The Birr River near Jiga: notice the river cross section

The Need for Strengthening Hydrometric Monitoring System in the Abbay Basin, Ethiopia

Policy Messages

- Increase funding for stream flow monitoring activities in the basin to enable the installation of new gauging stations and the maintenance of existing ones.
- Support with policy technical capacity development of technical staff responsible for operating and maintaining the gauging stations to ensure that data is collected continuously and reliably.
- There is a need for a formal hydrometric data quality assurance procedure that details how the data have been processed from collection of water level to the reporting of discharge.
- Encourage partnership and collaboration between the private and public sectors to coproduce hydrometric services in the basin and to ensure that data is shared and used to inform decision-making.
- Support the development of innovative technologies such as satellite-based methods to supplement the traditional gauging stations to enhance the data collection efforts.

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The Issue

The availability, quality, and quantity of water resources can be evaluated through hydrological monitoring and data collection. Such data is crucial for water management decisions and thus to achieving SDG 6 which is about 'ensuring water and sanitation for all', and indeed several of the SDGs targets. Beyond the water sector, for instance, hydrological data is useful in developing strategies for adaptation to and mitigation of impacts of climate change. It is therefore important to have accurate and reliable data from long-term hydrological monitoring to improve hydrological services and achieve water security for sustainable development.

As elsewhere in Africa in general and sub-Saharan African in particular, the hydrological monitoring network in Ethiopia is inadequate and declining, leading to frequently suboptimal decisions. The situation is no different in the Abbay river basin, which is the largest river of the country and where the largest dam in Africa is near completion. It is observed that the flow monitoring in the Abbay basin is spatially limited and stations are not being maintained, with manual operation and little real-time data collection. Furthermore, the river flow measurement

infrastructure is outdated which produces significant uncertainties and errors in flow estimation, impacting on water resource estimation. A poorly maintained hydrometric network can lead to inaccurate measurements and unreliable data for water resources management as it is impossible to manage something that is not measured or assessed appropriately.

On the other hand, the Abbay Basin is a crucial river system in Ethiopia, responsible for 50% of the country's total annual surface runoff while only covering 17.5% of its land area. It provides water resources for various sectors such as agriculture, hydropower, and domestic use, making accurate measurement and management of river flows vital for their sustainability and effectiveness. However, analysis of data from 122 river gauging stations reveals that the existing hydrometric monitoring networks suffer from poor temporal coverage, low density of measurement stations, unreliable equipment and a lack of quality control. This situation has resulted in data scarcity, inaccuracy and inconsistencies, which negatively affects water resources management and decision-making processes in the basin.

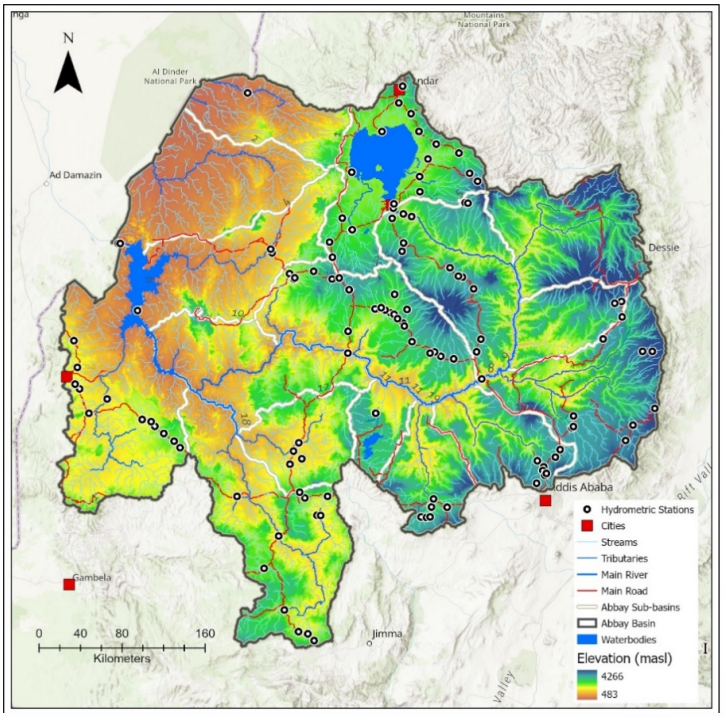

Figure 1. The Abbay basin, also known as the Upper Blue Nile, is located in the central-western part of Ethiopia and covers an area of 199,800 km2

Approaches and Setting

The Water and Land Resource Center (WLRC), Addis Ababa University, and Newcastle University collaborated to conduct extensive analysis on the state of hydrometric monitoring networks of the Abbay Basin. The analysis focused on river flow data from 122 river gauging stations, which are mainly located along the road network in accessible areas to major settlements as shown in Figure 1. Additionally, two consultative workshops were conducted. The first workshop took place in Bahir Dar City (Teferi and Kassawmar, 2021), with 23 participants attending from various organizations, including the Ministry of Water and Energy, Abbay Basin Administration Office, National Meteorology Agency, universities, and WLRC. The second workshop took place in Addis Ababa and involved 28 delegates from a diverse range of water related organizations. These workshops allowed experts to discuss existing gaps and challenges related to data provision and the hydrometric monitoring networks, while exploring future opportunities to advance the hydrological service delivery. Finally, a total of 19 key informant interviews (KIIs) were conducted: four with hydrological data observers, three with hydrology technicians, five with hydrology experts, and seven with hydrology data users. We used the SWOT (Strength-Weakness-Opportunity-Threat) analysis tool to systematically organize the findings.

Research Findings

The lack of reliable river flow data and poor hydrometric network density has resulted from a complex interplay of physical, technical, institutional, socio-economic and environmental factors. Understanding these factors can help improve monitoring practices and water management, leading to more reliable and accurate decision making. The SWOT Analysis of the state of hydrometric monitoring networks from 122 river gauging stations of the Abbay basin reveals the following strengths, weaknesses, opportunities and threats (Figure 2).

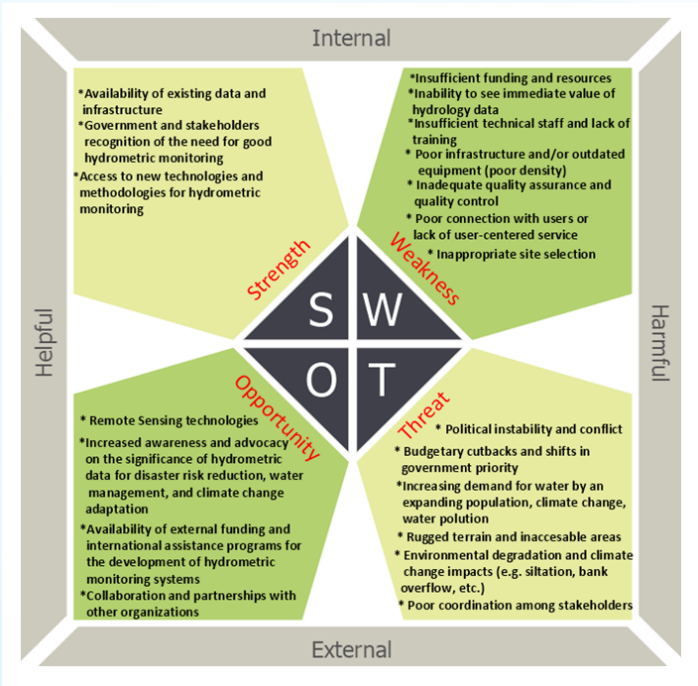

Figure 2. SWOT analysis of the hydrometric network in the Abbay basin

Strengths

In the context of the hydrometric network, strengths include the existing knowledge and expertise of the local team responsible for maintaining and improving the network. The Ministry of Water and Energy (MoWE) has a tradition of collecting hydrometric data since 1960, indicating that the country has considerable experience and knowledge in this area. In the Abbay basin the number of manual streamflow-gaging stations administered by MoWE increased steadily from four gaging stations in 1960 to about 122 gaging stations in 2022. Some 17% of the flow stations have a record length of more than 30 years, indicating that there is a wealth of long-term data available, which can be used for analysis and decision-making. By leveraging this knowledge and expertise, the organization can identify areas of the network that need attention and prioritizing them based on the existing conditions, understanding the unique needs of the local community and tailoring the solutions to meet those needs, or developing innovative solutions to address complex challenges.

Weaknesses

The number of hydrometric network stations is spatially limited and in decline, with data series characterized by gaps (Figure 3 and Figure 4). Importantly, there is an absence of metadata, particularly relating to rating curves. This is due to inadequate data quality checking, outdated equipment, weak data management procedures, and insufficient training of personnel, among other factors. Even worse, the number of stations in the hydrometric network has decreased since 2002 (Figure 3 and Figure 4). Moreover, the distribution of stations is biased towards the road network, resulting in significant differences in density of gauges between different areas (Figure 1). Eight of the 15 sub-basins of the Abbay river basin do not meet the WMO's recommendation for a minimum stream gauge density of 1/1875 km2 for hilly/ undulating watersheds or 1/1000 km2 for mountainous watersheds (WMO, 2008). The area per gauge varies greatly between sub-basins in the Abbay basin, with the highest density found in the southern part of Gojjam and Tan sub-basins and the lowest in the Wonbera, Dinder, Rahad, and Fincha sub-basins. High altitude areas are particularly challenging due to rugged terrain and inaccessibility, resulting in the underrepresentation of stations above 3000 m a.s.l.

The lack of adequate financing is also a significant weakness, leading to lack of qualified staff, insufficient training, and equipment maintenance. These deficiencies result in a high level of uncertainty in water resource management and development making it difficult to describe and quantify flow regime diversities among the sub-basins. There is a need to identify gaps and obstacles and embark on solutions in the hydrological data collection and processing urgently.

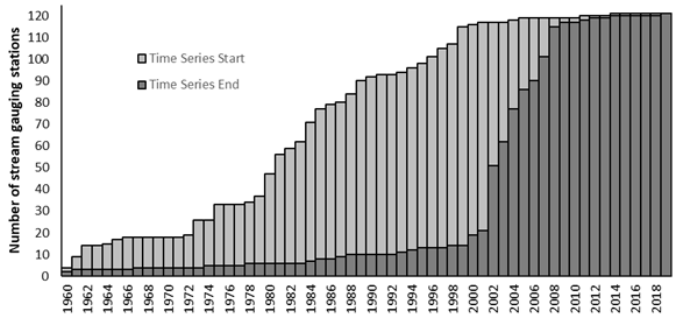

Figure 3. Hydrometric stations time series start and end (years)

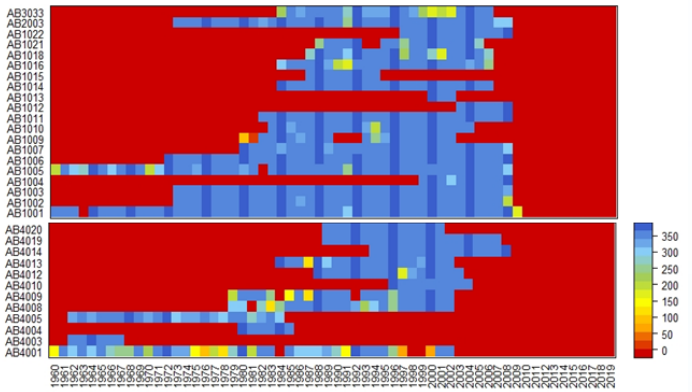

Figure 4. Days with information of river gauging stations shown by sub-basins: Lake Tana sub-basin (top) and Didessa sub-basin (bottom)

Opportunities

Investing in new technology and resources can provide an opportunity to gather more accurate data on river flow and other important auxiliary variables crucial to water resources. This can be attributed to four factors: Firstly, new and advanced technologies for flow measurement, such as acoustic doppler current profiler (ADCP) that can be used either in real-time mode through a telemetry system, or in self-contained mode, offer an opportunity to improve accuracy. Secondly, advanced technologies for water level measurement such as automated monitoring and communications (telemetry). Thirdly, space-based monitoring of water level for lakes, major rivers, and flood plains using satellite altimetry can augment in situ observations with high-quality remote sensing information. Finally, geospatial data are increasingly integrated with hydrometric data, including catchment boundary, river networks, topography data, soil data, and land cover data, through digital technology.

Inadequate collaboration and communication among stakeholders and organizations lead to discrepancies in gathering and evaluating information, resulting in unsuitable decision-making. To address this concern, a partnership could be implemented, which could lead to the development of supplementary monitoring networks maintained by volunteers, universities, and investors, that can be achieved through effective coordination and communication. Additionally, raising awareness and education about the importance of hydrometric data can lead to a greater prioritization of the issue among stakeholders. Advocacy for the importance of hydrometric data for disaster risk reduction and climate change adaptation is also a crucial opportunity to increase visibility of hydrology data and make stakeholders see the benefit of investing in hydrometric monitoring networks.

Threats

Due to budget cuts and government priorities, the maintenance and upgrading of hydrometric networks has suffered, experiencing deterioration over time. Institutionally, the immediate benefits of investing in hydrological data are not apparent, leading to neglect. This may have serious consequences for sustainable water management, given uncertainty in future climate and an expanding population. Institutional changes can also pose a threat to the continuity of collecting and processing hydrometric data. Political instability or conflict can prevent the collection of accurate data from monitoring stations, making it important to invest in alternative data collection methods and develop mitigation measures. Finally, environmental degradation can cause siltation and bank erosion, reducing the accuracy of monitoring station.

Conclusion

In conclusion, the state of hydrometric monitoring networks in the Abbay basin indicated the need for urgent action to address the challenges and to ensure continued availability of reliable river flow data. Proper SWOT analysis was done to generate useful evidence for action. The strengths include the existing infrastructure and trained staff, while weaknesses include insufficient funding and outdated technology. Opportunities include new funding sources, collaborations with other organizations, and adoption of advanced flow measurement technologies, while threats include environmental degradation, conflict, shifting government priorities, and the rugged terrain. By identifying these factors, stakeholders can develop strategies to address the weaknesses and threats while leveraging the strengths and opportunities to improve the performance of hydrological monitoring networks. This can ultimately lead to more effective monitoring and management of water resources, and better decision-making for communities and stakeholders who rely on these resources. Overall, the SWOT analysis highlights.

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Acknowledgements and funding

This work was supported by the Water Security and Sustainable Development Hub funded by the UK Research and Innovation's Global Challenges Research Fund (GCRF) [grant number: ES/S008179/1]. We are also grateful to the Ministry of Water and Energy (MoWE) for providing streamflow data.

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Acknowledgement: This project is supported by the Water Security and Sustainable Development Hub funded by the UK Research and Innovation's Global Challenges Research Fund (GCRF) [grant number: ES/S008179/1].

Citation:

Ermias Teferi, Woldeamlak Bewket, Greg O'Donnell, and Gete Zeleke. The need for strengthening hydrometric monitoring system in the Abbay basin, Ethiopia. *Research Evidence for Policy.* Water and Land Resource Centre, Addis Ababa University (WLRC, AAU): Addis Ababa

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WLRC, AAU/2023