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Technical Report

Empowering Citizen Scientists for Sustainable Water Management in the Limpopo River Basin: An Incentive-Based Approach

Design Implementation and Early Evaluation in Botswana, Mozambique and South Africa

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Front cover photos: Citizen scientists conducting miniSASS (*photo*: IWMI)

Back cover photo: Citizen scientists in Mozambique collecting turbidity data using a clarity tube instrument (*photo*: IWMI).

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Executive summary

This report evaluates the design and early implementation of citizen science incentives for water monitoring in Botswana, Mozambique and South Africa. It combines a focused literature review, stakeholder consultations and a cross-sectional survey of 43 citizen scientists conducted from 1 September to 14 October 2026. The findings describe early experiences and implementation feasibility, rather than measured effects on monitoring frequency or data quality.

Youth Marketplace Agency (YOMA) supported courses, certificates and verified credentials, including hosting the River Monitors course through which participants received certificates. Platform, funding and cross-country logistical constraints prevented the intended financial disbursement through YOMA to participating countries. Other incentives required manual coordination, including external service providers which limited planned digital tracking.

Respondents generally valued incentives, but 30 of 41 answering the receipt-frequency item were receiving their first incentive. Only 18 of 43 fully understood how incentives were earned; 27 of 43 preferred cash or a stipend. Data and connectivity costs were reported by 14 of 43. Although stated willingness to continue without incentives was high, it cannot establish actual retention. Inconsistent satisfaction responses were retained and flagged for follow up.

The priority is a workable combination of educational recognition, participation support and transparent delivery rules. Future implementation should confirm country-specific payment capabilities, funding, providers and monitoring functions before launch, retain assisted access, and assess the same participants over repeated incentive cycles using verified submission records.

Keywords: citizen science; incentives; water quality monitoring; Limpopo River Basin; YOMA; digital credentials

Abbreviations

AWARD	Association for Water and Rural Development
DIWASA	Digital Innovations for Water Secure Africa
IWMI	International Water Management Institute
LIMCOM	Limpopo Watercourse Commission
LMS	Learning Management System
LRB	Limpopo River Basin
miniSASS	mini Stream Assessment Scoring System
NPS	Net Promoter Score
PPE	Personal Protective Equipment
UNICEF	United Nations Children's Fund
YOMA	Youth Marketplace Agency

1 Introduction

1.1. Citizen science and water monitoring

Citizen science in water monitoring involves members of the public in producing scientific knowledge (Buytaert et al., 2014). Contributions can include defining locally relevant questions, collecting observations, interpreting trends, checking findings, and communicating evidence to communities and water managers. Incentive design should recognise this broader scientific contribution rather than reward data collection alone. This aligns both with European standards of mutual benefit, feedback, and societal outcomes (ECSA, 2015) and with African citizen science frameworks (Haile et al., 2026; Goldin et al., 2022 and Graham & Taylor, 2018) that centre community-led priorities, power-sharing, and reciprocal knowledge return for local water stewardship.

The Limpopo River Basin is shared by Botswana, Mozambique, South Africa and Zimbabwe. This study's geographical scope covers Botswana, Mozambique and South Africa; although Zimbabwe is part of the basin context, it is not included in the survey findings or research conclusions of this incentive report. Citizen observations can complement institutional monitoring and contribute to the basin's Digital Twin, provided that methods, verification and governance are appropriate. They do not replace the regulatory responsibilities of water authorities.

A review of 56 water-quality citizen science studies (Langa, 2025) identified success factors at three levels: participants, institutions and their interactions. Knowledge, motivation and socioeconomic conditions matter alongside adequate funding, organisational support, communication and feedback (San Llorente Capdevila et al., 2020). This shifts the design question from whether a reward attracts participation to whether the whole monitoring arrangement supports reliable and sustained contributions.

Training and quality assurance remain necessary even when participants are motivated. Scott and Frost (2017) illustrate how trained volunteers can generate useful water-quality observations and measurements, but participation rates and data quality require separate assessment. An incentive survey can describe participants' views; it cannot by itself verify the accuracy of water observations or demonstrate that incentives caused more frequent sampling. Therefore, the purpose of this report is to provide insights on the incentives and how it impacted citizen scientist contribution.

1.2. Motivation, participation costs and fairness

Motivation is heterogeneous and can change through a project. Rotman et al. (2012) describe shifts in motivation across participation, while Geoghegan et al. (2016) identify communication, feedback and evidence that contributions are used as important influences on continued engagement. Recruitment messages, initial training and long-term recognition therefore address different needs, even when delivered within the same programme.

Environmental values and learning can motivate participation without a financial reward. Maund et al. (2020) found that values and understanding were prominent among both regular and occasional contributors to conservation citizen science. Career development and social contact were less prominent in those particular projects. These findings do not justify assuming that all participants share the same priorities; project demands and socioeconomic conditions affect what people can contribute.

Evidence from African settings supports a contextual approach. Asingizwe et al. (2020), studying a malaria citizen science programme in Rwanda, found that motivations and barriers differed across participation stages and groups. The subject matter differs from water monitoring, but the study supports assessing access, perceived relevance and communication throughout participation rather than only at recruitment.

In water-quality monitoring around Lake Tanganyika, financial compensation coexisted with interest in research, local knowledge and participation in environmental decisions. Cash was the most preferred incentive, while airtime also supported data transmission (Moshi et al., 2023). This evidence is especially relevant to distinguishing reimbursement and participation support from rewards intended to recognise achievement. It does not establish appropriate payment levels for the Limpopo countries.

An incentive can have several functions. Transport, connectivity, meals, equipment and protective clothing may make participation feasible; training and credentials recognise learning; financial payments compensate effort; and feedback or community decision-making opportunities make contributions meaningful. Treating all these as interchangeable rewards obscures their different costs, purposes and delivery requirements. This report uses "incentive" broadly while making these distinctions explicit.

Financial rewards also require careful design. Experimental research shows that some forms of expected tangible reward can reduce intrinsic motivation, depending on how they are structured (Deci, Koestner and Ryan, 1999). Those findings should not be read as a reason to withhold reasonable cost support. For this programme, the practical implication is to combine transparent compensation with participant choice, learning, recognition and feedback, and to test effects rather than assume them.

1.3. Regional examples and digital delivery

Selected projects illustrate the range of benefits and enabling conditions relevant to this study (Table 1). They are contextual examples, not a representative inventory or a comparative test of incentive effectiveness. Project descriptions, proposed activities and measured findings are distinguished; no prevalence percentages are inferred from this small purposive set.

Table 1. Selected contextual examples of participation support and incentives

Example and evidence	Participation support or benefit	Relevance to this study
Amakhala water monitoring, South Africa Research article: Nqowana et al. (2024)	Co-created monitoring, access to testing tools, learning and continuous feedback.	Local relevance and interpretation of results can support community agency and continuing participation.
University of Limpopo river health initiative, South Africa Project description: Rhodes University (2021)	Planned school and student training, miniSASS and basic monitoring tools, linked to knowledge of pollution risks.	Training and usable tools are enabling conditions; a project description does not prove retention or incentive impact.
Kalahari San Master Tracker Programme Programme description: CyberTracker (2022)	Mentorship and digital support intended to recognise and transmit Indigenous tracking knowledge.	Recognition should value knowledge holders and make participation accessible; this is a broader biodiversity comparator.
Lake Tanganyika, Tanzania Research article: Moshi et al. (2023)	Airtime support for monthly monitoring; financial compensation and decision-making were valued.	Connectivity support and compensation can coexist with environmental and scientific motivation.

The reviewed initiatives demonstrate that effective participant support relies on a multi-tiered incentive structure rather than financial compensation alone. Across these regional contexts, non-monetary provisions—particularly structured training programmes, access to technical monitoring tools, and continuous feedback—function as primary incentives in their own right. As demonstrated by the Amakhala study (Nqowana et al., 2024), involving citizen scientists in co-design and data interpretation builds community agency and local relevance, which are foundational to sustained engagement. Direct material support, such as the airtime allowances observed at Lake Tanganyika (Moshi et al., 2023), acts as a complementary enabling condition that offsets the practical friction of participation rather than replacing intrinsic environmental motivations.

Digital platforms serve as the operational bridge across these incentive types, capable of integrating structured training, credentialing, and community recognition into a unified record. However, the presence of a digital platform does not automatically resolve delivery barriers. While initiatives like YOMA demonstrate how digital tokens can formalise engagement pathways (IIASA, n.d.), deploying hybrid incentives across diverse regions requires distinguishing between learning delivery and functional financial infrastructure. Effective digital delivery must align administrative support, accessible capacity building, and reliable payout channels according to regional connectivity and community priorities.

1.4. Conceptual foundations

The four-stage model in Figure 1 draws on complementary theories as design lenses. Self-determination theory highlights autonomy, competence and relatedness (Ryan and Deci, 2000). Communities of practice explains learning through shared participation (Wenger, 1998). The Technology Acceptance Model focuses on perceived usefulness and ease of use (Davis, 1989). Social exchange theory considers reciprocity, trust and the perceived balance of contributions and benefits (Cook et al., 2013).

These theories inform questions about relevance, learning, usability and fair recognition. They are not mutually exclusive stages or a validated causal model. Needs may overlap, participants may enter at different points, and retention is shaped by institutional support as well as individual motivation. The survey measures selected perceptions and experiences; it does not test the four theories as latent constructs.

2 Aim and research questions

The aim is to assess the feasibility and early reception of a contextual incentive model for citizen science water monitoring in Botswana, Mozambique and South Africa, and identify improvements that support inclusive participation and reliable data contributions.

The report addresses three questions: What incentives and enabling support do participants report receiving and preferring? How do participants understand and experience the model, platforms and credentials? What delivery arrangements and evaluation evidence are needed before the model can be sustained or expanded?

3 Methodology

3.1. Study design and evidence sources

This is an exploratory programme evaluation combining contextual literature, stakeholder consultation evidence and a descriptive cross-sectional participant survey. The literature and consultations informed the proposed model; the survey examined its early reception. Together, these sources support interpretation of implementation experience, but they do not constitute an experimental or longitudinal impact evaluation.

The desktop review was a focused narrative review of citizen science motivation, participation support, water monitoring and digital incentives, supplemented by regional project descriptions. It was not a systematic review and no exhaustive search, screening flow or pooled effectiveness estimate is claimed. Peer-reviewed studies were used for empirical claims; institutional descriptions were used to establish project purpose and proposed activities.

The 2025 consultations covered IWMI, LIMCOM, AWARD, UNICEF/YOMA and GroundTruth. Their purposes included discussing inclusion, engagement, platform functions, verification and integration with the Digital Twin. Annexure B lists the dated consultations documented in the project record. Organisational coverage is reported separately from interview numbers because the record does not establish a complete respondent count. Consultation material is used as design and implementation context, rather than as independently coded interview findings.

3.2. Survey population timing and consent

The survey dataset comprised 43 citizen scientists: 12 in Botswana, 9 in Mozambique and 22 in South Africa recruited by local implementing partners and their networks. Data was collected from 1 September to 14 October 2026 through a single KoboToolbox form version. The survey analysis records consent for every submission and no duplicate submissions (IWMI, 2026a). Findings are restricted to these respondents; the sample is not used to estimate basin-wide or national participation patterns.

Field periods differed: Botswana, 1–8 September; South Africa, 18 September–9 October; and Mozambique, 12–14 October. Experience also differed substantially across these groups. Country, survey timing and monitoring experience therefore cannot be separated in this evaluation. No Zimbabwe respondents are included, even though the original survey form retained Zimbabwe as a country option.

The instrument begins with a participation-consent question and collects country, monitoring location, gender, age group and collection experience. The report presents aggregate results and paraphrased themes, without participant names, contact details or individual location coordinates. Survey completion times and response inconsistencies were treated as diagnostic flags, rather than automatic grounds for deleting observations.

3.3. Survey instrument

The questionnaire contains sections A–L, combining single-choice, multiple-choice, ordinal rating, ranking and open-text items (IWMI, 2026b). Table 2 links the domains to the analysis. Questions use first-incentive and “too early to tell” options to accommodate new participants. Annexure A reproduces the questions and response options, including the original wording and country choices. Its Zimbabwe option is retained as part of the historical instrument, not as an extension of this study’s scope.

Table 2. Survey domains and analytical use

Survey section	Content	Analytical use
A	Country, location, gender, age and collection frequency	Respondent profile and monitoring experience
B–E	Training, credentials, WhatsApp, platform ranking and recommendation	Access, confidence, recognition and platform experience
F–G	Awareness, understanding, incentive types and receipt frequency	Clarity of rules, exposure and delivery experience
G–H	Timeliness, process, value, motivation, contribution link and fairness	Eight separate incentive statements; no composite score
H–I	Preferred incentives, adequacy, perceived frequency or quality change, retention	Preferences and reported intentions; not observed behavioural effects
J–L	Challenges, suggestions, satisfaction and recommendation score	Implementation improvements and response consistency

3.4. Analysis and quality checks

Descriptive results are reported as counts with explicit denominators where available. Percentages from counts are given to one decimal place; agreement percentages and NPS are rounded to whole numbers Multiple-response questions allow more than one selection, so totals can exceed 100%. Agreement combines “Agree” and “Strongly agree”, divided by respondents expressing an opinion; blank and “too early to tell” responses are excluded. The eight statements are treated separately rather than combined into an unvalidated scale.

Collection-frequency responses define first-time participants (16), returning participants who collect weekly, monthly or occasionally (26), and one lapsed participant. First data collection and first incentive are distinct: a returning monitor may still be receiving a first incentive. The receipt-frequency item has 41 responses, of which 30 indicate first receipt.

Non-parametric tests were used because the responses are ordinal and recommendation scores were not normally distributed (Shapiro–Wilk $p < 0.05$ in all groups). Results were unchanged using Kendall's tau-b, permutation p-values and parametric alternatives." Checks done include: Shapiro–Wilk $p = 0.00001$ overall and 0.0000–0.02 in every country and experience group; Levene $p = 0.50$; ANOVA $p = 0.61$ and Welch t-test $p = 0.21$ give the same conclusion as Kruskal–Wallis and Mann–Whitney; Kendall's tau-b gives 0.31 ($p = 0.04$) and 0.28 ($p = 0.04$).

The survey analysis used Spearman rank correlations for associations between ordered responses, and Kruskal–Wallis and Mann–Whitney tests for exploratory group comparisons. Reported p-values are nominal; no multiple-comparison adjustment was applied (IWMI, 2026a). They are interpreted as exploratory signals, not confirmatory evidence. The recommendation score is summarised descriptively as Net Promoter Score (NPS): the percentage scoring 9–10 minus the percentage scoring 0–6; scores of 7–8 are classified as passive.

Portuguese open responses were read in the original in the survey analysis. Open comments were grouped into themes, with each respondent counted once per theme. Several themes can therefore apply to the same person. Free-text site names were consolidated into river or locality groups for descriptive reporting, rather than treated as independently verified monitoring sites.

Quality checks identified four submissions completed in under seven minutes and 11 left open for more than one hour, including one open for 13 days. The reported median was 14 minutes. This form was completed in about 6 minutes, and the same respondent's open answer asks for more cash ('Getting over R500 monthly') Three very dissatisfied responses in Mozambique conflicted with high recommendation scores and favourable statement ratings; one South African response selected “Strongly disagree” throughout the eight statements despite favourable satisfaction and recommendation responses. All records were retained and the inconsistencies are reported without recoding. Excluding the 4 flagged records changes two of the correlations. NPS without these 4 is +44.

4 Incentive model and implementation

4.1. Four stages of engagement

Figure 1 presents the revised model, linking awareness and outreach, onboarding and capacity building, active engagement and optimised performance, and retention and legacy. Its incentive categories describe different functions: engagement attracts participation; enabling support develops skills; immediate support reduces operational barriers; short-term incentives recognise contributions; and longer-term or community benefits recognise learning and sustained engagement.

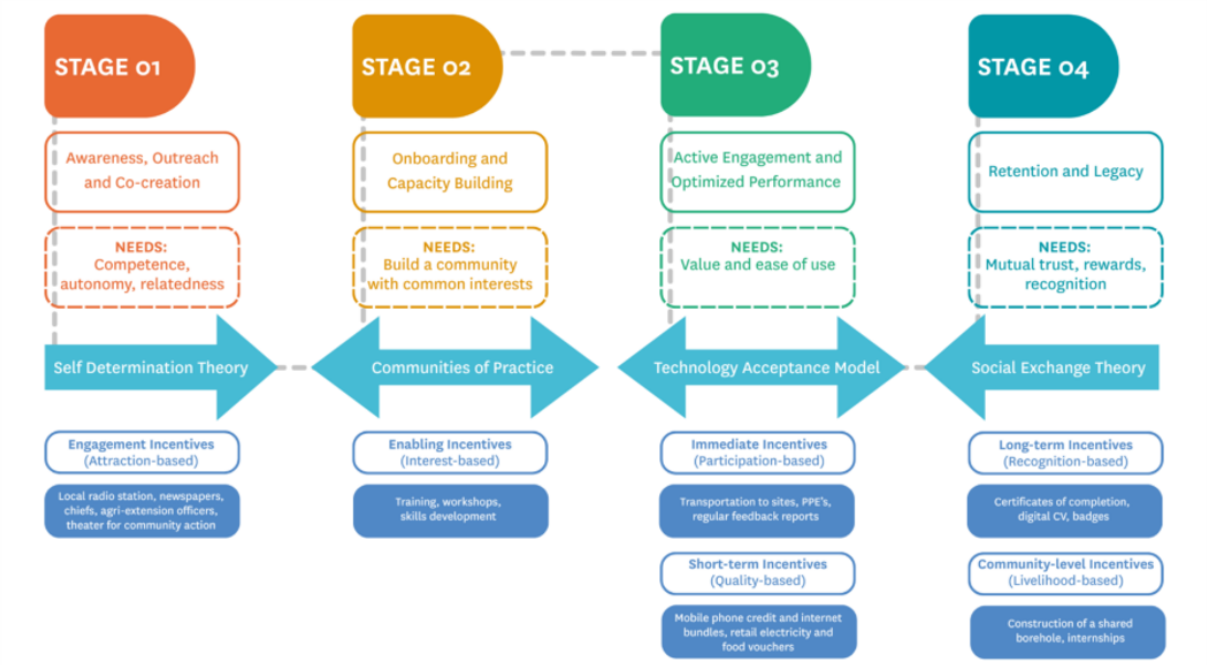


Figure 1. Four stages of citizen science engagement and incentives

Source: IWMI, 2025

The model should be implemented as a flexible sequence with feedback, rather than a fixed progression. Certificates and digital credentials support recognition; transport, equipment and protective clothing support safe and feasible participation; and airtime or data can serve both practical access and incentive functions. Community infrastructure and internships shown in the model remain possible design options and must not be presented as delivered project benefits.

Citizen scientists' contributions should also include interpretation, communication and peer learning. Future recognition can cover explaining trends, preparing community feedback, supporting new monitors and discussing data with LIMCOM. Any financial recognition for these activities would require agreed criteria, verified funding and an operational delivery channel.

4.2. YOMA learning and recognition

YOMA supported the educational and recognition components of the project. Courses, certificates and verified credentials were operational, including the River Monitors course hosted on YOMA, through which participants received certificates. This is an achieved educational incentive. It should be distinguished from the anticipated financial and material incentive distribution functions that were not realised.

Course completion and credentials can document learning and participation. They do not independently establish the scientific validity of water-quality observations, ensure employment, or demonstrate that a cash payment was made. Technical partners and monitoring protocols remain responsible for data verification; participants also need practical guidance on accessing and using their credentials.

4.3. Financial and other incentive delivery

Financial incentive distribution did not work as intended because of platform, funding and cross-country logistical constraints. YOMA could support courses and credentials, but the cross-country financial distribution required for this project was unavailable. Unexpected platform and logistical limitations prevented disbursement of funds through the platform to the participating Limpopo River Basin countries.

Consequently, other incentives had to be organised and distributed manually, including through external service providers. The anticipated platform support for coordinating and distributing these incentives was not realised. Manual delivery increased coordination demands on the project team and limited the planned digital tracking and monitoring of incentives. Participant reports of receiving airtime, meals, transport or equipment should therefore not be interpreted as evidence that these incentives were automatically distributed or tracked through YOMA.

The implementation lesson is to verify the full delivery chain before making commitments: available funding, country-specific payment capabilities, mobile network compatibility, provider contracts, participant eligibility, receipt confirmation and monitoring functions. A platform's general reward features or availability elsewhere cannot substitute for testing these arrangements in Botswana, Mozambique and South Africa.

4.4. Lessons from external platform examples

The earlier design discussions referred to DonateWater in Nigeria as an example of youth-led water data collection associated with YOMA Operational Research. Grey (2026) describes that initiative and its comparison with official water-access data. It is a contextual comparator outside this study's geographical scope. It does not establish that the same financial delivery arrangements were available in the three Limpopo countries; no reward amounts or causal incentive effects are inferred from that example.

4.5. Verification and partner responsibilities

IWMI coordinated project implementation and incentive arrangements; LIMCOM provided the transboundary institutional link; AWARD supported technical integration with the Digital Twin; and GroundTruth supported monitoring tools, training and scientific quality assurance. UNICEF/YOMA provided the learning and credential platform. Local partners and service providers were necessary for field coordination and manual incentive delivery. Scientific verification, course recognition and financial reconciliation require separate records and responsibilities.

Peer checks and automated screening are possible future support mechanisms. A trained peer might check whether a monitoring activity took place, while technical review assesses whether the data meet agreed standards. Automated outlier detection can flag records for review but should not determine entitlement without human assessment and an appeal route. These are proposed improvements, not verified operational features of the implemented incentive model.

5 Results

5.1. Respondent profile and incentive exposure

The 43 respondents included 24 women (55.8%) and 33 people under 35 (76.7%). South Africa contributed 22 responses (51.2%), Botswana 12 (27.9%) and Mozambique 9 (20.9%). These describe the sample composition, rather than the demographic coverage of the program as a whole. Table 3 shows the uneven distribution of monitoring experience.

Table 3. Respondent profile and collection experience

Country	n	Women	Under 35	First collection	Weekly	Monthly or occasional	Stopped
Botswana	12	6	6	8	0	4	0
Mozambique	9	3	6	6	0	2	1
South Africa	22	15	21	2	13	7	0

Country	n	Women	Under 35	First collection	Weekly	Monthly or occasional	Stopped
Total	43	24	33	16	13	13	1

Source: IWMI (2026a). All entries are counts. First collection refers to the collection-frequency item, not first receipt of an incentive. Returning participants comprise weekly, monthly and occasional monitors.

All 13 weekly monitors were in South Africa. The 16 first-time participants comprised eight in Botswana, six in Mozambique and two in South Africa. One respondent in Mozambique had stopped submitting data. Reported monitoring locations were grouped as Madikwe River/Sikwane in Botswana; Lower Limpopo/Guijá in Mozambique; and Luvuvhu, Mohlatsengwane, Marakalala, Klaserie, Olifants and Phiring in South Africa. 33 free-text entries (28 after fixing capitalisation and spacing).

Most respondents answering the receipt-frequency item were receiving a first incentive: 30/41 (73.2%). This included 17/25 respondents in that item's regular-monitor subgroup. This included 17 of the 25 returning participants who answered this question. The predominance of first receipt limits interpretation of subsequent motivation and perceived behavioural change.

5.2. Awareness and understanding

Thirty-two respondents (74.4%) knew incentives were available, but only 18 (41.9%) fully understood how they were earned. Fifteen (34.9%) understood partly and ten (23.3%) did not understand at all. Together, 25/43 (58.1%) lacked full understanding. The country pattern is not statistically significant overall (exact test $p \approx 0.10$; χ^2 is unreliable here because expected counts are around 2). Botswana's 1 of 12 is descriptive only. This is shown in Figure 2, with counts labelled within the bars. Awareness and understanding of incentives per country are illustrated in Table 4.

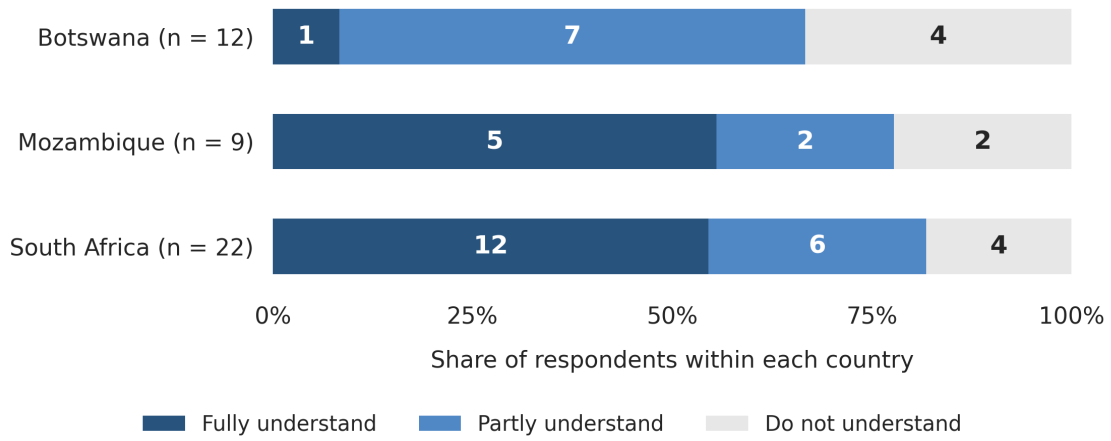


Figure 2. Understanding of incentive rules by country

Source: IWMI (2026a). Labels show respondents; bar lengths show percentages within each country. Country differences are descriptive and confounded by survey timing and monitoring experience.

Table 4. Incentive awareness and first receipt

Indicator	Botswana	Mozambique	South Africa	Total
Aware of incentives	6/12	9/9	17/22	32/43
Fully understand earning rules	1/12	5/9	12/22	18/43
Do not understand earning rules	4/12	2/9	4/22	10/43

Indicator	Botswana	Mozambique	South Africa	Total
First incentive at survey	9/12	7/9	14/20	30/41

Among the 32 respondents aware of incentives, 15 cited onboarding or training and 15 a coordinator; 8 cited other citizen scientists, 5 WhatsApp and 1 a website. Multiple selections were allowed. Seventeen open responses addressed unclear aspects, particularly how incentives were earned or calculated (7), payment timing and process (5), and possible salary or transport support (3). One respondent understood incentives to apply to group activities but not individual monitoring.

Eleven respondents were unaware of incentives but still answered the incentive questions. Their ratings may combine expectations, general programme experience and actual receipt; they should not all be treated as informed assessments of an established reward mechanism.

5.3. Incentives received and perceived experience

Airtime or data was the most frequently reported incentive, selected by 35/43 (81.4%). Other reported benefits included food, transport, equipment, certificates and training (Figure 3). 2 respondents reported receiving no incentive yet. These categories include support provided at training and monitoring events as well as incentives received at the time of survey; multiple responses were permitted.

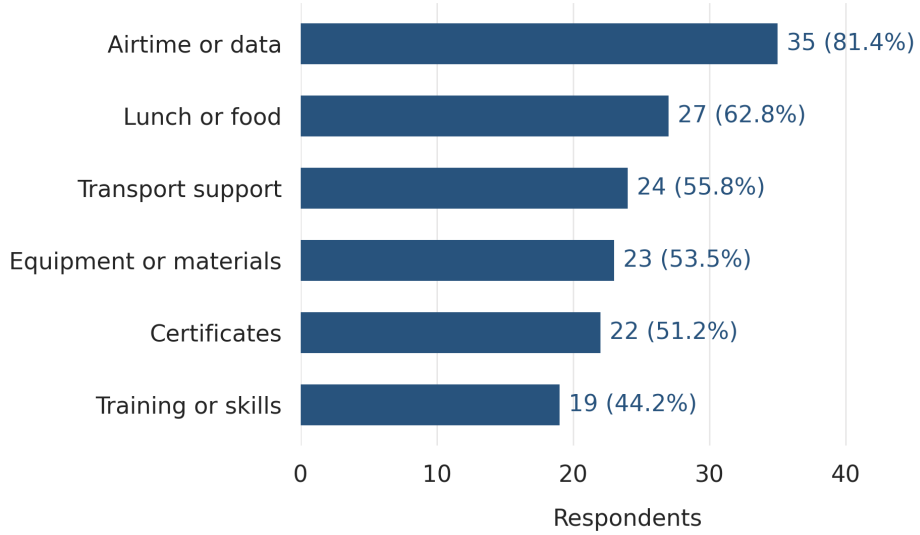


Figure 3. Incentives respondents reported receiving

Source: IWMI (2026a). n = 43; labels show counts and percentages of all respondents. Multiple responses were allowed. The chart records reported receipt, not YOMA payment transactions.

Among respondents expressing an opinion, agreement was highest for motivation to continue collecting data (92%), motivation to collect more accurate data (86%), trust in fair distribution (84%) and fair value for effort (80%). Agreement was lower for timely receipt (74%), a simple receipt process (73%), a clear link to contribution (70%) and continuing without incentives (65%). Figure 4 reproduces these rounded aggregate percentages.

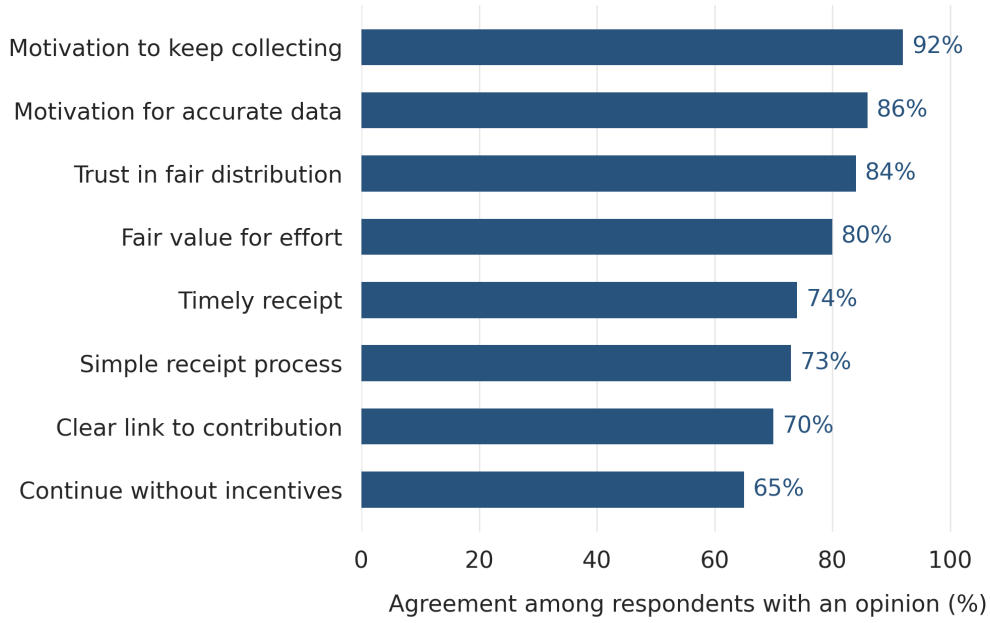


Figure 4. Agreement with incentive statements

Source: IWMI (2026a). Agreement is Agree plus Strongly agree among respondents giving an opinion. Valid opinion denominators ranged from 31 to 40; blanks and "too early to tell" are excluded. Percentages are rounded as reported in the analysis. These are perceptions, not measured effects.

Ten respondents selected "too early to tell" for timeliness, consistent with limited delivery experience. Nine neutral responses on the contribution-link item support the broader finding that earning rules were unclear. Understanding was positively associated with perceived fairness of value (Spearman $\rho = 0.35$, $p = 0.04$) and programme recommendation ($\rho = 0.32$, $p = 0.04$). These modest, exploratory associations do not establish causality and were not adjusted for multiple testing. This result is driven by the 3 Mozambique 'Very dissatisfied' respondents, who all answered 'Yes, fully' to understanding and gave NPS 10. Without the 4 flagged records: $\rho = 0.24$, $p = 0.14$. The fairness association holds ($\rho = 0.40$, $p = 0.02$, $n = 31$).

5.4. Preferences and continuation intentions

Cash or a stipend was the single most motivating option for 27/43 respondents (62.8%); training or skills was selected by nine (20.9%). Airtime/data, equipment and recognition/certificates each attracted two selections, and one respondent selected other (Figure 5). Cash was chosen by 10/12 respondents in Botswana, 5/9 in Mozambique and 12/22 in South Africa. Seven of the nine training preferences were in South Africa.

Thirty-nine respondents (90.7%) said they would definitely or probably continue if incentives were removed; 24 (55.8%) selected definitely. Sixteen of those 24 also preferred cash. Four said they probably would not continue, all four were on their first incentive, three of them preferred cash, and two were in Botswana. These responses are compatible with valuing financial support while caring about the programme, but they do not show that participation would persist after support stops.

The separate agreement statement about continuing without incentives obtained 65% agreement among those giving an opinion. The difference between the two retention questions suggests sensitivity to wording, answer format and question order. Social desirability is also possible, but cannot be quantified from this dataset.

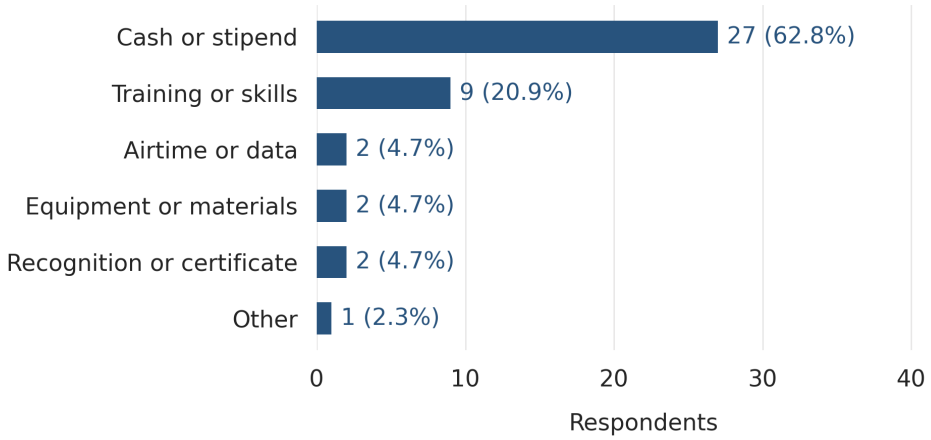


Figure 5. Most motivating incentive selected by respondents

Source: IWMI (2026a). n = 43; one preferred option per respondent. Other comprised one request for all options. Differences between countries are descriptive.

Twenty-four open responses addressed adequate incentives, of which 13 were judged interpretable in the analysis. Suggestions included South African monthly stipends of R360–R2,000, or R100–R300 per lesson or monitoring round; P500 per month or training in Botswana; and cash after each collection in Mozambique. Other requests included equipment, postgraduate training and temporary opportunities for young people. These sparse, non-standardised suggestions are not sufficient to set a payment rate or compare purchasing power across countries.

5.5. Recommendation and satisfaction

Twenty-four respondents scored programme recommendation at 9–10, 16 at 7–8 and three at 5–6. NPS was therefore (24 − 3)/43 × 100 = +48.8, reported as +49. The median score was nine. Thirty-eight respondents also selected “Definitely” in the separate categorical recommendation question. The two questions measure related but distinct responses.

Table 5. Recommendation scores and reported satisfaction

Group	n	Median score	NPS	Satisfied or very satisfied	Very dissatisfied
Botswana	12	8.5	+33	7	1
Mozambique	9	10	+67	5	3
South Africa	22	9	+50	15	0
Returning	26	9.5	+58	18	1
First time	16	8.5	+31	8	3
All respondents	43	9	+49	27	4

Source: IWMI (2026a). NPS rounded to the nearest integer. Country and experience rows are separate classifications and must not be summed together. The lapsed respondent is included in the overall total but not in first-time or returning rows.

No clear difference in recommendation scores was detected by countr

y (Kruskal–Wallis p = 0.73) or between first-time and returning participants (Mann–Whitney p = 0.30). Small subgroup sizes limit power; these results do not establish equivalence. Satisfaction correlated weakly with recommendation score (ρ = 0.19, p = 0.26). However, there is a stronger correlation without the 4 inconsistent records: ρ = 0.42, p = 0.015. Satisfaction and recommendation are therefore related.

Twenty-seven respondents (62.8%) selected satisfied or very satisfied; four (9.3%) selected very dissatisfied. Three of those four, all in Mozambique, also gave a recommendation score of ten and favourable ratings elsewhere. This

raises a possible response-scale, translation or administration issue that requires validation. The dissatisfaction responses remain part of the results.

5.6. Training platforms and credentials

Thirty-five respondents (81.4%) felt fully equipped to collect water-quality data. In-person workshops were preferred by 24 (55.8%), peer-to-peer training by 11 (25.6%) and online YOMA training by eight (18.6%). All eight preferring online training reported feeling fully equipped, but this small self-selected group cannot demonstrate the superiority of online delivery.

Data/connectivity costs were the most frequently reported training barrier: 14/43 (32.6%), including 6/12 in Botswana, 7/22 in South Africa and 1/9 in Mozambique. Device limitations were selected by three respondents, language by one and digital literacy by one; 25 reported no barrier. As multiple responses were allowed, these counts are not mutually exclusive.

Only 24 respondents supplied complete valid platform rankings. YOMA was ranked most useful 13 times and had a reported mean rank of 1.7, compared with WhatsApp at 2.1 and miniSASS at 2.2; lower ranks indicate greater perceived usefulness. These tools serve different functions, and the restricted ranking subset prevents treating this as a programme-wide platform comparison. Thirty-one of 43 rated WhatsApp groups effective or very effective; four South African respondents reported not belonging to a group.

Twenty-five respondents held a YOMA digital passport and 12 a paper certificate, with one holding both. Thus 36/43 held at least one of these and seven held neither; five of the seven were in Botswana. Of the 25 passport holders, 14 found it very valuable, 2 had used it in an application, 18 planned to, 4 did not plan to, 1 was unsure how and 2 said they did not understand how to use the passport. Courses and verified credentials were operational, but evidence of use for jobs or education was still limited.

Seventeen open responses discussed platform improvements. Themes included YOMA login/navigation difficulties (four), requests for a single YOMA/Atlas login and automatic certificate synchronisation (three), miniSASS identification concerns (three), and inadequate explanation of incentives (one). These are user reports, not independently verified technical defects. Among 40 training suggestions, advanced biomonitoring and data analysis/mapping each appeared five times, chemical testing three times, and communication or leadership skills four times.

5.7. Challenges and improvement themes

Of 41 respondents answering the challenge item, nine reported unclear earning criteria, five technical/network issues, four delays, two travel cost or difficulty and one poor communication. Twenty-four reported no challenge. Categories were multiple response and could overlap. The prominent concerns about criteria and timing were also reflected in the open responses (Table 6).

Table 6. Themes from open responses

Theme	Total people	Botswana	Mozambique	South Africa
Clearer criteria and communication	8	3	3	2
Cash, stipends or other money	8	1	3	4
Faster or more regular delivery	6	1	2	3
Travel, transport and exposure	5	1	0	4
Branded clothing and safety wear	4	1	0	3
More training and opportunities	4	0	0	4
Airtime matched to mobile network	2	0	1	1
Keep as is, too early or no suggestion	13	5	3	5

(IWMI, 2026a)

Project implementation experience adds a delivery constraint that the participant questionnaire does not independently audit: YOMA supported educational incentives and verified recognition, while cross-country financial distribution was unavailable. Other incentives required manual coordination and external providers, increasing workload and limiting digital monitoring. The survey's positive perceptions therefore assess the benefits people encountered across the programme, rather than validating the intended automated financial model.

6 Discussion

6.1. Educational delivery and financial feasibility

The main implementation distinction is between an operational educational incentive and an unrealised cross-country financial mechanism. The River Monitors course, certificates and verified credentials demonstrate that YOMA contributed to learning and recognition. The reported passport holdings and positive training experiences are consistent with that role. They do not demonstrate a functioning payment mechanism or automated tracking of all incentives.

Platform, funding and logistical constraints prevented the intended disbursement through YOMA across participating countries. Manual arrangements allowed other benefits to be organised, but shifted procurement, provider liaison, receipt confirmation and follow up to the project team. Future budgets should therefore include delivery and reconciliation labour, not just the face value of incentives. This operational requirement is consistent with the importance of institutional support and funding in water citizen science (San Llorente Capdevila et al., 2020).

6.2. Clear rules as part of a fair model

The most actionable survey finding is the gap between knowing incentives exist and understanding how they are earned. Awareness reached 32/43, but full understanding reached only 18/43. This result is influenced by the 3 Mozambique 'Very dissatisfied' respondents, who all answered 'Yes, fully' to understanding and gave NPS 10. The association between understanding and perceived fairness is compatible with the importance of transparent procedures, although better communication cannot be claimed to cause higher fairness ratings from these data.

Fairness concerns eligibility, predictable timing, transparent valuation and a way to query decisions. A plain-language explanation should distinguish support for participation, recognition of learning and any payment for approved activities. It should also explain individual versus group participation. Verifiable criteria need to remain understandable to contributors with different levels of digital access and experience.

6.3. Cash preferences and sustained participation

The preference for cash does not negate environmental or educational motivations. It may reflect immediate needs or the opportunity cost of monitoring. Evidence from Lake Tanganyika likewise places compensation alongside contribution to knowledge and local decision-making (Moshi et al., 2023). The Limpopo data support consulting participants on feasible benefits; they do not support assuming that courses alone will compensate for transport, data or time costs.

High stated willingness to continue without incentives should not be used to justify withdrawing practical support. The two retention questions yielded different patterns, and most respondents had limited incentive experience. Actual retention must be observed over time, including whether contribution rates remain stable, decline or shift to groups with fewer access barriers. Sustainable funding and institutional feedback are therefore part of the model, alongside individual motivation.

6.4. Learning recognition and inclusion

The preference for in-person and peer learning supports combining the River Monitors course with local facilitation. Connectivity costs affected a third of respondents and half of those in Botswana. Digital credentials are valuable only when participants can access them, understand what they certify and use them in relevant applications. The small number already using credentials is an early uptake result, not evidence of employment impact.

The young and predominantly female sample is relevant for interpreting these preferences but does not establish equitable reach. Future monitoring should compare participation and benefit receipt across gender, age, country, language and digital-access groups, including people who never enrolled or stopped participating. Accessible alternatives and human support should be assessed as part of delivery rather than treated as optional additions.

6.5. Recognising scientific contributions and data quality

A credible incentive model should value interpretation and communication as well as collecting observations. Community sessions can help monitors identify patterns, explain uncertainty and discuss responses with water managers. This aligns with citizen science principles on feedback and mutual benefit (ECSA, 2015), and with the emphasis on relevant research and ongoing communication in Amakhala (Nqowana et al., 2024).

Rewarding submission volume alone may encourage repetitive or low-value records. Future criteria should prioritise agreed monitoring schedules, complete metadata, quality checks and useful geographic coverage, while also recognising mentoring and interpretation. A scientifically valid unexpected observation should not be penalised because it differs from a model prediction. Participation verification and scientific validation should remain separate, with human review of disputed records.

6.6. Limitations and strength of evidence

This evaluation has a small sample, unequal country representation and no comparison group or linked pre-incentive measurement. Timing and experience differ by country; recent receipt, recall and social desirability may influence answers. No causal claim about submission frequency, data quality, retention, livelihood outcomes or Digital Twin performance is warranted.

Ratings also include respondents unaware of incentives and several internally inconsistent response patterns. These are retained, which avoids post hoc deletion of unfavourable responses but leaves uncertainty about interpretation. Portuguese wording and scale comprehension require checking before another round. Site names need standardisation; recorded form duration is not a reliable measure of active interview time.

The exploratory correlations are small, with nominal p-values and no multiple-testing adjustment. Additionally, correlations change when the 4 flagged records are excluded, and that none survives a Bonferroni correction (threshold 0.0125 for 4 tests). The programme's strongest evidence concerns participant preferences, awareness gaps, access barriers and delivery feasibility. Evidence of sustained impact requires linked monitoring and benefit records over repeated cycles, rather than stronger claims from the present cross-section.

7. Recommendations and future evaluation

7.1. Immediate operational priorities

Publish a short explanation of eligibility, earning criteria, benefit value, schedule, verification, individual/group participation and how to raise a query. Prepare English, Setswana and Portuguese versions, with additional local-language facilitation where needed, and test comprehension with participants. Give a realistic delivery commitment only after funding and provider arrangements are confirmed.

Retain YOMA for the functions delivered successfully: the River Monitors course, certificates and verified credentials. Confirm that participants can retrieve certificates, understand their meaning and use their digital passport. Pair online learning with in-person or peer guidance and help with access costs where needed.

Before promising financial incentives, test country-specific payments and service-provider coverage from approval to successful receipt and reconciliation. Confirm mobile network compatibility for airtime or data. Where benefits continue to be delivered manually, use a simple protected register of approved activities, expected benefits, delivery dates and receipt confirmations, with a named coordinator and a budget for their time.

7.2. Evaluation over repeated cycles

Table 7 outlines actions for future development. Re-survey the same consenting participants after at least three completed incentive cycles, using a pseudonymous identifier linked to verified monitoring records. Record the actual receipt date and delivery route, not just eligibility. Distinguish training-event support, regular monitoring support and recognition of learning in the next questionnaire.

Assess active contributors and submission frequency over agreed intervals; completeness, protocol compliance and scientific quality; continuity after support changes; geographic coverage; credentials obtained and used; delivery timeliness; participant understanding; and coordination time and cost. Include lapsed participants where

feasible and document recruitment, non-response and missingness. Place retention questions before incentive statements and cognitively test the Portuguese response scales, including back-translation.

Any trial of payments linked to verified contributions should use a pre-agreed capped budget, transparent criteria, human review and an appeal process. Evaluation should compare outcomes with pre-incentive records or a defensible comparison strategy where feasible. No standard cash rate can be derived from the 13 interpretable adequacy comments.

Table 7. Priorities for implementation and follow up

Priority and suggested timing	Lead roles	Evidence of completion
Before the next incentive cycle Clarify rules and test understanding	IWMI, local coordinators and participants	Plain-language rules; comprehension checks; accessible query channel
Before financial commitments Test funding, payment and provider arrangements	IWMI, UNICEF/YOMA, country partners and providers	Successful end-to-end country tests; signed responsibilities; reconciliation records
Each delivery cycle Track all benefits and coordination costs	Country coordinators, IWMI and providers	Protected benefit register; receipts; unresolved cases; staff time
During ongoing learning Support courses and credential use	YOMA, GroundTruth and local facilitators	Course completions; certificate retrieval; guidance and accessibility feedback
After at least three completed cycles Assess continued participation and quality	IWMI, technical and local partners	Linked survey and monitoring records; stated and observed retention; quality checks

Source: IWMI, 2026

Suggested sequencing from October 2026 onward; these are recommendations, not funded commitments or confirmed delivery dates.

7.3. Safeguards and accountability

Participation support should include safe access, appropriate protective equipment and clear field procedures. Incentive criteria should not encourage entry into hazardous water or require monitoring when conditions are unsafe. Provide a way to report a cancelled or incomplete visit without misrepresenting the observation, and distinguish reasonable participation support from any reward linked to a verified contribution.

Keep personal identity and payment details separate from substantive monitoring records, restrict access and record who approves and confirms each benefit. Check duplicates and unusual submission patterns through technical and human review, with a route for participants to query decisions. Communicate that certificates and skills do not guarantee a job, and avoid announcing collective infrastructure benefits without funding and implementation agreements.

7.4. Sustainability and scaling

Scaling should follow evidence of a workable delivery and monitoring arrangement. Expanding community networks increases reach; embedding responsibilities in institutions supports continuity; and strengthening local ownership deepens participation. These are distinct processes, consistent with scaling out, up and deep (Moore, Riddell and Vocisano, 2015). Reusable data interfaces do not by themselves make incentive distribution transferable.

Before expanding into new communities or countries, confirm local needs, payment capabilities, provider coverage, ongoing funding and the ability to track benefits. Reduce dependence on the central project team by resourcing accountable local coordination. Share results with contributors and water authorities so that the monitoring has an intelligible purpose beyond a reward cycle.

8 Conclusion

The evaluation in Botswana, Mozambique and South Africa found positive early perceptions of incentives, strong demand for cash or stipends and generally favourable fairness ratings. However, fewer than half of respondents fully understood the earning rules. Participants valued in-person and peer training, while connectivity costs and device limitations constrained inclusion. Women and young people formed a large share of the sample, but equitable programme reach remains uncertain.

YOMA successfully supported the River Monitors course, certificates and verified credentials. Platform, funding and logistical constraints prevented cross-country financial distribution. Other incentives required manual coordination and external providers, increasing workload and limiting digital tracking.

The small, uneven sample, limited incentive exposure and inconsistent self-reported responses restrict generalisability and leave effects on data quality, collection frequency and sustained participation unproven. The next phase should clarify earning rules, strengthen accessible training and participation support, monitor fairness and inclusion across groups, and confirm country-specific payment and provider arrangements before committing to financial incentives. Following participants over repeated incentive cycles, with linked records of verified contributions and benefit receipt, would strengthen evidence on delivery, participation and potentially data quality.

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Annexure A Survey questionnaire

Citizen Science Incentive Model Evaluation

Questions and response options from the original KoboToolbox instrument (IWMI, 2026b), with layout adapted for this annexure. Original spelling, numbering and options are retained. Zimbabwe appears in the original form, but the research and analysis in this report cover Botswana, Mozambique and South Africa only. Open response fields are identified below; no answers are reproduced.

Do you agree to participate in this survey?

Options: Yes; No.

A About You

Which member state do you reside in?

Options: Botswana; Mozambique; South Africa; Zimbabwe.

Which water body, site, or community are you monitoring or collecting data at today?

e.g., river name, borehole, site, or community name.

Open response.

Gender

Options: Female; Male; Other; Prefer not to say.

Age group

Options: 18-24; 25-34; 35-44; 45-54; 55-64; 65 or older; Prefer not to say.

How often do you currently collect or submit water quality data or observations?

Options: Daily; Weekly; Monthly; Occasionally / ad hoc; I have stopped submitting data; This is my first data collection / I have not submitted data before.

B Training and Skills Building Platforms

Original section heading: B. Training & Skills-Building Platforms (miniSASS application and YOMA)

1. How easy was it to access the training content on these platforms?

If you have not accessed the training content yet, select the corresponding option.

Options: Very easy; Easy; Neutral; Difficult; Very difficult; I have not accessed the training content yet.

2. Did the training you received through the YOMA and/or Train-the-trainers program equip you with the skills needed to collect water quality data confidently?

If this is your first data collection, answer based on how prepared and confident you feel.

Options: Yes, fully; Partially; No; Too early to tell / this is my first data collection.

3. Which training format worked best for you?

Options: In-person workshop; Online via Yoma; WhatsApp-based guidance; Peer-to-peer (trained by another citizen scientist).

4. Have you experienced any barriers accessing training content? (Select all that apply)

Options: Data/connectivity costs; Language of content; Device limitations; Digital literacy; None; Other.

Other barrier (please specify)

Open response.

5. What additional training or skills would you like the platforms to offer?

Open response.

C Recognition Platforms

Original section heading: C. Recognition Platforms (Yoma Digital Passport, certificates)

6. Have you received a certificate or digital credential for your participation?

Options: Yes, digital (Yoma Digital Passport); Yes, paper certificate; Both; Neither.

7. How valuable is your Yoma Digital Passport / digital CV to you?

Options: Very valuable; Somewhat valuable; Not valuable; I don't understand how to use it.

8. Have you used (or do you plan to use) your digital credentials when applying for jobs, learnerships, or education?

Options: Already have; Plan to; No; Unsure how to.

D Communication and Feedback Platforms

Original section heading: D. Communication & Feedback Platforms (WhatsApp)

9. How effective are the WhatsApp groups for receiving project updates and, where applicable, feedback on your data?

Options: Very effective; Effective; Neutral; Ineffective; I am not in a group; I have not submitted data yet / this is my first data collection.

E Overall Platform Evaluation

10. Rank the platforms you have used from most to least useful in supporting your participation. Use each numeric rank only once, and select 'Not used / not enough experience to rank' for any platform you cannot assess.

Apply the ranking options separately to Yoma, miniSASS and WhatsApp.

Options: 1 - Most useful; 2; 3 - Least useful; Not used / not enough experience to rank.

11. If you have enough experience to assess them, which platform needs the most improvement, and what specifically should change? (Optional)

Open response.

12. Based on your experience so far, would you recommend joining the citizen science programme to others?

Options: Definitely; Probably; Not sure; No.

13. Any other comments on how incentives are delivered?

Optional

Open response.

F Awareness and Understanding of the Incentive Model

Were you aware that this program offers incentives to citizen scientists for their participation?

Options: Yes; No.

How did you learn about the incentives available? (Select all that apply)

Options: Program training / onboarding session; Program staff / coordinator told me; Fellow citizen scientists / volunteers; WhatsApp / social media group; Poster, flyer, or printed material; Program website or app; Other.

Please specify:

Open response.

Do you understand how incentives are earned or calculated in this program?

Options: Yes, fully; Partially; No, not at all.

What part of the incentive system is unclear to you?

Open response.

G Type and Receipt of Incentives

Which of the following incentives have you personally received through this program, including any received today? (Select all that apply)

Options: Airtime or mobile data bundles; Lunch/food; Transport support; Certificates from trainings; Access to equipment or materials (e.g., test kits); Training / skill-building opportunities; I have not received any incentive; Other.

Please specify:

Open response.

Including today, approximately how many incentives have you received through this program in the past 6 months?

Options: This is my first incentive; 2 times; 3-5 times; 6 or more times.

I received the incentive(s) in a timely manner.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

The process for receiving incentives (e.g., submitting proof, verification) is simple and easy to follow.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

H Perceived Value Fairness and Motivation

The value of the incentive(s) I have received is fair given the time and effort I put into data collection.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

Based on my experience so far, the incentive motivates me to continue collecting and submitting water quality data.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

Based on my experience so far, the incentive motivates me to collect more accurate and higher-quality data.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

I would continue participating in this program even without receiving any incentive.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

It is clear to me how the incentive(s) I have received are linked to my performance or contribution.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

I trust that incentives are distributed fairly among all citizen scientists in this program.

Options: Strongly disagree; Disagree; Neutral; Agree; Strongly agree; Too early to tell / not enough experience.

If you could choose, which type of incentive would motivate you the most?

Options: Cash payment / stipend; Airtime or mobile data bundles; Recognition / certificate; Equipment or materials; Training / skill-building opportunities; Other.

Please specify:

Open response.

In your own words, what would feel like an adequate incentive to you (amount, frequency, or type)? (Optional)

Open response.

I Effect on Participation and Data Quality

Based on your experience so far, how has the incentive affected how OFTEN you collect or submit data?

Options: Increased a lot; Increased somewhat; No change; Decreased; Too early to tell / this is my first incentive or data collection.

Based on your experience so far, how has the incentive affected the QUALITY / accuracy of the data you collect or submit?

Options: Increased a lot; Increased somewhat; No change; Decreased; Too early to tell / this is my first incentive or data collection.

If incentives were removed, how likely would you be to continue volunteering as a citizen scientist?

Options: Definitely would continue; Probably would continue; Probably would NOT continue; Definitely would NOT continue.

J Challenges and Barriers

What challenges, if any, have you faced while receiving incentives, including your first incentive? (Select all that apply)

Options: Delays in receiving the incentive; Unclear criteria for earning the incentive; Technical / network issues (e.g., mobile money, connectivity); Cost or difficulty travelling to collect the incentive; Poor communication from the program about incentives; No challenges; Other.

Please specify:

Open response.

Please describe any challenge in more detail. (Optional)

Open response.

K Suggestions for Improvement

What would you suggest to improve the current incentive model?

Open response.

Is there a specific new incentive you would like to see introduced? Please describe. (Optional)

Open response.

L Overall Satisfaction

Based on your experience so far, how satisfied are you with the current incentive model?

Options: Very dissatisfied; Dissatisfied; Neutral; Satisfied; Very satisfied; Too early to tell / this is my first incentive.

On a scale of 0-10, how likely are you to recommend participating in this citizen science program to a friend or colleague?

Numeric response from 0 to 10.

Any other comments or feedback about the incentive model? (Optional)

Open response.

Annexure B Stakeholder consultations

The following consultations are dated in the project record. They informed discussion of inclusion, institutional roles, platform capabilities and the proposed incentive approach. The record is not a respondent sampling frame, and the number of entries should not be interpreted as the total number of interviews or interviewees.

Mariangel Garcia Andarcia — 4 April 2025. Citizen Science Inclusiveness Assessment discussion.

Khanya Bashe — 17 April 2025. UNICEF Citizen Science Inclusiveness Assessment discussion.

Jai Clifford-Holmes — 14 April 2025. Citizen Science Inclusiveness Assessment discussion.

Laura Danga — 4 April 2025. LIMCOM Citizen Science Inclusiveness Assessment discussion.

Camila Haux — 4 April 2025. YOMA application tour.

Desme Jacobs — 4 April 2025. YOMA application tour.

Dr Eddie Riddell — 4 April 2025. LIMCOM Citizen Science Inclusiveness Assessment discussion.

Dr Maryna Storie — 10 April 2025. LIMCOM Citizen Science Inclusiveness Assessment discussion.

GroundTruth consultation is also described in the project record, but a dated entry is not included in the list above. Evidence from these discussions is used as programme context; the participant survey reported in the main text is the empirical basis for the three-country evaluation.



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