of Hygiene and Sanitation, Mozambique	Installing a submersible pump powered by a solar panel to supply water to 2,000 people.	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Groundwater Mapping and Wellfield Development in Chongwe District, Zambia	Identifying and characterizing a local aquifer in the Chongwe area with sufficient productive capacity to be used for settlement-level water supply and to develop a wellfield to supplement the existing wellfield developed by the LWSC.	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Rehabilitation of the existing Council borehole (BH 2813) through technical assessments, Botswana	Rehabilitating a borehole	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 1	Rehabilitation of Dite and Whunga Community Water Supply Projects	Rehabilitating two boreholes	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Improving knowledge on groundwater availability, Eswatini	Innovating approaches for improving knowledge on groundwater resources in the country and capacitating managers and relevant stakeholders in groundwater monitoring	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Groundwater Monitoring, Mauritius	Acquiring real-time data for effective groundwater management by equipping 10 representative monitoring wells in the main aquifers with automatic data loggers and telemetry system.	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Groundwater Assessment of Machangulo Region, Matutuine District, Mozambique	Assessing groundwater availability in study area in Phase I and constructing infrastructure for water supply in Phase II.	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Review and Update of Hydrogeological Map Series and Information Brochure Polokwane Area, South Africa	Producing a synoptic overview of the hydrogeological character of an area.	Indicator 5.1	Mobilized

Sustainable Groundwater Management in SADC Member States Phase 2	Groundwater Monitoring in the Save Alluvial Aquifer of Zimbabwe	Redesigning the monitoring network, rehabilitating identified monitoring wells, installing real-time telemetric groundwater monitoring, and training technical staff.	Indicator 5.1	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Water supply project in Congo Central, DRC.	Drilling three boreholes	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Construction of Groundwater Monitoring and Water Supply Systems, Lesotho	Identifying the location of existing boreholes and natural springs, drilling new boreholes, and capacity building for the communities on sustainable use.	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Rehabilitation of 20 existing monitoring wells, Malawi	Rehabilitating 20 monitoring wells	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Enhancing Sustainable Groundwater use in arid Southern Namibia /Karas Region	Promoting sustainable and coordinated management of groundwater resources for improved livelihoods, ecosystem health, and economic development.	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Groundwater Development and Management of Nzunguni Aquifer, Tanzania	A groundwater assessment studies project and drilling exploratory boreholes, which will advise on the development of safe and reliable sources for augmenting water supply of Dodoma City.	Indicator 2.2	Mobilized
Sustainable Groundwater Management in SADC Member States Phase 2	Groundwater Mapping and Development at Sumbwa Basic Scholl in Kazungula District Southern Province – Zambia	Identifying and characterizing aquifers in the Sihumbwa area with sufficient productive capacity, determining water demand, and constructing production boreholes.	Indicator 2.2	Mobilized

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