International Water Management Institute

Project Brief

Competing for Hydrologic Ecosystem Services: Using Remote Sensing Data and Water Accounting to understand current water resources status in the Rift Valley Lakes Basin

Summary

The Problem: *The There has been an increased competition for available water resources in the Rift Valley Lakes Basin. However, there is lack of hydro-climatic data in the basin with no rainfall stations and discharge with large data gaps.*

The Approach: *The Digital Innovation for Water Secure Africa (DIWASA) initiative of the International Water Management Institute is motivated to address water data scarcity issues through the water accounting plus (WA+) framework. The WA+ approach addresses the challenge of the data gap by focusing on the use of data from earth observation satellites to provide an understanding of water availability and water use of the Rift Valley Lakes Basin.*

What do we learn from the Rift Valley Lakes Basin WA+ study (2010-2020)?

- *Long-term (2010-2020) average monthly rainfall analysis over the basin shows a bimodal rainfall distribution with April/ April – May signifying the heavy rainfall season with peaks of approximately 246 mm/month and September-November known as the "small" rainfall season with a mean rainfall of 110 mm/month.*

- *The primary source of inflow into the basin is precipitation amounting to 56 km³ on an annual basis.*

- *On average, 16 km³ of water is withdrawn from the basin annually.*

- *As an endorheic basin, there is no surface water discharge out of the basin.*

- *On average, the total inflows into the Lakes systems is 18 km³/yr of water.*

- *The net water storage is 1.8 km³ meaning that withdrawals are not of major concern in the basin.*

- *49% of exploitable water is available for further development. Although this water is available for future use, any increase in consumptive use in the basin could reduce the net inflows into the lake and adversely affect the lake levels.*

- *Non-recoverable outflow (the water that cannot be recovered due to pollution) is about 45% of utilizable outflow, showing that water quality might be a potential issue if trends continue. Investments to treat/reduce water pollution would increase the utilizable flows.*

The Rift Valley Lakes Basin (RVLB) is an incredible biodiversity hotspot covering an area of 54,643 km², most of which lies in Ethiopia (>97%) and a small portion in Kenya (about 3%). It is home to lakes, wetlands, woods, grasslands, and savannahs, all offering various ecosystem services, such as serving as a natural habitat for numerous birds, fish, and animal species. The Rift Valley Lakes Basin consists of 10 major lakes with a total area of over 7,400 km² and 7,185 km of major rivers. Many of the lakes in the area, in particular, serve as a focal point for rare or endangered species and large populations of wildfowl and waders of international importance. In the Rift Valley Lakes basin, 45% of the area is covered by Agriculture, 18% by Forest and 20% by Grass. Subsistence agriculture is the main livelihood in the basin. Coffee is the primary source of income and a significant contributor to the country's export market. The rainfed agricultural system mostly supports the economy. The Rift Valley Lakes Basin is an endorheic basin that does not have surface outlet discharge, and flows are discharged into lakes. The basin supplies water for more than 15 million people, mainly for irrigation, fishing, domestic water supply, transportation, and recreation.

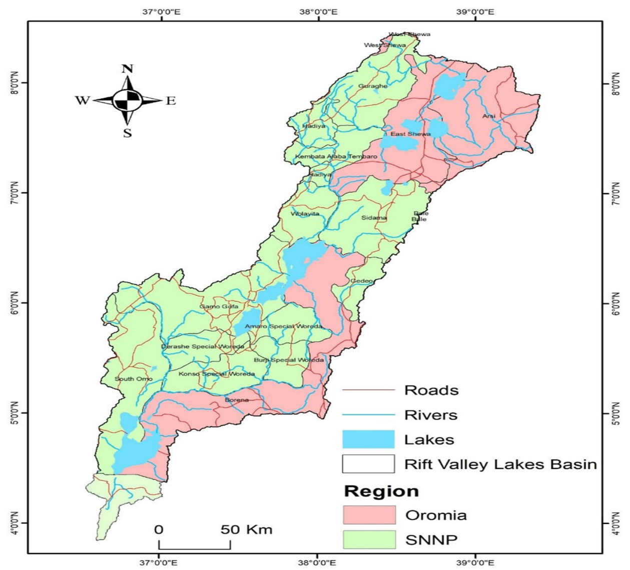

Figure 1. The Rift Valley Lakes Basin showing a cascade of lakes, roads, and river network.

Challenges in the Rift Valley Lakes basin

There has been increased population growth in the RVLB, agricultural activities, and irrigation expansion. This resulted in some contrasting changes in the basin, that is, expansion and reduction of lakes. Large-scale water abstraction and inflow from over-irrigated farms are the main factors behind the major changes in terminal lakes (Ayenew, 2007). Over the past decades, the RVLB has experienced major droughts and extreme flood events resulting from the variable nature of precipitation. The basin also suffers from increased competition for available water resources. However, there is a lack of hydro-climatic data in the basin with no rainfall stations and discharge with significant data gaps.

What kind of approaches are available to address the challenges?

The The WA+ framework is designed for use in data-scarce basins, where in situ data from hydrological and meteorological networks is scarce or unavailable. The approach uses open access inputs, focusing on remote sensing datasets to compute a river basin or watershed's water balance and calculate seasonal and annual water accounts. Implementation of the framework consists of five major steps to calculate and present the water accounts: i) data download and pre-processing, ii) water balance modeling, iii) calibration/validation of outputs, iv) generation of water accounts, and v) interpretation and presentation of results. During the initial data preparation step, various remote sensing datasets and tabular data were acquired from different sources and calibrated to address systematic errors in the remotely sensed data. The hydrological variability of the basin is then characterized by computing various water balance indicators across the Rift Valley Lakes Basin. Assuming that the cascading Rift Valley Lakes form one lake system, all flows from all the sub-basins were summed and assumed to flow into the Lake system. The endorheic lake system was modeled with total inflow from all sub-basins. Basin-wide water accounts were generated based on the various water balance indicators and presented for each major land use class.

Water accounts for the Rift Valley Lakes basin

On average, 1.8 km3/yr of water is stored from 2010 to 2020, which corroborate other studies that have shown a positive change of storage in the basin, including the United States Department of Agriculture website of Global Reservoirs and Lakes Monitor. About 49% of exploitable water is available for further development. There has been a decrease in precipitation between 2013 and 2017. The changes in water placed in the river basin (positive changes in storage) show a fluctuating trend from 2010 to 2020. There is a decreasing trend between 2011 and 2013, a sharp decrease between 2014 and 2017, and from 2018 to 2020. Non-recoverable flows, considered as flows that are too polluted to be used, averaged 4 km3 from 2010 to 2020. This indicates that water quality might be a potential concern if current trends continue. The water quality degradation threat might be attributed to an increase in population growth, resulting in increased agricultural activities in the basin.

Figure 2. Lake Ziwayi (left); Meki catchment (top right): Night storage at Meki catchment (Bottom right).

The Rift Valley Lakes Basin has experienced increasing water resource competition over the past several years. However, a lack of adequate hydro-climatic data for the basin, rainfall, and discharge stations with large data gaps has made the current water resources status challenging to determine. The water accounts provide a set of baseline indicators that can be used to identify potential measures to increase water availability and productive use in a sustainable manner. As reflected in the water accounts, there is adequate groundwater storage, although this may have to be carefully considered with any planned expansion and/or intensification of agricultural activities. Pollution of water to the extent that it is unavailable for further use is a potential issue in the basin that requires monitoring. The WA+ study highlights the utility of using remote sensing to estimate complex hydrologic processes for sustainable water resources planning and management in data-scarce regions such as the Rift Valley Lakes Basin.

Figure 3. Water pollution in the Rift Valley Lakes Basin due to small-scale mining (left); Furrow irrigation for small scale irrigation (right).

Indicator	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Mean (2010-2020)	SD (2010-2020)
Storage change	0.2	1.6	1.4	-5.5	-4.1	-3	-0.2	0.7	-5.3	-6.8	1.4	-1.78	3.05
Exploitable water	18.4	16.2	19.1	20.9	20.1	16.9	14.8	13.3	19.1	17.8	24.5	18.28	2.92
Utilized flow	4.5	3.9	4.5	4.8	4.6	3.9	3.6	3.2	4.6	4.2	5.8	4.33	0.66
Utilizable outflow	8.9	7.2	9.5	11	10.4	7.9	6.2	5	9.5	8.5	13.6	8.88	2.26
Non-recoverable flow	4.0	3.5	4.2	4.6	4.5	3.7	3.2	2.9	4.2	3.9	5.4	4.01	0.66

Table 1. Key water accounting indicators for the Rift Valley Lakes Basin from 2010 to 2020. Values in (values in km³).

Acknowledgement

The authors gratefully acknowledge The Leona M and Harry B. Helmsley charitable trust for their financial support and Tanmoy Bhaduri (Communications Consultant, IWMI) for preparing the layout of the brief. The authors' views are their own and do not necessarily reflect the views of the funding agency.

Contacts

Abdulkarim Seid, Project Leader (DIWASA) and Country Representative, IWMI-Ethiopia (a.seid@cgiar.org)
Naga Velpuri, Senior Researcher - Water Accounting and Productivity, IWMI, Sri Lanka (n.velpuri@cgiar.org)
Mansoor Leh, Researcher - Spatial Hydrology, IWMI, Sri Lanka (m.leh@cgiar.org)
Primrose Tinonetsana, Consultant, IWMI, Sri Lanka (p.tinonetsana@cgiar.org)

International Water Management Institute

IWMI is a CGIAR Research Center

The International Water Management Institute (IWMI) is an international, research-for-development organization that works with governments, civil society and the private sector to solve water problems in developing countries and scale up solutions. Through partnership, IWMI combines research on the sustainable use of water and land resources, knowledge services and products with capacity strengthening, dialogue and policy analysis to support implementation of water management solutions for agriculture, ecosystems, climate change and inclusive economic growth. Headquartered in Colombo, Sri Lanka, IWMI is a CGIAR Research Center with offices in 14 countries and a global network of scientists operating in more than 30 countries.

International Water Management Institute (IWMI)

Headquarters
127 Sunil Mawatha, Pelawatte,
Battaramulla, Sri Lanka

Mailing address:
P. O. Box 2075, Colombo, Sri Lanka
Tel: +94 11 2880000
Fax: +94 11 2786854
Email: iwmi@cgiar.org
www.iwmi.org

Published: August 2023