IWMI
International Water Management Institute

Technical Brief

Applying citizen science to water security challenges in Ethiopia: A structured approach

Summary

Citizen science (CS) is an important approach to involve the public in scientific research and contribute to addressing water security issues. CS programs, led by the International Water Management Institute (IWMI) and local partners in Ethiopia, meaningfully engage communities in data collection and knowledge co-generation. However, challenges such as limited resources, data quality issues and lack of awareness among decision-makers highlight the need for training, sustained funding and alignment with local problems. The technical brief emphasizes the importance of leveraging CS to fill hydrometeorological monitoring gaps, ensuring data accuracy and community engagement, and developing frameworks for expanding CS programs. By aligning with community needs and fostering inclusive participation, CS can strengthen water security initiatives in Ethiopia, creating a foundation for sustainable and locally relevant solutions to water management.

The context

Citizen science (CS) is the practice of voluntary public participation and collaboration in scientific research to increase scientific knowledge and solve local problems. CS programs offer opportunities for local communities and scientists to monitor, analyze and co-generate knowledge about their environment. In Ethiopia, many CS initiatives have focused on collecting hydrometeorological data and engaging local communities in knowledge co-generation. CS can address societal needs, mitigate water-related risks and contribute to the achievement of the Sustainable Development Goals (Buytaert et al. 2014; Nardi et al. 2022).

However, the effectiveness of CS programs depends upon the degree to which the definitions and concepts of CS resonate with the social attributes of the community. Therefore, improving current CS programs is necessary to optimize both immediate and long-term impacts. A key challenge is ensuring that community members see tangible short-term benefits of participating in these programs. To address this, appropriate incentives and programs designed to meet local needs are critical with consideration of social inclusion. This technical brief aims to identify challenges and opportunities to enhance CS programs in Ethiopia. It draws on evidence gathered from IWMI's CS projects conducted over the past ten years, which have focused on shallow groundwater (Ferede et al. 2020), rainfall (Tedla et al. 2022a), water quality (Babiso et al. 2023) and other critical topics related to water security.

Participants of the review workshop held in Debre Zeit (Bishoftu), Ethiopia to gather stakeholder input for the technical brief (*photo:* Rahel Mesganaw).

Framework for the citizen science program

A broad framework has emerged from the insights gained through diverse CS initiatives. Figure 1 illustrates how the CS program in Ethiopia leverages the power of community engagement and collaborative knowledge to tackle local challenges. At the core of this framework is a two-stage cyclical process that begins with identifying local problems, existing initiatives and research gaps. CS initiatives should seek to address these research gaps while resolving local problems. This tailored approach ensures CS projects meet the specific needs of communities, ensuring greater relevance and ownership.

Assessing existing community efforts is always preferable to starting anew. For example, IWMI's first CS program focused on the governance of shallow groundwater in the Dangila District in Ethiopia. The next stage involves recruiting and equipping volunteer citizen scientists from diverse social groups, providing them with the training and resources necessary for effective participation. Since voluntary involvement is the primary characteristic of CS, only those who choose to participate should be enlisted. Additionally, participation should be inclusive and free from discrimination based on gender, age or ethnicity.

Following training, robust monitoring and data quality control are essential. Collected data must be analyzed and feedback provided to the community. The quality of the data and the capability of its CS collectors are key concerns; however, there are numerous examples illustrating how citizen scientists can provide high-quality data under appropriate conditions, including proper supervision and monitoring (Walker et al. 2016).

The final stage of the inner circle in Figure 1 emphasizes collaborative decision-making, where insights gained from CS activities are used to inform and engage stakeholders in collective actions to help address community challenges. This collaboration empowers citizen scientists by facilitating a two-way flow of knowledge between stakeholders and the community, motivating more volunteers to engage through the demonstration effect.

Surrounding the inner circle is an outer layer, which highlights the importance of documenting lessons learned, disseminating knowledge gained and raising awareness about the CS program. This ensures that the successes and challenges are shared, paving the way for replication and scaling in other regions while enhancing a broader understanding and appreciation of the CS approach among policymakers, researchers and the general public.

By integrating these two complementary circles, the Citizen Science Program Framework in Ethiopia aims to create a sustainable and impactful platform for community-driven problem-solving and knowledge co-generation.

Figure 1. The Citizen Science Program Framework in Ethiopia.

Challenges

Limited understanding of CS among decision-makers and researchers, along with fragmented institutional collaboration, hampers its benefits and wider adoption in Ethiopia. Resource constraints and misalignment with local needs further challenge the realization of its potential. During a recent consultation workshop (Figure 2) conducted by IWMI in Ethiopia, experts identified the following key challenges:

i. **Perception of CS:** The concept of CS must be adjusted to better align with Ethiopia's local context. There is a risk that CS programs may be used solely to fill scientific data gaps rather than to achieve meaningful outcomes for communities. This mismatch between CS program objectives and community expectations can lead to diminished participation and interest over time, hindering the realization of overall development benefits. Moreover, the presumption that citizens are merely data collectors restricts their ability to collaborate on knowledge co-generation and may erode public trust in the CS program.

ii. **Resource constraints:** CS initiatives face challenges due to limited resources, including a lack of technical skills in rural areas, poor access to affordable monitoring equipment and insufficient experience with digital platforms. Furthermore, the absence of sustained financial support results in relatively few pilot CS programs, making it difficult to provide sufficient evidence to convince donors and government organizations to support the expansion of such programs across the country.

Technical evidence

Data quality: The data collected through the current CS programs implemented by IWMI in Ethiopia have varying levels of accuracy and reliability. Addressing this challenge is crucial to ensuring that data generated can be effectively used for decision-making and tackling local water security challenges.

i) Reference data used to evaluate the quality of citizen science data

The primary reference data used to evaluate the quality of citizen science data—specifically, rainfall, streamflow and groundwater levels—are obtained from nearby official monitoring stations operated by government agencies, as well as reanalysis and satellite rainfall estimates (e.g., Walker et al. 2016). Tedla et al. (2022a) utilized multiple neighboring CS monitoring stations and two automatic tipping bucket rain gauges as a reference for validating the quality of rainfall data recorded by citizen scientists. Water quality data collected by citizen scientists were assessed against conventional laboratory data as a reference (Babiso et al. 2023). The quality of CS data was also assessed by joint plots of rainfall and groundwater level data in a micro-watershed in the Rift Valley Basin of Ethiopia (Ferede et al. 2024). Biweekly observations by professional hydrologists also served as a key reference point for evaluating the quality of river water level data recorded by citizen scientists in the Big Akaki River in Ethiopia (Alemu et al. 2023; Mengistie et al. 2024).

ii) Accuracy of citizen science data

Results from several CS research projects in Ethiopia indicate that CS data can achieve a high degree of accuracy and scientific value when compared to professional monitoring data, provided that proper protocols, training and oversight are in place. The highest values of the coefficient of determination (R^2) and root mean square error (RMSE) between CS rainfall data and conventional data from the Ethiopian Meteorological Institute (EMI) were above 0.8, suggesting a good correlation, although the CS data tended to underestimate rainfall amounts (Walker et al. 2016; Tedla et al. 2022a). Similarly, CS river water level data was found to be of high quality and useful for improving flood modeling (Alemu et al. 2023). These findings demonstrate that, with appropriate measures, CS can produce data of similar quality to that collected by experts, making it a valuable contribution to scientific research and socio-ecological understanding (Mengistie et al. 2024).

iii) Recommendations for ensuring the quality of citizen science data

The quality of CS data is crucial for its effective integration into research, policy and decision-making processes. Clear protocols and comprehensive training enhance data accuracy, while quality control procedures, such as comparing data to reference stations, help identify and rectify errors (Tedla et al. 2022a). Additionally, incentive and feedback mechanisms (see Box 1) can sustain motivation and engagement, leading to higher-quality data over time (Haile et al. 2019). Integrating citizen science data with official and professional monitoring networks can fill observational gaps and improve understanding of hydrometeorological processes (Walker et al. 2016; Tedla et al. 2022b; Alemu et al. 2023; Mengistie et al. 2024).

Value: Evidence generated by IWMI indicates that CS data can be applied in various contexts, including rainfall forecasting, hydrological modeling, shallow groundwater assessment, sustainable land management and community-based flood early warning systems. However, its value is not yet fully recognized by stakeholders. To ensure that CS data inform evidence-based decision-making and address water monitoring gaps, more pilot studies, stakeholder awareness activities, enhanced guidelines, training programs and sustained collaboration between scientists, researchers and policymakers are needed.

Box 1. Incentives of citizen scientists under IWMI projects in Ethiopia.

Citizen scientists in the Wutame and Branti watersheds of Ethiopia expressed a desire for compensation for their time and commitment to frequent monitoring activities. They proposed monetary incentives to increase observation frequency. In Wutame, they suggested a daily payment of 0.73 USD for monitoring each hydrological variable. In Branti, they asked for a daily incentive of 0.73 USD for river water level measurement and 0.37 USD per day for rainfall and groundwater level monitoring. In the Kelekindo and Chemeri watersheds, citizen scientists received only umbrellas, gum boots and airtime as incentives. In contrast, citizen scientists on the outskirts of Addis Ababa were willing to participate in the citizen science program without monetary compensation. Their primary motivation was to minimize flood damage in their community by facilitating the dissemination of flood early warnings.

Linking citizen science with existing initiatives: The CS programs in Ethiopia have been amalgamated with existing initiatives in the region, including sustainable land management efforts, shallow groundwater monitoring and community-based flood early warning systems. This integration enhances both the impact and relevance of CS programs. To further strengthen the integration of CS programs with existing initiatives, the following key steps can be taken:

a) **Strengthen institutional linkages:** Formalize partnerships and coordination mechanisms between IWMI, government agencies and community organizations to institutionalize the integration of CS activities.

b) **Expand training and capacity building:** Provide comprehensive training to help community and other stakeholders understand the relevance and application of CS monitoring work.

c) **Improve data sharing and feedback loops:** Establish robust protocols and mechanisms to efficiently channel the citizen science data into relevant programs and provide feedback to the citizen scientists.

d) **Develop a cohort of citizen scientists through 'training of trainers':** Establish a capacity development program in Ethiopia (and the wider region) on doing citizen science.

e) **Secure long-term funding:** Pursue sustainable funding sources to support the continued integration of CS programs with existing initiatives.

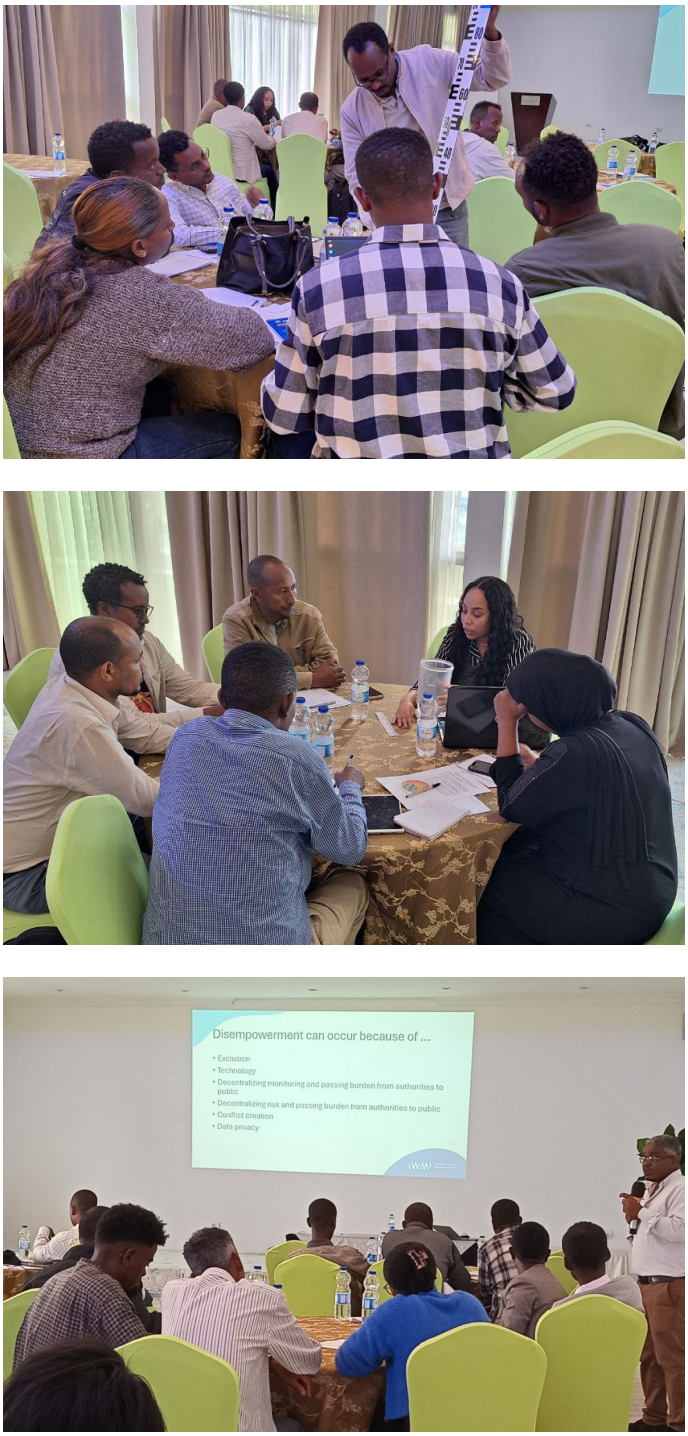
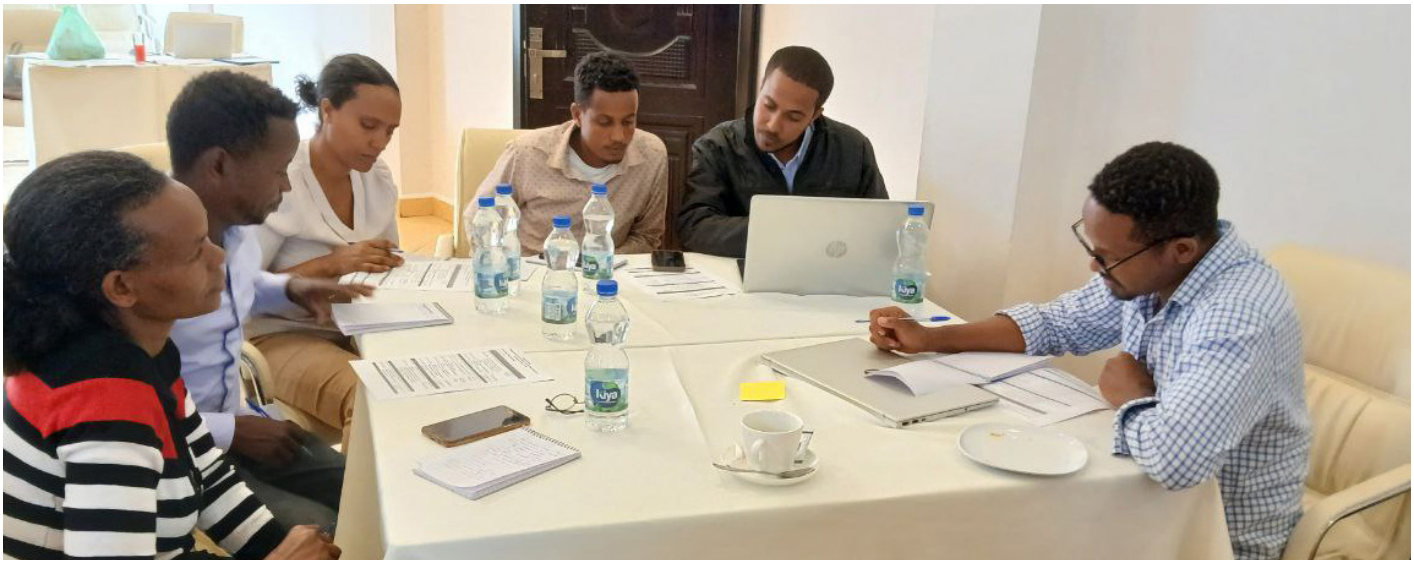


Figure 2. Workshop on demonstrating the water level monitoring equipment (top), plastic rain gauges used to monitor rainfall through a citizen science program in the Akaki catchment, Ethiopia (middle), and awareness creation for the community, professionals and policymakers (bottom).

Source: Rahel Mesganaw

Awareness creation and guidelines employed: Effective awareness creation and the development of clear guidelines for CS participants are essential to ensure the success and long-term sustainability of CS programs. This includes providing training, consultation workshops, capacity building and continuous support to the citizen scientists involved. The CS program in Ethiopia has developed a community-based monitoring guideline (Walker et al. 2019) that can be expanded to cover a wide range of relevant topics.



Experts reviewing the technical brief (*photo*: Rahel Mesganaw).

Opportunities

The CS program in Ethiopia has created several major opportunities:

i) **Leveraging spatial and temporal data gaps:** The involvement of many citizen scientists allows for the systematic and coordinated collection of data, which can effectively fill spatial and temporal data gaps in monitoring. By leveraging community engagement, hydrological and meteorological agencies, as well as research centers, can support and strengthen citizen science programs, enhancing data coverage and reliability.

ii) **Adaptability and responsiveness:** Citizen science programs are inherently adaptable and responsive due to their community-driven approach, flexible design, diverse participation, collaborative learning and technological integration. These programs address local needs, foster community engagement, enhance scientific knowledge and promote interdisciplinary collaboration. They facilitate real-time monitoring, feedback mechanisms and capacity building across local, basin and national levels of participation, with a potential to generate gender-disaggregated data.

iii) **Leveraging existing initiatives:** Existing CS programs and community-based initiatives present valuable opportunities to expand the approach in Ethiopia. Sustainable land management initiatives, shallow groundwater for irrigation development, and the Green Legacy initiative can provide a platform for citizen scientist involvement. By synergizing CS with these existing initiatives, new CS programs can draw on existing experiences and best practices, thereby amplifying their overall impact. For example, IWMI linked citizen science with evaluating the hydrological impact of a sustainable land management program with the Ministry of Agriculture, which helped secure continued funding from donors.

Recommendations

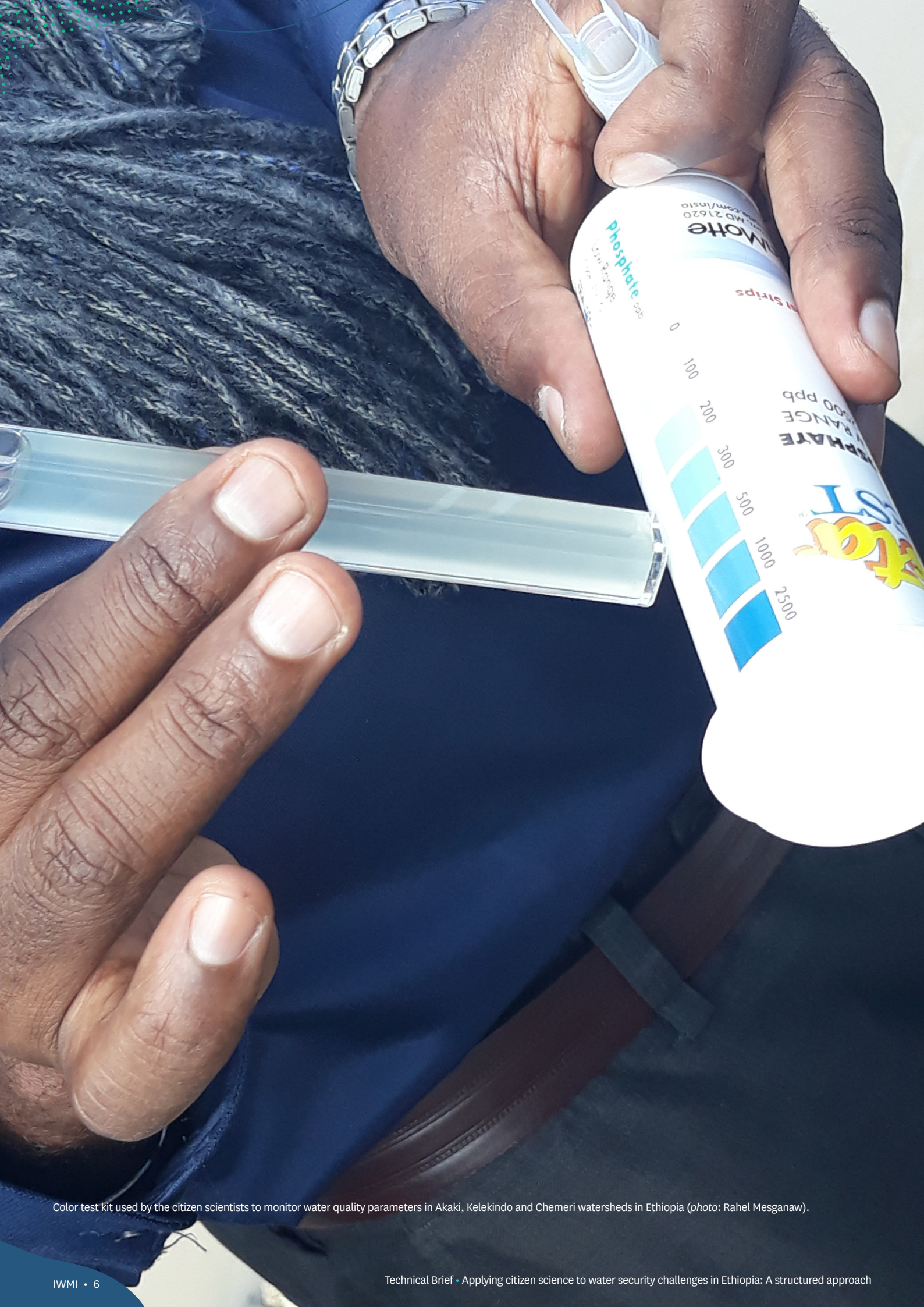
Based on IWMI research and expert consultations, the following recommendations aim to enhance the establishment and implementation of citizen science programs in Ethiopia:

i) **Establish a citizen science platform:** Creating a dedicated CS platform will facilitate opportunities for collaboration, cross-disciplinary engagement and advocacy, leading to more practical and effective CS programs. Such a program would improve data accessibility and knowledge co-generation and sharing.

ii) **Adapt new technologies:** Incorporating user-friendly data sharing and feedback mechanisms can make the CS program more effective and engaging for participants. An online platform could facilitate information exchange and self-paced training for those interested in setting up and implementing a CS program.

iii) **Integrate with existing community challenges:** Aligning the CS program with visible community challenges and problems—including issues of gender and inclusion—can foster a strong sense of ownership and active engagement among participants. Linking bottom-up and top-down approaches, while focusing on community needs, can contribute to the long-term sustainability and practicality of the program. By aligning with tangible local concerns, the program can cultivate a deeper understanding of the community's needs, thereby enhancing its practical impact.

iv) **Harness opportunities to sustain citizen science programs:** Sustainability requires strategic funding approaches, such as integrating CS into government budgets or pursuing hybrid financing from public, private and nongovernmental organizations. Furthermore, the integration of CS into school curriculums can help to expand and sustain citizen science programs.



Color test kit used by the citizen scientists to monitor water quality parameters in Akaki, Kelekindo and Chemeri watersheds in Ethiopia (*photo*: Rahel Mesganaw).

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The project

The NSSID program harnesses the expertise and experience of ten international and national nongovernmental organizations, associations and academic institutions to deliver an ambitious integrated environmental, sustainable development and climate resilience program that will respond to these identified challenges and deliver at scale across Ethiopia. The Water Security and Sustainable Development Hub was funded by the UK Research and Innovation's Global Challenges Research Fund (GCRF), grant number: ES/S008179/1. The hub tests and applies a systems approach for water security challenges in Ethiopia, India, Colombia and Malaysia. The Digital Innovations for Water Secure Africa (DIWASA) project is funded by The Leona M. and Harry B. Helmsley Charitable Trust (https://helmsleytrust.org/). DIWASA aims to enhance water security across scales in Africa through improved water data availability, accessibility and institutional capacity, and to leverage innovative digital techniques for sustainable water resources management.

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