Fostering Community-Based Water Quality and Quantity Monitoring through Citizen Science in the Ashanti Region of Ghana

A Citizen Science Training Report

AUGUST 2023

Citation

Adusei-Gyamfi, J.; Gyebi, A. S. A.; Amponsah, A. K.; Atampugre, G.; Tilahun, S.; Cofie, O. 2023. *Fostering community-based water quality and quantity monitoring through citizen science in the Ashanti Region of Ghana: a citizen science training report.* Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on West and Central African Food Systems Transformation. 38p.

The Authors:
Junias Adusei-Gyamfi, Department of Environmental Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.
JUNIA, ULR 4515-LGCgE, Laboratoire de Génie Civil et géo-Environnement, F-59000 Lille, France

Afia Sarpong Anane Gyebi, Department of Environmental Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Andoh Kwaku Amponsah, International Water Management Institute (IWMI), Accra, Ghana

Gerald Atampugre, IWMI, Accra, Ghana

Seifu Tilahun, IWMI, Accra, Ghana

Olufunke Cofie, IWMI, Accra, Ghana

Disclaimer: This work was carried out by the International Water Management Institute (IWMI) as part of the CGIAR Initiative on West and Central African Food Systems Transformation (TAFS-WCA) and has not been independently peer reviewed. Responsibility for editing, proofreading, and layout, opinions expressed, and any possible errors lies with the authors and not the institutions involved. The boundaries and names shown, and the designations used on maps do not imply official endorsement or acceptance by IWMI, CGIAR, our partner institutions, or donors.

Acknowledgement: We would like to thank all the funders who support this research through their contributions to the CGIAR Trust Fund. To learn more about TAFS-WCA and other initiatives in the CGIAR research portfolio, please visit https://www.cgiar.org/research/cgiar-portfolio/. The authors also acknowledge the invaluable contributions of all officials and organizations who provided information used for this report.

SUMMARY

Citizen Science (CS) is increasingly being integrated into advanced scientific approaches to address complex problems and produce real-time evidence-based information for decision-making. The CS approach has also been used as a tool to foster community-based monitoring and learning, particularly on the sustainability of productive landscapes/watersheds. As part of the CGIAR regional initiative, West and Central African AgriFood Systems Transformation (TAFS-WCA), the International Water Management Institute (IWMI) trained seven (7) citizen scientists (CSs) in communities in and around the Mankran watershed in the Ahafo-Ano Southwest District (AASWD) in Ashanti Region of Ghana for a one-year intensive hydrological monitoring campaign. Researchers from IWMI and the Kwame Nkrumah University of Science and Technology (KNUST) conducted a kick-off stakeholder engagement to initiate the program, recruited local volunteer citizen scientists, co-identified monitoring stations, and co-installed field equipment. This was followed by a CS training workshop aimed at enhancing CSs' understanding of hydrology and water quality assessments. An evaluation of the perception of the CSs before the training revealed that most of them are not first-time volunteers, as three of them volunteer at least once a month for varied purposes. Although none have ever volunteered for any water research projects, most agree that they would be personally affected if the quality of the environment deteriorates. Knowledge acquisition was the driving force for participation, with one participant motivated by financial or unemployment reasons. A follow-on trend analysis will be performed after one year to assess the evolution of CSs perception. The training program proved to be an exceptional journey of immense significance for the CSs and the researchers applying the CS approach. Through a series of hands-on activities and practical exercises, CSs were equipped with skills in water sampling and quality monitoring, operating and maintenance of scientific instruments, and accurate data collection to build indigenous competent volunteers who inspire behavioral change and enhance environmental stewardship and active citizenship for the successful implementation of an inclusive landscape management plan.

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The integration of the citizen science (CS) approach into the modern-day scientific research of diagnosing, investigating, and analyzing complex problems to produce real-time evidence-based information to support decision-making continues to expand over the years and has become significantly important, particularly in hydrological monitoring programs (Weeser et al., 2018; Shinbrot et al. 2020). This approach overcomes the constraints of continuous observation of in-situ hydrological parameters over long temporal scales, funding, and accessibility. It provides an easy method for capacity building and accurate data collection. In Ghana, particularly in the southern sector, many river bodies and basin landscapes are severely impacted by the expansion of illegal mining activities (locally called 'galamsey'), directly threatening the nation's food security (Gilbert & Albert, 2016). However, the challenge of data deficiencies and limited inclusion of stakeholders from the grassroots level continue to be major concerns for resource managers in alleviating the problem.

The CGIAR Regional Integrated Initiative on West and Central African Food Systems Transformation (TAFS-WCA), aims to improve nutrition, incomes, and food security through nutritious, climate-adapted, and market-driven food systems. One of the ways of achieving this objective is by creating pathways for scaling land and water innovations for resilient agrifood systems, combining participatory tools and citizen science to co-develop and implement inclusive landscapes owned by communities that enable sustainable scaling of bundled land, water, aquaculture, and climate-smart agronomic and digital innovations. In this context, the CS approach is deployed to investigate the hydrology and water quality status of the targeted landscape in the Ahafo-Ano Southwest district of the Ashanti Region of Ghana. As CS is a collaborative method of scientific investigation that has gained immense popularity in the past decade, its projects come in many shapes, formats, and scopes, with the four most common features being (a) opened to all non-experts, (b) citizens use the same protocol to collect high-quality and frequency data which can be merged, (c) data can help scientists come to accurate conclusions, and (d) data can be shared with the entire community to enhance environmental stewardship. The goal is to produce an informed indigenous public who would further influence other indigenes to play a valuable role in shaping larger national and regional decisions about science policy. The design adopted for this initiative for investigating hydrology and water quality combines informal technical training with scientific data collection, analysis, and reporting goals.

This project was therefore structured to engage Citizen Scientists (CSs) in co-designing and co-developing a one-year (with potential extension for 2nd year) intensive hydrological monitoring program that encompasses three distinct land use characteristics: 1. Forested landscape; 2. Agrarian landscape, and 3. Galamsey watershed. The project team conducted a comprehensive training program focused on equipping citizen scientists to understand the fundamental concepts of the hydrosphere and the skills to undertake basic water quality and hydrological assessments. The specific objectives of the training were:

- to enhance citizens' understanding of the basic concepts of hydrology and water quality assessments;
- to equip citizens with skills in the use and maintenance of scientific instruments, accurate data collection, and water sampling methods; and
- to build an indigenous associate of competent volunteers who inspire behavioral change and enhance environmental stewardship and active citizenship in successfully implementing a sustainable landscape management plan.

This training report presents an overview of the executed CS training programs. It conveys the training's objectives, methodologies, outcomes, and overall impact on the participants.

COMMUNITY ENGAGEMENT

A kick-off workshop was convened at the Ahafo Ano Southwest District Assembly to introduce the stakeholders to the TAFS-WCA project, demonstrate the field equipment, co-identify, and visit potential installation sites for this study. Fifteen (15) participants were involved in the workshop, including prospective citizen scientists, researchers from KNUST, representatives from the district assembly, and IWMI researchers. After the workshop, the participants engaged in a field trip to the three communities to meet with the local authorities to introduce or validate the potential CSs, raise community awareness of the importance of the CS approach, and solicit local knowledge of the landscape to delineate the main course of the Mankran River and identify accessible locations for hydrological monitoring of streamflow, rainfall, groundwater, and water quality. Subsequently, the project team installed the field equipment (rain gauges and staff gauges in streams) in the targeted locations (Figure 2).

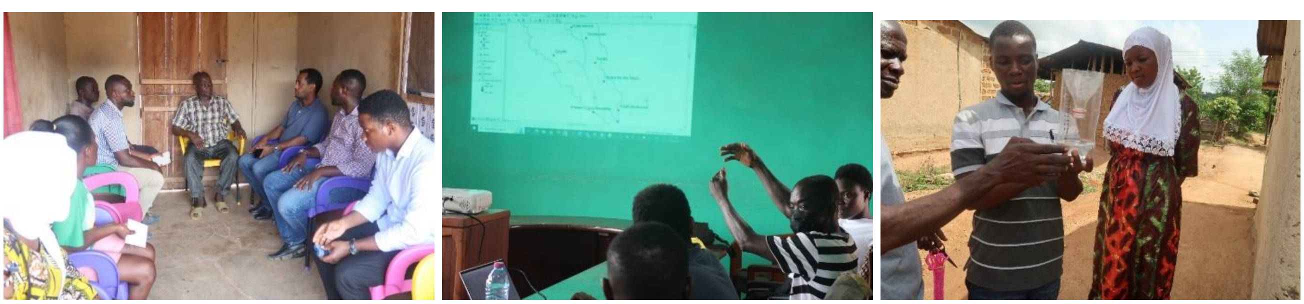


Figure 1: Images of **a**. Stakeholder engagement with local authorities at Kunsu, **b**. Selection of monitoring sites with citizens, **c**. Field rain gauge graduation and training with citizen scientists at Barniekrom.

Photo credit: Andoh Kwaku Amponsah

PRE-TRAINING PREPARATION

Selection of citizens

This project team used a snowball sampling method to identify and invite prospective volunteers from the selected communities for the CS training program. Before the training, field agents from the district assembly were contacted via phone to nominate one prospective volunteer from the three respective communities using the following selection criteria:

- Equal distribution of gender
- No previous experience by participants in conducting water-related research
- Interest and willingness to participate
- Commitment to take responsibility
- Their residence should be close to the sampling site.

Each nominated volunteer was tasked to nominate two additional people from their communities following similar selection criteria with the intent of fully engaging two (a male and a female) volunteers per community as CSs, while one served as a reserve to be called in case of a dropout. Unfortunately, only one community had all three volunteers present for the training. All seven preselected volunteers were trained through an intense workshop covering theoretical and practical training before finally reducing the number to six. This combined approach facilitated hands-on field exercises and delivered a complete learning experience that will guarantee the effective engagement of CSs in the research.

Site selection

The study was conducted in the Mankran watershed in the Upper Offin Sub-basin of the Pra Basin. The Upper Offin watershed covers an area of 3070 km^2, draining directly to the Offin River, while the Mankran watershed covers 122 km^2. Three communities within the district were selected to represent the different drivers of change within the micro-watershed. Whereas Kunsu represented the impact of illegal mining drivers, Barniekrom and Mmbrobem represented drivers associated with agricultural expansion and deforestation, respectively. Sites for the monitoring of surface water, groundwater, and rainfall parameters were identified in these communities (Figure 2).

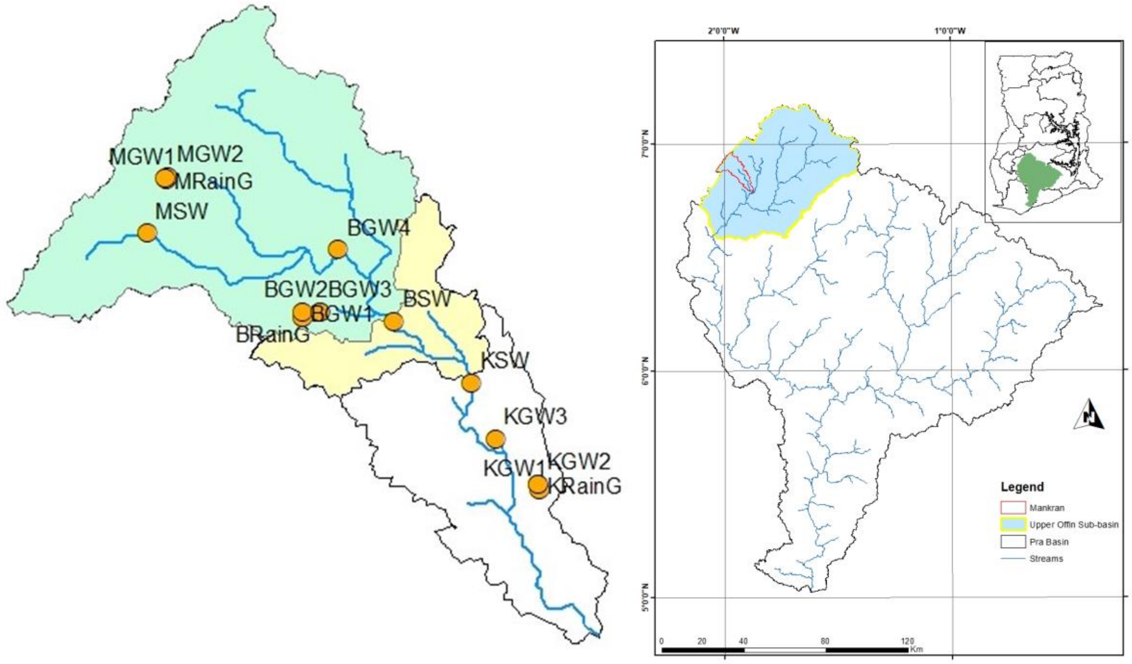


Figure 2: A map showing the study area and sampling points in the Mankranso watershed

Note: 'MGW' represents observation wells at Mmrobem, 'MrainG' represents rain gauge at Mmrobem, 'MSW' represents streamflow gauge at Mmrobem; 'BGW' represents observation wells at Barniekrom, 'BrainG' represents rain gauge at Barniekrom, 'BSW' represents streamflow gauge at Barniekrom; 'KGW' represents observation wells at Kunsu, 'KrainG' represents rain gauge at Kunsu, 'KSW' represents streamflow gauge at Kunsu.

Participants' survey and results

Before the training, CSs were assessed to understand their perception of the CS approach and the role of CSs in protecting the environment, previous experience in related projects, and their motivations for volunteering for this study. The questions were read and interpreted in the local language (twi) for easier comprehension. The questionnaire was made up of five broad sections (Appendix 0):

a. Demographic characteristics

Of the seven (three males and four females) CSs trained, five were aged between 20 and 30 years, while one was between 31 and 40 or above 41 years, respectively. The highest level of education attained by most participants is secondary, followed by primary and tertiary education, respectively (Table 1 in Appendix A.2). The level of education of CSs influences their understanding of assigned tasks and their efficiency. CSs with only primary education are often unable to thoroughly read and understand written instructions, which could lead to measurement errors. This challenge was overcome by using a variety of methods to engage participants during the training, such as visual aids, hands-on activities, and peer-to-peer learning.

Most participants (six) have lived in the community for at least ten years. This is very important as participants have strong attachments to the communities and are most likely to be motivated to support research projects that meet the needs and expectations of the community. The long stay of participants in the community also means that knowledge and skills acquired can be transferred and retained since they are unlikely to relocate. However, whereas four CSs are unemployed, the rest are either self-employed, privately employed, or government-employed. The high unemployment status of CSs threatens the project's continuity as participants may quit the project for available job opportunities with better conditions.

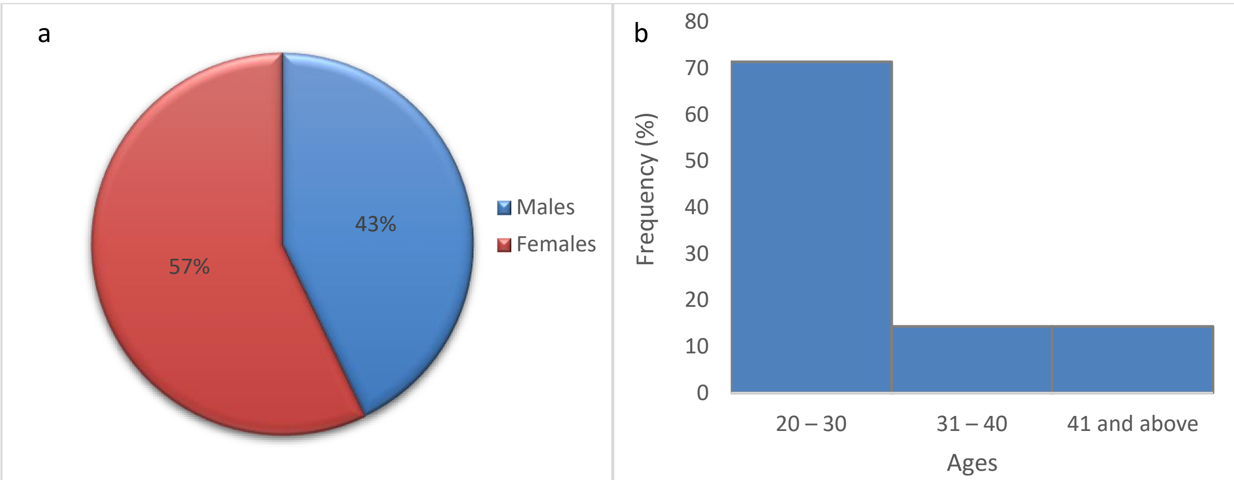


Figure 3: Demographic characteristics of CSs based on (a) gender and (b) age.

b. Previous experience and current interest in participating in any scientific research

Three CSs volunteer at least four times a year, while two have never volunteered or cannot remember when last they volunteered (Table 2 in Appendix A.2). Only one person volunteers 1 to 4 times a year or monthly. Since CS is mainly based on volunteerism, seeing more than five participants volunteer at least once a year is encouraging. However, the duration of the previous volunteerism experience of CSs is unclear since various levels of commitment are required for short and long-term projects. Long-term projects like this require higher levels of motivation, dedication, perseverance, and enthusiasm from CSs. Although none of the participants were familiar with the concept of CS, many participants (four) assisted in a scientific project, mainly in agriculture, economic, and population research. None of the participants, however, has been part of any research project on water. Their main responsibility in previous projects was data gathering and community mobilization. It was encouraging to know that knowledge acquisition was the driving force for participating in these projects, although one person was motivated by financial or unemployment reasons. Even though three participants were remunerated in their previous projects, they would still have participated without wages. However, when asked to rank their motivation as CSs in this current project, knowledge acquisition and finances were ranked high. Whereas four participants ranked finances as 8 and above on a scale of 1 to 10, five participants ranked knowledge acquisition as 9 and above. Unemployment was ranked as the motivation for two of the participants. Three of the participants were willing to volunteer 8-14 hours of their time to this project, while five were willing to volunteer beyond 12 months. This gives some security for the project's continuity, although caution still needs to be exercised. Even though CSs are being remunerated monthly, six would still volunteer if there were no remuneration. For this project, CSs are mainly interested in acting as representatives to explain the concern that society has about water resource research (ranked no. 1), followed by water quality and quantity analysis (no. 2) (Figure 4). This is reassuring as citizen scientists are expected to serve as change agents in communicating research findings to their communities to enhance environmental governance. The activity that least interests citizens is helping to process data on water resources (no. 7).

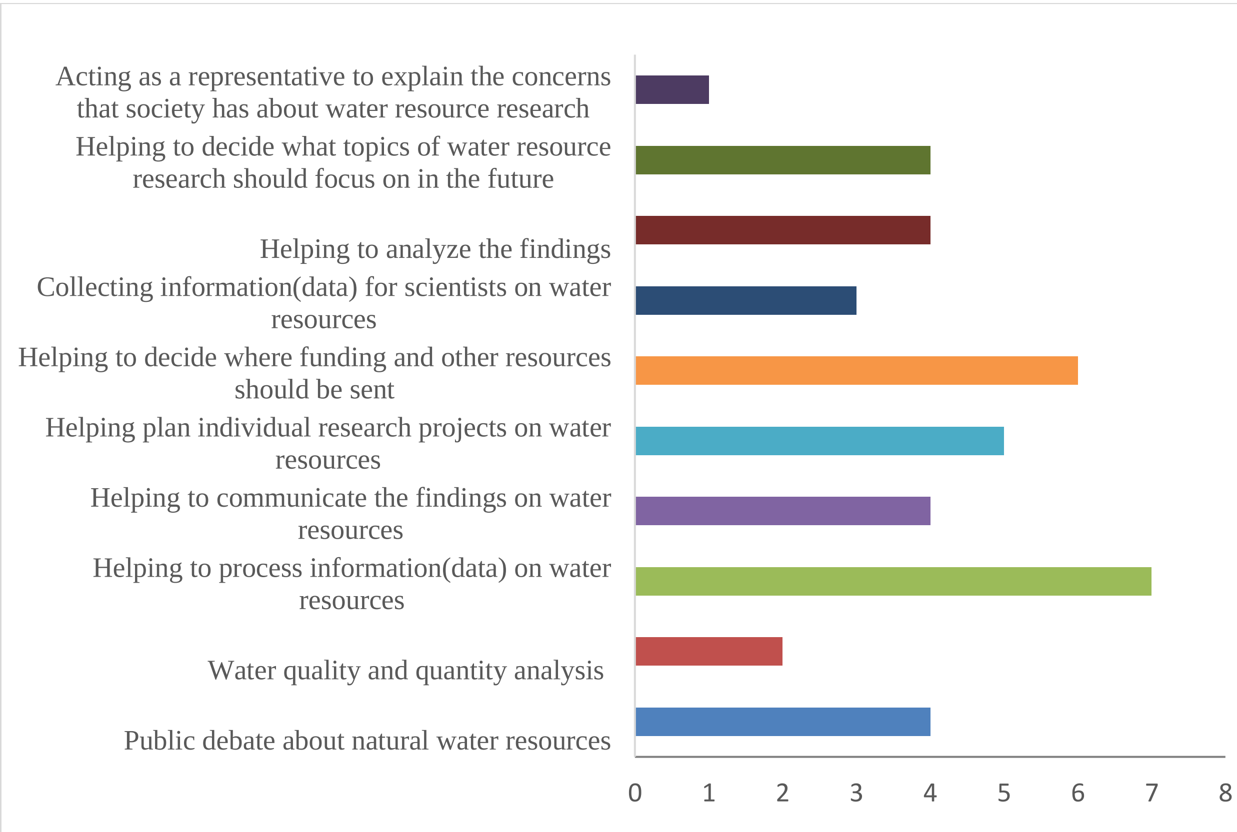


Figure 4: Previous experience and current interest in participating in any scientific research.

c. Perceptions towards the importance of the environment and citizen science

Most participants strongly agree that they would be personally affected if the quality of the environment declines (no. 1) (Figure 5). This perception would drive participants to work assiduously to protect their environment. The second-ranked perception is the agreement of most CSs that their participation in water resource research will empower communities and individuals to improve their well-being. The least ranked perception where most participants agree to a varied extent is their confidence that the citizen science findings on water resource research would be comparable to those generated by professional scientists. The validation of the results of CSs by conventional laboratory methods would encourage CSs and increase their confidence in the results of their analysis.

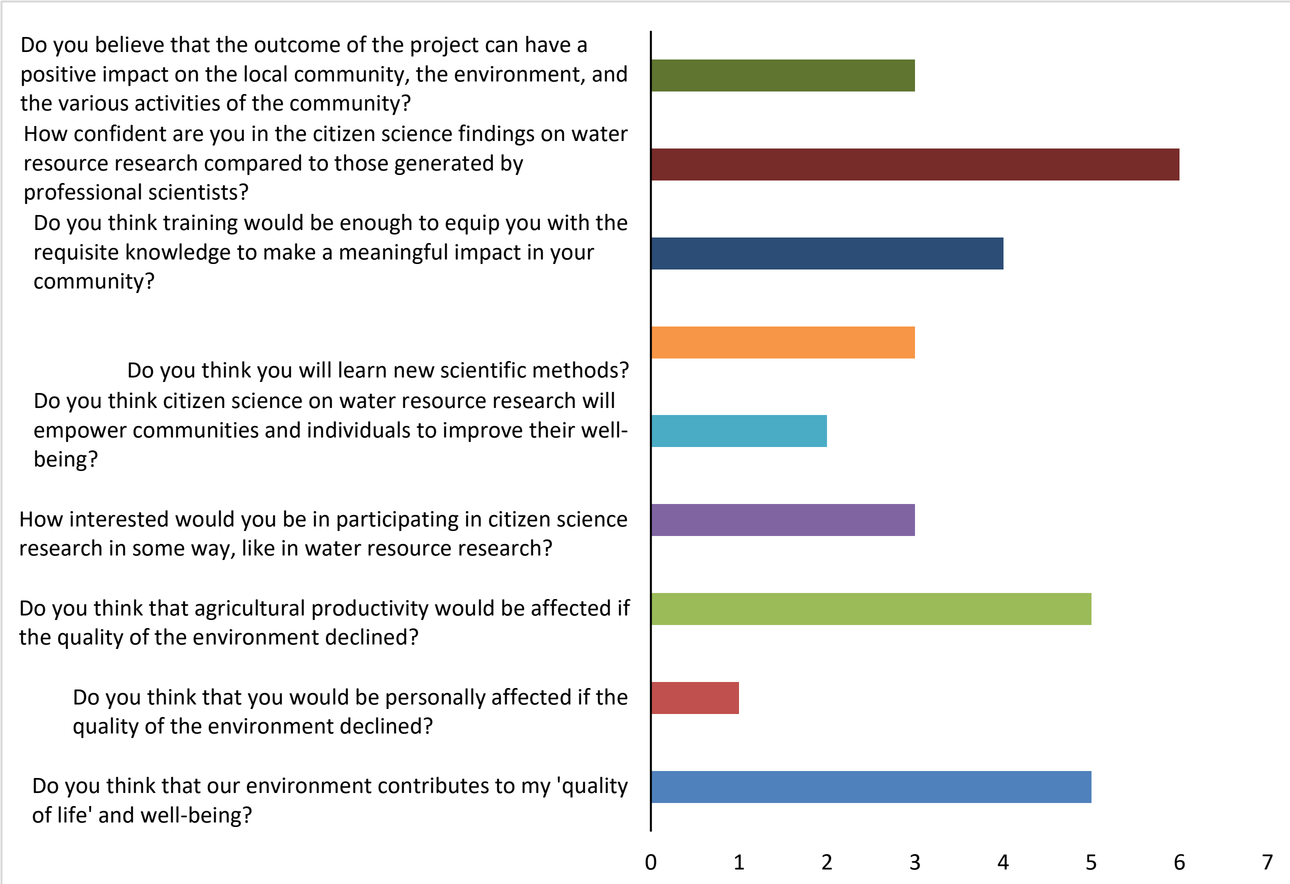


Figure 5: Perceptions towards the importance of the environment and Citizen Science

d. Preliminary knowledge of hydrological monitoring

Whereas all participants depend on rainfall and consider it an important parameter to be measured, only six think there is a linkage between rainfall, surface water, and groundwater (Table 5 in Appendix A.2). Six participants are concerned about the state of the surface water bodies in their communities and have observed a change in the size of the rivers in their communities. However, about three of the participants indicated that the surface water bodies in their communities are clean, while all the participants think that clear and colorless water can still be polluted.

e. Expectations from this current project

It is reassuring that three of the participants expect the current project to enhance their knowledge (Table 6 in Appendix A.2). However, participants highlighted the gain of permanent employment, continuity of education, and poor community networks as some of the challenges they are likely to face in carrying out their responsibilities. To overcome these potential challenges, participants requested that measures be put in place to replace them if they quit during the project or that their incentives be increased to retain them.

TRAINING DELIVERY

Training Overview

The training program was designed to introduce the seven non-expert citizens to basic climate and hydrological principles and assessments. The first training day occurred at the Ahafo Ano Southwest District Assembly, where participants were introduced to some theoretical concepts of water quality assessment, such as water sampling protocols, choice of sampling devices and containers, sample preservation, and transport. The CSs had the chance to practically demonstrate the sampling and assessment protocol they had learned at the various sampling sites.

Training content

The first day of the training was a workshop where participants were presented with training manuals that covered a step-by-step guide of the parameters they would be assessing (Appendix 0). The training covered the significance and protocols in measuring hydrological and water quality parameters such as rainfall depth, pH, temperature, electrical conductivity, total dissolved solids, turbidity, dissolved oxygen, stream stage, stream velocity, and groundwater level.

Rainfall: Rainfall was monitored with manual rain gauges constructed with a 1.5L plastic bottle stripped off its label and laterally cut into two halves. Permanent graduation marks (cm) were made on the bottom half. The top half was inverted, inserted into the bottom half, and fixed to a pole installed in an open space to serve as a manual rain gauge.

Surface water: The stream stage and velocity were measured using metallic poles with graduation markings (cm) on them to serve as manual staff gauges. The surface velocity (m/s) was determined by dropping a leaf upstream of the staff gauges over a distance of 10 m. The time required for the floating leave to reach the staff gauge was recorded by the CSs (Appendix A.3).

Groundwater level: This parameter was measured with the help of a graduated electrical cable connected to an AC Clamp meter at one end and opened at the other end. The working principle was that once the exposed cable touched the water, ions in the water served as a bridge and caused current flow, which was recorded by the voltmeter. The open exposed cable (0 cm mark) was lowered gradually into the observation well until there were readings on the voltmeter. The water level was measured by noting the readings on the meter at the ground level. The cable was pulled out gradually until the voltage dropped significantly.

Turbidity: The turbidity of the surface water was measured with the help of a home-built Secchi disk using a 20 cm diameter white circular disk divided into four quadrants using masking tape. Two opposite quadrants were colored black, and a hole was drilled at the center of the disk. A graduated rope was attached to the disk at the center while a stone was tied at the end of the rope that emerged at the back of the disk to increase its density.

Dissolved Oxygen: The dissolved oxygen concentration of the water was determined by the Winkler method (Pomeroy and Kirschman 1945; Carvalho et al. 2021). A sample bottle was filled with water with no headspace. The dissolved oxygen in the sample was then "fixed" by adding a series of reagents that formed an acid compound that was then titrated with a base. A color change at the endpoint signified neutralization. A detailed step-by-step procedure of this method and any other measuring parameters has been provided to the citizens (Appendix A.3).

Temperature and pH: The temperature and pH of surface waters are recorded daily using handheld multiparameter water quality meters. The tip of the electrode of the calibrated (verified periodically) device was uncapped and rinsed with deionized water. The parameter to be measured was selected before the electrode was fully immersed in the sample (but did not touch the contain walls) to begin measurement.

Figure 6: Participants at the CS training session in the Ahafo Ano Southwest district assembly

Practical Demonstration

Hands-on activities (Figure 4) were carried out at the selected study sites in the selected communities (Kunsu, Baniekrom, and Mmrombem), where participants applied the theoretical knowledge they had acquired in the classroom setting. The demonstration made it possible to correct mistakes and increase measurement accuracy. By physically collecting water samples and performing analysis, participants gained direct exposure to the tools and techniques used in measurement.

Citizen scientists were given reference guides, field manuals, personal protective equipment, measuring tools, equipment, reagents, and a data logging book. The specific items provided include pH, TDS, EC meter, stopwatches, life jackets, raincoats, Secchi disc, ice chests, sampling containers, masking tapes, markers, tissue wipes, chemical reagents for dissolved oxygen analysis, safety boots, gloves, paper tissues, etc.

Figure 7: Hands-on training session during the comprehensive training period

POST TRAINING REFLECTION

Whereas four CSs are unemployed, the rest are either self-employed, privately employed, or government-employed. This poses a risk to the continuous stay of citizen scientists throughout the project's lifetime as they are likely to quit and possibly relocate whenever and wherever they find permanent employment. As insurance, backup citizens should be trained in each community to step in once a vacancy is created. However, there is no guarantee that the backup citizens would be available when needed as they are equally in search of job opportunities. This will require the training of new CSs to ensure project continuity if this happens. For the sake of the project's continuity, subsequent CS recruitment should be targeted at persons with some minimum form of employment, or the monthly remunerations of CSs could be increased to reduce their risk of flight. The highest educational level of CSs influences the ability to understand written instructions and carry out semi-advanced scientific measurements fully. Provided they can record measured data, training participants with only primary education should be mainly practically based, using their local languages to form a routine pattern. For technical projects like this, where scientific protocols need to be strictly followed, the recommended minimum education level for recruiting CSs should be secondary.

CONCLUSION & NEXT STEPS

The citizen science training program has been an exceptional journey that has profoundly impacted both the participants and the field of citizen science itself. Through a series of engaging and practical activities, participants have gained valuable skills that have the potential to significantly influence the outputs of the TAFS-WCA initiative by serving as credible environment stewards to inspire behavioral change and promote active citizenship for the successful implementation of an inclusive landscape management plan. Evidence of the CS program's success include:

- Increased understanding: Participants have acquired a deeper and more nuanced understanding of the research project's goals, methodologies, and significance.
- Diversified skill set: Participants have developed a broad range of skills relevant to citizen science, including data collection, analysis, and communication.
- Enhanced data accuracy: Their ability to accurately gather and interpret data has increased, leading to more reliable and valuable research outcomes.
- Deeper local knowledge: Participants have gained a deeper understanding of local hydrology and water quality dynamics, allowing them to contribute unique insights to the research project.
- Broader scientific investigation: With their newfound knowledge and skills, participants can now contribute to a wider range of scientific investigations, expanding the scope and impact of the research.

Changes in the knowledge, skills and abilities of the citizen scientists will be monitored throughout the project life cycle. It is expected that at the end of the program, there will be an improvement in the level of participants' knowledge, confidence, and commitment to citizen science. This will translate into an enhanced capacity for the research project and a greater contribution to local understanding of water quality.

Most importantly, the citizens will be engaged in the co-design of landscape management plan of the area. They will participate in the village level and district level co-design meeting to share their experience and their perspective in the chalnnges and potential solutions.

REFERENCES

Carvalho, A., Costa, R., Neves, S., Oliveira, C. M., & da Silva, R. J. B. (2021). Determination of dissolved oxygen in water by the Winkler method: Performance modelling and optimisation for environmental analysis. *Microchemical Journal*, *165*, 106129.

Gilbert, D. & Albert, O. B. (2016). Illegal small-scale gold mining in Ghana: A threat to food security. *Journal of Food Security*, *4*(5), 112-119. https://doi.org/10.12691/jfs-4-5-2

Pomeroy, R., & Kirschman, H. D. (1945). Determination of dissolved oxygen. Proposed modification of the Winkler Method. *Industrial & Engineering Chemistry Analytical Edition*, *17*(11), 715-716.

Shinbrot, X. A., Muñoz-Villers, L., Mayer, A., López-Portillo, M., Jones, K., López-Ramírez, S., ... & Manson, R. (2020). Quiahua, the first citizen science rainfall monitoring network in Mexico: filling critical gaps in rainfall data for evaluating a payment for hydrologic services program. *Citizen Science: Theory and Practice*, *5*(1). 1-15. https://doi.org/10.5334/cstp.316

Weeser, B., Kroese, J. S., Jacobs, S. R., Njue, N., Kemboi, Z., Ran, A. & Breuer, L. (2018). Citizen science pioneers in Kenya–A crowdsourced approach for hydrological monitoring. *Science of the Total Environment*, *631*, 1590-1599. https://doi.org/10.1016/j.scitotenv.2018.03.130

APPENDICES

APPENDIX 1: ASSESSING THE LEVEL OF PARTICIPANT PERCEPTIONS IN CITIZEN SCIENCE BEFORE THE IMPLEMENTATION OF WATER RESOURCE RESEARCH

I. Demographic characteristics

1. What is your age?
2. Sex ☐Male ☐ Female
3. Highest level of education? ☒ Primary ☐ Secondary ☐ Tertiary
4. How long have you lived in this community?

   ☐ Below 1 year ☐1 – 5 years ☐ 6 -10 years ☐ Over 10 years
5. What is your current occupation?

   ☐ Unemployed ☐ Self employed ☐ Private Employee ☐ Government Employee

II. Previous experience and current interest in participating in any scientific research

6. How often do you volunteer?

   ☐ Every month ☐ 1-4 times/year ☐ More than 4 times/year ☐ Never
7. When did you last volunteer?

   ☐ Last 6 months ☐ Last year ☐Within the last 3 years ago ☐ Can't remember
8. Have you ever helped any scientific research in the past?
   ☐ Yes ☐ No ☐ Not sure / can't remember.
9. If yes,

   i. What type of scientific research were you involved in?

      ☐ Medical Research ☐ Environmental Research ☐ Agricultural Research ☐ Economic and population Research ☐ Others, specify……………………..

   ii. What was your main responsibility in this research project?

      ☐ Data gathering ☐ Data analysis ☐ Community mobilisation ☐ Others, specify……………………………………

   iii. What was your motivation for participation?

      ☐ Financial ☐ Knowledge acquisition ☐ Unemployment ☐ Others, specify……………………………………

   iv. Did you receive any remuneration or wages?

      ☐ Yes ☐ No

v. Would you have participated if there were no wages

☐ Yes ☐ No

10. Have you ever been part of a research project on water? ☐ Yes ☐ No
11. Are you familiar with the concept of citizen science? ☐ Yes ☐ No
12. On a scale of 1-10, rank your motivation for volunteering as a citizen scientist in this project.

    ☐ Financial ………… ☐ Knowledge acquisition……. ☐ Unemployment………… ☐ Others, specify…………………….
13. How many hours per week would you be willing to volunteer for this citizen science research if there was monthly remuneration?

    ☐ 1-7 hours ☐ 8 - 14 hours ☐ 15-21 hours ☐ 22- 28 hours ☐ 29-35 hours ☐ above 35 hours
14. How long are you willing to volunteer for this citizen science research?

    ☐1-3 months ☐ 4- 8 months ☐ 9-12 months ☐ Beyond 12 months
15. Would you still volunteer if there were no remuneration? ☐ Yes ☐ No
16. If yes, how many hours per week would you be willing to volunteer for the current citizen science research? ☐ 1-7 hours ☐ 8 - 14 hours ☐ 15-21 hours ☐ 22- 28 hours ☐ 29-35 hours ☐ above 35 hours
17. As a citizen scientist for this research, which of the following activities will interest you in getting involved?

	Very Unlikely -3	-2	-1	0	+1	+2	Very Likely +3
Public debates about natural water resources	❑	❑	❑	❑	❑	❑	❑
Water quality and quantity analysis	❑	❑	❑	❑	❑	❑	❑
Helping to process information (data) on water resources	❑	❑	❑	❑	❑	❑	❑

Helping to communicate the findings on water resources	❑	❑	❑	❑	❑	❑	❑
Helping plan individual research projects on water resources	❑	❑	❑	❑	❑	❑	❑
Helping to decide where funding and other resources should be spent	❑	❑	❑	❑	❑	❑	❑
Collecting information (data) for scientists on water resources	❑	❑	❑	❑	❑	❑	❑
Helping to analyze the findings	❑	❑	❑	❑	❑	❑	❑
Helping to decide what topics water resource research should focus on in the future	❑	❑	❑	❑	❑	❑	❑
Acting as a representative to explain the concerns that society has about water resource research	❑	❑	❑	❑	❑	❑	❑

Perceptions towards the importance of the environment and citizen science

How strongly do you feel about the following?

N.o	Questions	1 (Strongly disagree)	2 (Disagree)	3 Do not know	4 Agree	5 Strongly agree
Q18	Do you think that our environment contributes to my 'quality of life' and well-being?	❑	❑	❑	❑	❑
Q19	Do you think that you would be personally affected if the quality of the environment declined?	❑	❑	❑	❑	❑
Q20	Do you think that agricultural productivity would be	❑	❑	❑	❑	❑

	affected if the quality of the environment declined					
Q21	How interested would you be in participating in citizen science research in some way, like in water resource research?	❑	❑	❑	❑	❑
Q22	Do you think citizen science on water resource research will empower communities and individuals to improve their well-being?	❑	❑	❑	❑	❑
Q23	Do you think that you will learn new scientific methods?	❑	❑	❑	❑	❑
Q24	Do you think this training would be enough to equip you with the requisite knowledge to make a meaningful impact in your community?	❑	❑	❑	❑	❑
Q25	How confident are you in citizen science findings on water resource research compared to those generated by professional scientists?	❑	❑	❑	❑	❑
Q26	Do you believe that the outcome of the project can have a positive impact on the local community, the environment, and the various activities of the community?	❑	❑	❑	❑	❑

Preliminary knowledge of hydrological monitoring

27. Do you depend on the rainfall pattern for your activities? ☐ Yes ☐ No

28. Are rainwater, surface water, and groundwater connected? ☐ Yes ☐ No
29. Do you consider it important to measure the amount of rainfall? ☐ Yes ☐ No
30. How is rainfall measured?
…………………………………………………………………………….
………………………………………………………………………………………………
…………………………………
31. Is the state of the river in your area of interest to you? ☐ Yes ☐ No
32. How is the state of the river now? ☐ Very polluted ☐ Polluted ☐ Clean ☐ Very Clean
33. Have you observed any change in the size of the river? ☐ Yes ☐ No
34. In which month is the river in your community at its peak?..........................
35. In which month is the river at its lowest?.......................................
36. How has the change in the color of the river affected you?................................
37. Can clear, colorless water still be polluted? ☐ Yes ☐ No

Expectations from this current project

38. What are your expectations regarding your role as a citizen scientist?
....
....
39. What would be your greatest challenge in carrying out your responsibility?
....
....
40. How can you be assisted in dealing with these challenges?
....
....

APPENDIX 2: QUESTIONNAIR FOR ASSESSING THE LEVEL OF PARTICIPANT PERCEPTIONS IN CITIZEN SCIENCE BEFORE THE IMPLEMENTATION OF WATER RESOURCE RESEARCH

Table 1: DEMOGRAPHIC CHARACTERISTICS

Variable	Frequency	Percentage (%)
Age		
20 – 30	5	71.4
31 – 40	1	14.3
41 and above	1	14.3
Sex		
Male	3	42.9
Female	4	57.1
Highest level of education		
Primary	2	28.6
Secondary	4	57.1
Tertiary	1	14.3
How long have you lived in this community?		
6 – 10 years	1	14.3
Over 10 years	6	85.7
What is your occupation?		
Unemployed	4	57.1
Self-employed	1	14.3
Private employee	1	14.3
Government employee	1	14.3

Table 2: PREVIOUS EXPERIENCE AND CURRENT INTEREST IN PARTICIPATING IN ANY SCIENTIFIC RESEARCH

Variable	Frequency	Percentage (%)
How often do you volunteer?		
Every month	1	14.3
1 – 4 times/year	1	14.3
More than 4 times/year	3	42.9
Never	2	28.6
When last did you volunteer?		
Last 6 months	3	42.9
Within the last 3years ago	1	14.3
Can't remember	2	28.6
Have you ever helped any scientific research in the past?		
Yes	4	57.1
No	2	28.6
Not sure	1	14.3
If yes, what type of scientific research were you involved in?		
Environmental research	1	14.3
Agricultural research	2	28.6
Economic and population research	2	28.6
Climate change	1	14.3
What was your main responsibility in this research project?		
Data gathering	2	28.6
Community mobilization	2	28.6

What was your motivation for participation?		
Financial	1	14.3
Knowledge acquisition	2	28.6
Unemployment	1	14.3
Did you receive any remuneration or wages?		
Yes	3	42.9
No	1	14.3
Would you have participated if there were no wages?		
Yes	3	42.9
No	1	14.3
Have you ever been part of a research project on water?		
No	7	100
Are you familiar with the concept of citizen science?		
Yes	1	14.3
No	6	85.7
On a scale of 1 – 10, rank your motivation as a citizen scientist in this project(financial).		
4	1	14.3
5	1	14.3
7	1	14.3
8	2	28.6
10	2	28.6
On a scale of 1 – 10, rank your motivation as a citizen scientist in this project (knowledge acquisition).		
5	1	14.3
8	1	14.3
9	3	42.9
10	2	28.6

On a scale of 1 – 10, rank your motivation as a citizen scientist in this project(unemployment).		
4	1	14.3
5	2	28.6
6	1	14.3
7	1	14.3
8	1	14.3
How many hours per week would you be willing to volunteer for this citizen science research if there was monthly remuneration?		
8 -14 hours	3	42.9
22-28 hours	1	14.3
29 -35 hours	2	28.6
Above 35 hours	1	14.3
How long are you willing to volunteer for this citizen science research?		
1 -3 months	1	14.3
9 – 12 months	1	14.3
Beyond 12 months	5	71.4
Would you still volunteer if there were no renumeration?		
Yes	6	85.7
No	1	14.3
If yes, how many hours per week would you be willing to dedicate to volunteering for current citizen science research?		
1 – 7 hours	1	14.3
8 – 14 hours	2	28.6
15 – 21 hours	1	14.3
22 – 28 hours	1	14.3
29 – 35hours	1	14.3

Above 35 hours	1	14.3

Table 3: PREVIOUS EXPERIENCE AND CURRENT INTEREST IN PARTICIPATING IN ANY SCIENTIFIC RESEARCH

Variable	-3	-2	-1	0	+1	+2	+3	∑FiWi	∑Fi	WAI	Rank
As a citizen scientist for this research, which one of the following activities will interest you											
Public debate about natural water resources	0	0	0	4	5	12	21	42	7	6.000	4
Water quality and quantity analysis	0	0	0	0	0	12	35	47	7	6.714	2
Helping to process information(data) on water resources	0	0	0	4	0	12	21	37	7	5.286	7
Helping to communicate the findings on water resources	0	0	0	4	10	0	28	42	7	6.000	4
Helping plan individual research projects on water resources	0	0	0	4	10	6	21	41	7	5.857	5
Helping to decide where funding and other resources should be sent	1	0	0	0	5	18	14	38	7	5.429	6
Collecting information(data) for scientists on water resources	0	0	0	4	0	12	28	44	7	6.286	3
Helping to analyze the findings	0	0	3	0	5	6	28	42	7	6.000	4

Helping to decide what topics of water resource research should focus on in the future	0	0	3	0	5	6	28	42	7	6.000	4
Acting as a representative to explain the concerns that society has about water resource research	0	0	0	0	0	6	42	48	7	6.857	1

Table 4: PERCEPTIONS TOWARDS THE IMPORTANCE OF THE ENVIRONMENT AND CITIZEN SCIENCE

Variable	**Strongly disagree**	**Disagree**	**Do not know**	**Agree**	**Strongly agree**	**∑FiWi**	**∑Fi**	**WAI**	**Rank**
Do you think that our environment contributes to my 'quality of life' and well-being?	1	0	0	4	25	30	7	4.286	5
Do you think that you would be personally affected if the quality of the environment declined?	0	0	0	0	35	35	7	5.000	1
Do you think that agricultural productivity would be affected if the quality of the environment declined?	1	0	0	4	25	30	7	4.286	5
How interested would you be in participating in citizen science research in some way, like in water resource research?	0	0	0	8	25	33	7	4.714	3

Do you think citizen science on water resource research will empower communities and individuals to improve their well-being?	0	0	0	4	30	34	7	4.857	2
Do you think you will learn new scientific methods?	0	0	0	8	25	33	7	4.714	3
Do you think training would be enough to equip you with the requisite knowledge to make a meaningful impact in your community?	0	0	0	12	20	32	7	4.571	4
How confident are you in the citizen science findings on water resource research compared to those generated by professional scientists?	1	0	0	12	15	28	7	4.000	6
Do you believe that the outcome of the project can have a positive impact on the local community, the environment, and the various activities of the community?	0	0	0	8	25	33	7	4.714	3

Table 5: PRELIMINARY KNOWLEDGE ON HYDROLOGICAL MONITORING

Variable	Frequency	Percentage (%)
Do you depend on the rainfall pattern for your activities?		
yes	7	100
Is there a linkage between rainfall, surface water, and groundwater?		
Yes	6	85.7
No	1	14.3
Do you consider it important to measure the amount of rainfall?		
Yes	7	100
How is rainfall measured?		
Measurement in water	1	14.3
Rain gauge	1	14.3
Rain gauge in mm	3	42.9
Staff gauge/ rain gauge	1	14.3
Is the state of the river in your area of interest to you?		
Yes	6	85.7
No	1	14.3
How is the state of the river now?		
Very polluted	3	42.9
Polluted	1	14.3
Clean	2	28.6
Very clean	1	14.3
Have you observed any change in the size of the river?		
Yes	6	85.7
No	1	14.3
In which month is the river in your community at its peak?		

July	2	28.6
July – June	1	14.3
May	1	14.3
October	2	28.6
September	1	14.3
In which month is the river at its lowest?		
December	2	28.6
February	2	28.6
January	3	42.9
How has the change in color of the river affected you?		
Cannot be used for domestic purposes	1	14.3
Clean water crisis	1	14.3
Colorless	1	14.3
Health	1	14.3
My health	1	14.3
Change river colour to green	1	14.3
-	1	14.3
Can clear, colorless water still be polluted?		
Yes	7	100

Table 6: EXPECTATIONS FROM THE CURRENT PROJECT

Variable	Frequency	Percentage (%)
What are your expectations regarding your role as a citizen scientist?		
To gain knowledge about water resource quality and volume(quantity), stream flow, etc.	1	14.3
I expect a good impact on water bodies for the well-being of the community.	1	14.3

I will be proud if my role helps achieve good results at the end of the research.	1	14.3
To acquire knowledge	3	42.9
To learn new scientific methods	1	14.3
What would be your greatest challenge in carrying out your responsibility?		
Expectation and acquisition of future permanent employment	1	14.3
Financial problem	1	14.3
I am preparing to continue my education	1	14.3
Poor network in my community	1	14.3
Transportation and the standpoint to read streamflow velocity is risky (poor/weak bridge)	1	14.3
Traveling	1	14.3
-	1	
How can you be assisted in dealing with these challenges?		
A replacement in such times	3	42.9
Adequate financial support to carry on with the job well.	1	14.3
Provide fuel allowance and change standpoint	1	14.3
To do better with more network	1	14.3
-	1	14.3

APPENDIX 2: CITIZEN SCIENCE TRAINING MANUAL ON WATER QUALITY AND QUANTITY ASSESSMENT

Stream measurements: - Open Channel Flow using the Float Method

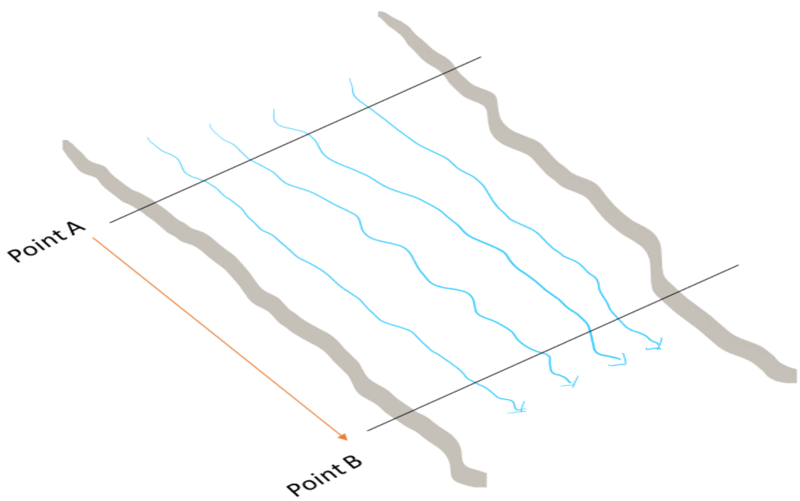
Objective: The basic idea of the float method is to measure the time it takes a floating object to travel a specified distance downstream.

Materials:

1. Tape measure
2. Stopwatch
3. A meter/yardstick
4. Three colored sticks

Step 1: Measure and record the stream stage value from the metallic staff gauge installed on the stream.

Step 2: Mark/identify the beginning (point A) and end (point B) of your floating object's travel distance.



Step 3: Throw your floating object into the center of the stream upstream of point A.

Step 4: Start the timer when the object crosses **point A** and stop it when it crosses **point B**.

Step 5: Repeat the measurement thrice and find the average time.

Step 6: Divide the average time by the distance between points A and B to get the velocity.

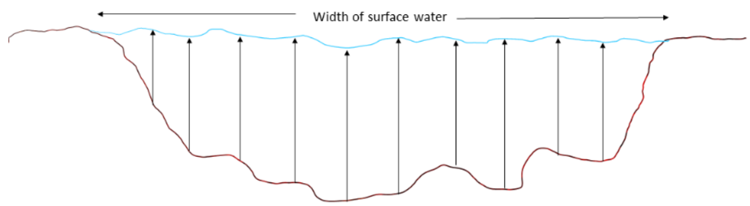
V (Velocity, m/s) = Distance Traveled/Time to travel (feet traveled divided by seconds)

Record the velocity reading.

Step 7. Measure the stream's width across the channel at point B.

NB: Be sure it is safe to wade before getting in the channel.

Step 8: Slice the channel into equal columns (see image below) and use a yardstick to measure the depth at regular intervals across the channel. Find the average depth across the channel by adding the measured depth at each column and dividing it by the number of columns.



Step 9: Multiply the depth and width to obtain the cross-sectional Area.

A (Area) = Width of Channel (feet) x Depth of Water (feet)

Step 10: Calculate the discharge by multiplying the Area and Velocity

Discharge (cubic feet per second, cfs) = Area (A) x Velocity (V)

It is recommended to do these calculations in Feet and Seconds for convenience in converting to CFS (Cubic Feet Per/Second flow rate).

NB: 1 meter = 3.281 feet

Tip: *To improve the accuracy of measurement in wide channels, more velocity readings should be taken at different locations across the width of the channel.*

pH, Temperature, TDS, EC measurements

CAREFULLY READ THE MANUAL ACCOMPANYING THE DEVICE BEFORE USE

The device has already been calibrated and will be verified periodically.

Step 1: Uncap the electrode and rinse the tip in deionized water.

Step 2: Press your meter's on/off button to turn your device on.

Step 3: Press the mode/cal button to select the desired measuring parameter.

Step 4: Insert your electrode in your sample and begin reading.

NB: Make sure the tip of the electrode is fully immersed in the sample but does not touch the walls of the container.

Step 5: Record the stabilized value.

Step 6: Rinse your electrode and cap the tip. Be careful your finger does not touch the tip of the electrode.

Step 7: Press your meter's on/off button to turn your device off.

Note:

1. *Pick one stream sample weekly in the wide-mouth sampling bottle for sediment concentration analysis.*
2. *Pick one stream sample monthly in the narrow-mouth sampling bottle for water quality analysis.*

Rainfall depth measurement

Step 1: Make sure the rain gauge is empty after each reading and before each rainfall.

Step 2: Bring the inverted funnel to eye level. The top of the water line must be at eye level to ensure an accurate reading.

Step 3: Record the height of the water. The surface of the water will be slightly curved because its surface tension tends to make it stick to the sides of the container. This is known as the meniscus. **Read the height of the water at the base of the meniscus**.

Step 4: If rain has fallen, but there is little to no water in the rain gauge, then record that a "trace" of precipitation has fallen.

Step 5: Empty the rain gauge for the subsequent measurement or bring it to the zero mark.

Note:

The monthly rainfall sample for laboratory analysis should be collected from the ungraduated container attached to the gauge.

Groundwater level measurement

Step 1: Insert the two probes into the AC Clamp meter. The red probe is inserted into the right port (INPUT), while the black probe is inserted into the left port (COM).

Step 2: Turn the rotation knob of the device to the voltage direct current symbol $\overline{\text{V}}$ (a dotted line with a solid line above it over the V). You should see voltage DC on the screen.

Step 3: Note that the reading on your meter is zero or near zero.

Step 4: Straighten your graduated electrical cable and gently lower it into the well while observing the screen of the meter. **The voltage readings would suddenly rise as soon as the cable touches the surface of the water.**

Step 5: Record the stabilized voltage readings and the length of the cable that was lowered.

Step 6: Turn the knob of your device to the off position and unplug the probes.

Turbidity measurement using a Secchi disk.

Step 1: Attach your weight to your Secchi disk.

Step 2: Position yourself at or close to the center of the stream.

Step 3: Keep lowering the disk slowly until it disappears. Note the depth of the cord that is immersed in the water.

Step 4: Slowly pull the disk up until you see it again. Note the depth on the cord.

Step 5: Average the two recorded depths.

Step 6: Repeat the procedure thrice and record the average value in the datasheet provided with the date and time of the reading.

Dissolved oxygen measurement using the Winkler method.

<u>Before you begin, ensure you are well dressed in the appropriate personal protective equipment (PPEs), such as safety shoes and gloves.</u>

STEP 1: Fetch a bucket of water from the water source to be analyzed.

STEP 2: Fully immerse your 120 ml narrow-mouth sampling bottle in the bucket of water and open the cork of the sampling bottle under the water. Allow the bottle to fill up, and cover the sampling bottle with a cork while still under the water.

STEP 3: Using your graduated dropper, add **1 ml** of **Solution A (Manganous sulphate)** to your water sample.

STEP 4: Rinse your dropper thrice with your distilled water.

STEP 5: Use the dropper to add **1 ml** of **Solution B (Alkaline Iodide)** to your water sample.

Cork and shake vigorously and allow to stand to observe the formation of precipitation.

Caution: You are about to add a very toxic and dangerous chemical. Please handle it with care!!!

STEP 6: Rinse your dropper thrice with your distilled water

STEP 5: Using your dropper, add **1 ml** of **Solution C (Concentrated Sulphuric acid)** and shake vigorously till there's a complete disappearance of the precipitate.

NB: Colour observation - Dark Brown

STEP 6: Transfer 50 ml of the sample into a wide-mouth container.

STEP 7: Add drops of **Solution D (Sodium thiosulphate) while counting** till there's a change in sample color from **Dark brown to Pale yellow.**

NB: Record the number of drops that were added to obtain the color change.

STEP 8: **Add 3 to 5 drops** of freshly prepared **Solution E (Starch indicator)**

Colour observation – **From Pale yellow to Blue-black coloration.**

Note: A fresh starch solution should be prepared every three days by filling the wide-mouth container with very hot water and adding one sachet of the supplied powder while stirring.

STEP 9: Again, add drops of **Solution D (Sodium Thiosulphate)** while counting until there's a change in sample color from Blue-black **to colorless.**

NB: Record the number of drops that were added to obtain the colour change.

NOTE: The number of drops of Solution D added to the sample at **STEP 7 and STEP 9** are to be noted or **recorded in the logging book.**