

Research Report

Enhancing Drought Resilience: Evaluating the Livelihood Outcomes of a Solar-Powered Water System in Hanzila Village, Southern Zambia

Carol Mweemba, Giriraj Amarnath and Barbara van Koppen



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IWMI Research Report 192

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Contents

Executive Summary	vii
1. Introduction	1
1.1. Enhancing Community Climate Resilience through Water Infrastructure Development	1
1.2. Background and Timeline of the Action Grant Program	2
1.3. Conceptual Approach	3
1.4. Objectives, Research Questions, and Report Structure	3
2. Methodology	5
2.1. Selection of the Study Participants	5
2.2. Conducting Interviews and Data Collection	6
2.3. Data Analysis	6
3. Horizontal Polycentricity: Locally Led Integrated Planning and Implementation of the Solar-Powered Borehole	7
3.1. Step 1: Initiating Collaboration	7
3.2. Step 2: Diagnosis	7
3.3. Step 3: Envisioning Solutions	8
3.4. Step 4: Fitting the Financial Framework	8
3.5. Step 5: Implementation	9
3.6. Step 6: Using the Infrastructure	10
3.6.1. <i>Water committee for the Hanzila solar-powered borehole</i>	10
3.6.2. <i>Management for the efficient use of the solar-powered borehole by the water committee</i>	11
3.6.3. <i>Challenges in maintaining a solar-powered borehole by the Water Committee</i>	12
4. Livelihood Outcomes	13
4.1. Outcomes of the Solar-Powered Borehole on Drinking and Domestic Water Use	13
4.1.1. <i>Drinking, other domestic water uses, and livelihood benefits</i>	13
4.1.2. <i>Challenges of unequal access to water for drinking and other domestic uses</i>	16
4.1.3. <i>Outcomes of the solar-powered borehole on health and wellbeing</i>	16
4.2. Outcomes of the Solar-Powered Borehole on Enhancing Agricultural Practices	18
4.2.1. <i>Water uses for cultivation and livelihood benefits</i>	18
4.2.2. <i>Challenges of access to water for enhancing agricultural practices</i>	22
4.3. Hanzila's Role in Seed Production and Community Development	23
4.4. Outcomes of the Solar-Powered Borehole on Water for Livestock	23
4.4.1. <i>Water uses for livestock and livelihood benefits</i>	23
4.4.2. <i>Challenges of accessing water for livestock</i>	27
5. Horizontal and Vertical Polycentricity and Upscaling: The Role of the Local Authority in Supporting and Sustaining Locally Led Water Infrastructure Projects	28
5.1. Local Authority's Key Role in Partnering with the Action Grant Program	28
5.2. Local Authority's Key Role in Replicating and Upscaling Cross-Sectoral Locally Led Rural Water Development for Drought Resilience	28
6. Conclusions and Recommendations	30
7. References	32
Annex 1: Household Interview Questionnaire	35
Annex 2: FGD Interview Guide for Community Members	39
Annex 3: FGD Interview Guide for the Water Committee Members	41
Annex 4: Key Interview Guide for the Local Authority in the Monze District	42

Executive Summary

Recent droughts in Zambia have caused severe impacts on people's livelihoods, the environment, and the economy. For instance, the droughts in the Southern Province, as observed during the 2023/2024 farming season, affected agricultural productivity, crop failure, and food security. Water in most of the streams, rivers, and groundwater sources either dried up or operated at critically low levels. This made it difficult to access clean water for drinking and other domestic uses, irrigation, and livestock.

In 2023, the ACTION Grant Program, in collaboration with the Ministry of Agriculture (MOA) and the Monze Town Council, supported a locally led process to enhance drought resilience in the Hanzila community. In order to enhance the potential for replication and upscaling of lessons learnt, this demonstration project was embedded in Zambia's horizontal and vertical polycentric decision-making frameworks. Horizontal decision-making at the national and district-level tiers avoided sectoral mindsets. This allowed openness in local authorities' vertical communication with communities to listen to all the needs and potential solutions within the local context. Community engagement from the onset of all six phases of the project cycle was critical for community members to provide insights into the actual problems they faced, and to identify integrated solutions that could alleviate some of the problems. Involving community members also helped to instill ownership of the intervention.

In the six-step locally led process that was implemented, a multipurpose solar-powered borehole for drinking and other domestic uses, irrigation, and livestock was identified as the preferred solution to enhance drought resilience. The system, with 10 taps distributed in various locations within the village, was finalized in September 2023.

In July 2024, an evaluation of the process and an assessment of the livelihood outcomes were conducted to determine the extent to which the project had met its developmental objectives of reducing the effects of climate change by sustainably increasing the community's resilience.

Sampling for the evaluation included participants for both qualitative and quantitative interviews. For quantitative interviews, a sample of 40 households—each consisting of individuals aged 18 and above who resided in Hanzila—was drawn from the community. An almost equal number of males and females were selected. Further, all research participants represented people accessing various water needs, including drinking and other domestic uses, livestock watering, and irrigation. Further, in this study, participants for the focus group discussions (FGDs) were purposively sampled. Purposive sampling was used to select research participants who had knowledge about

the implementation of the borehole, either technically or through community conversations. The sampling strategy also aimed at ensuring that both sexes and different age groups and occupations (i.e., livestock keeping or crop farming), participated in the FGDs. The discussion focused on the responsibilities of women and men in managing water at the household level, as well as women and men engaged in livestock and crop farming.

Further, the sample comprised of members from the water committee and leaders of the community. Research participants also provided details on borehole usage, challenges encountered, and their perceived effects on drinking water, livestock watering, and crop irrigation. The water committee provided insights into the borehole's maintenance, operation, and measures to ensure water supply reliability.

Research findings on the pre-implementation phase of the solar-powered borehole, serving as the baseline for the outcome assessment, revealed that the people of Hanzila relied on various water sources, including hand pumps, hand-dug wells, rivers and streams, scoop holes, and rainwater. These water sources were used for multiple purposes, such as drinking, cooking, cleaning, washing, watering livestock, and irrigation. A borehole with a hand pump that supplied water for drinking, other domestic uses, and livestock was the most reliable, clean, and safe water source. However, due to growing demand, they congested their only source of clean and safe water. This resulted in household members spending long hours waiting to access water. Some households avoided waiting long hours trying to access this clean water for drinking and instead opted for unclean sources such as dug wells and streams. The study found that 20% of respondents indicated having used water from sources such as streams and scoop holes for drinking and other uses in the home to avoid spending long hours at the borehole waiting their turn to get water. Such sources endangered people's health by exposing them to waterborne diseases. After the solar-powered borehole was installed, none of the respondents mentioned using open water sources for domestic purposes, including drinking. The solar-powered borehole had clean water, which helped people access a safer water supply and reduced their chances of contracting waterborne diseases. It also reduced the time taken for people to collect water. The availability of 10 taps allowed people to access water simultaneously without having to face the hardship of queuing. Distance has also been reduced. Before the implementation of the borehole, 63% of respondents indicated that they used water sources which were 500 meters (m) away, as opposed to only 13% since the borehole was installed.

In addition, the number of households that started practicing gardening activities had increased. Before the

solar-powered borehole was completed, only 23% of male and female respondents had gardens for cropping and vegetable gardening activities. This proportion increased to 69% since the implementation of the borehole initiative. This illustrates that the solar-powered borehole promoted farming because it provided year-round access to water. It also helped the community to practice crop diversification, where they grew crops like maize, tomatoes, cabbage, kale, sweet bananas, onions, chilies, and Chinese cabbage.

In addition to the provision of food production, the gardens catered to economic needs, whereby farmers took their produce to Monze town markets to earn some income for their families. For each day that their produce was taken for sale, farmers earned on average ZMW 250 (USD 10) to ZMW 1,000 (USD 40). This has helped to enhance financial stability and support households to purchase food not readily grown within the village, enabling families to afford balanced meals for the healthy growth and development of their children. Additionally, the revenue derived from the sale of these crops was channeled to other income-producing ventures within the community, including small-scale marketing of household necessities such as soap, cooking oil, and salt.

In general, livestock management has improved since the installation of the solar borehole. First, the percentage of people who used distant streams and rivers for cattle watering decreased from 52% prior to the implementation of the solar-powered borehole, to 20% post-implementation. About 48% of respondents did not own any cattle. Farmers have since taken their cattle to public water points where they used their own pipes to fill large basins or troughs manually from the taps.

Despite the many benefits seen after the installation of the solar-powered borehole, some challenges persisted. First, households that did not live near the laid out pipes and taps still had to travel long distances to access water. For others, they had to pay extra funds to extend the supply lines to their homestead for an infrastructure that was provided to the community free of charge. This created financial burdens for some members of the community. Moreover, there were still households that could not afford to extend supply lines closer to their homestead. Such households still had to walk far to the new taps and hardly benefited from the reduced distance to access water, which was one of the challenges the solar-powered borehole project intended to address for the Hanzila community.

Second, there were also challenges concerning agricultural-related activities that supported irrigation in the gardens. One pertinent issue of concern was the lack of conveyance, such as pipes, to water the fields. About 40% of respondents indicated that the lack of supply lines to convey water into their fields posed a constraint. People had to physically carry water using buckets from taps in the field, which was labor intensive. On the other hand, 29% of respondents who also gardened did not highlight the lack of conveyance as a challenge.

Third, the installation of the solar-powered borehole in Hanzila represented a significant technological advancement for the community and introduced new challenges alongside its benefits. Unlike the familiar hand pumps maintained by community-appointed pump minders, the solar-powered system required specialized knowledge and skills for operation and maintenance. Community members lacked the expertise in maintaining and repairing its components, which differs significantly from traditional hand pumps. This, however, could be addressed through the training of community members by the local authority to build capacity and ensure the borehole's continued operation.

Despite a few challenges noted from the Hanzila solar-powered borehole, it is recommended that this integrated locally led process be replicated and upscaled in other communities in Zambia. Participation in the detailed technical design is encouraged so everyone, irrespective of village layout, can benefit from available funding or from equitable supplementary contributions. As solar-powered boreholes are new and complex, capacity building for operation, maintenance, and repair of solar-powered boreholes is required. The local authority holds such a mandate for capacity building and post-construction support.

The government's horizontal and vertical polycentric decision-making frameworks enabled this demonstration project and has been recommended as a mechanism to further upscale sustainable year-round access to water for multiple uses, even in remote communities such as the Hanzila village. The findings showed that solar-powered boreholes improved community development, particularly by providing a reliable water source not only for domestic uses, but also for crop production. In addition, people saved time, remained healthy and food secure, achieved better nutrition, and generated an income, even during periods of droughts and under the impacts of climate change.

Enhancing Drought Resilience: Evaluating the Livelihood Outcomes of a Solar-Powered Water System in Hanzila Village, Southern Zambia

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1. Introduction

1.1. Enhancing Community Climate Resilience through Water Infrastructure Development

The global repercussions of climate change have continued to manifest throughout the world. Severe droughts, periods of flooding, and higher temperatures are occurring widely (Seneviratne et al. 2012; Seneviratne et al. 2021). Global warming and resulting changes in climate and weather regimes affect both the structure of natural systems and human societies (Mukheibir and Ziervogel 2007). These events cause extreme hardship and even death, especially for the most affected groups such as low-income rural farmers and pastoralists who depend on rainfed agriculture (IPCC 2014; FAO 2016; World Bank 2013). They have a very limited capacity to adapt to climate change and droughts, primarily owing to the limited number of resources (IPCC 2014; World Bank 2013). Significant droughts lessen their ability to grow crops to sustain a livelihood. This leads to poverty and compels many to migrate. The worsening lack of water during drought conditions also affects the availability of water for domestic uses, including safe and clean drinking water, toilets or latrines, and hygienic practices—increasing the health risks among already vulnerable populations, particularly women and children (UNICEF and WHO 2019).

The challenges observed in this context require both immediate response measures during weather emergencies and long-term measures to improve resilience and maximise adaptability to the situation at hand. Community-based initiatives and the use of solar energy in areas with sufficient sunlight are key to averting the problems of a climate-induced water shortage. These technologies enable the population to access water and eliminate the need to rely on erratic rainfall, thus increasing the community's ability to adapt to climate change, without adding greenhouse gases to the atmosphere.

Improved water management practices are considered vital for increasing climate resilience in rural areas as they safeguard public health, support economic growth, sustain ecosystems, and make communities less vulnerable to the consequences of climate change including—droughts, floods, and extreme weather events (Mosleh et al. 2023). The need for radical change in water

management strategies is also highlighted by global committees, including the 27th Conference of Parties of the United Nations Framework Convention on Climate Change (COP 27) (CRFS Alliance 2022).

Most countries in the Southern African region, Zambia included, have experienced persistent droughts. Droughts have impacted the availability of water resources to meet peoples' and animals' water needs. Yet, having adequate access to water resources serves as a lifeline for people, particularly in rural communities where water is needed year-round for drinking, other domestic purposes, livestock watering, as well as for dry spell, seasonal, or year-round irrigation, construction, and other productive uses (Mosleh et al. 2023). A regular water supply enables farmers to keep their crops and livestock thriving during dry spells or drought periods, which in turn reduces their susceptibility to food shortages. In addition, adequate moisture in fields through water harvesting or drip irrigation, and the practice of agroforestry enables rural populations to adapt to new climatic conditions and use water in a more efficient manner (Ray and Majumder 2024). However, infrastructure—such as boreholes equipped with hand pumps, deep and shallow wells (some with motorized drills and others using makeshift pulleys)—is still limited. Dependence on open sources like rivers, streams, and scoop holes remains high (Mweemba et al. 2023b). During the rainy season, people also harvest rainwater for household uses, but this is rarely stored because of a lack of infrastructure to conserve water.

Thus, in countries like Zambia, the reduced availability of water for multiple uses over time, especially during the dry season, affects the rural population most because of the limited availability of water infrastructure needed to access it (Delia 2022; Muller 2012; Patel et al. 2015). As a result, rural communities resort to accessing water from open scoop holes and streams despite such sources being unclean, which poses health risks to water users (Mweemba et al. 2023a).

The geology and landscape may exacerbate these challenges. Communities located far from primary water supply sources cover long distances to access water. This consumes time that could be allocated to other livelihood activities. It also requires considerable energy from people to carry heavy loads of water from distant sources. As a result, the amount of water that can be transported back home is significantly reduced due to these time and energy demands (Mweemba et al. 2023b).

Getting water for domestic use has been even more difficult in hilly terrain. In many communities, it is common to find women and children carrying water over long distances, sometimes balancing the vessels on their heads. Men also travel long distances to fetch water, mainly for livestock and, at times, for irrigation. However, high temperatures and decreased rainfall have led to an uptick in casualties (Jain 2007, Thurlow et al. 2009).

The southern part of Zambia also experiences changes in average annual rainfall (Jain 2007). For example, during the 2023/2024 season, the southern provinces received just about 250 millimeters (mm) of rain compared to northern provinces, which received above-average rainfalls of more than 2,000 mm. Moreover, rising temperatures have contributed to increased water loss in the southern region, further intensifying competition for limited water resources.

As a result of reduced rainfall, the 2023/2024 farming season suffered severe losses in crops, with a decrease of 53.6% in maize production. Most of the streams and rivers, such as the Zambezi River, Kafue River, and Luangwa River, reached their lowest records, and groundwater sources accessed through wells and boreholes became dry. This negatively impacted people's ability to access clean water for drinking, domestic purposes, and for rural populations, to support cropping and livestock production.

Addressing these challenges requires an integrated approach, involving various measures. For example, it may include the development of water infrastructure with the participation of the intended communities. It may also include investments in rainwater harvesting mechanisms to enhance water availability for irrigation. Constructing infrastructure for different purposes—including drinking, domestic needs, livestock watering, and small-scale irrigation—is essential for building resilience to various challenges related to water access challenges at the community level (Mweemba et al. 2023b; OECD 2018; World Bank 2020). In addition, having adequate water storage and distribution channels provides opportunities to maintain a reliable water supply even during droughts. In addition, promoting sustainable water use and adapting to the impacts of climate change are also critical to protecting people's livelihoods. For example, having water to irrigate crops during drought periods or during dry seasons of the year can contribute to improved well-being through enhanced food production (IWMI 2022).

As the impacts of climate change intensify and increase people's vulnerabilities, it is important to integrate targeted approaches into community programs aimed at reducing the impacts of climate change. For example, when addressing the negative effects on water resources, communities can be supported with the right tools and knowledge to sustain their water systems. Moreover, ensuring that rural communities have adequate water resources is one of the most effective ways to support

human life because this translates to improved health and enhanced economic activities. It is also necessary for achieving sustainable development and improving the quality of life for current and future generations. This was the goal of developing the solar-powered borehole for the Hanzila community in the Monze District in Southern Province of Zambia, from February 2023 onwards, and serves as the focus of this report. This was done in partnership with the Local Led Climate Adaptation ChAMPION (ACTION) Grant Program, together with the Monze Town Council and the Ministry of Agriculture (MOA).

1.2. Background and Timeline of the ACTION Grant Program

The ACTION Grant Program is part of the global CGIAR Initiative on Climate Resilience, abbreviated as ClimBeR (Amarnath et al. 2023; Mweemba et al. 2023b). The goal of the program is to reduce water challenges that are worsened by the impacts of climate change, specifically droughts, as people have a greater chance of losing their available water supply due to the drying up of water sources. Zambia is one such country. In collaboration with the MOA, scientists in the ACTION Grant Program sought to implement an integrated locally led project to enhance drought resilience embedded in Zambia's polycentric decision-making. By demonstrating a participatory approach and assessing outcomes, the innovative enhancement of drought resilience and adaptation to climate change was expected to be scalable for decision-makers.

As the 2023/2024 drought in Southern Province was the worst seen in recent decades, the MOA and ACTION scientists contacted the local authority of the Monze District. This region is dry, characterized by an arid subtropical climate. The local authority and an official from the MOA advised implementing the envisaged demonstration project in Hanzila. This community is located approximately 20 kilometers(km) west of Monze town and about 300 km south of Lusaka. At the time, it faced severe water challenges, including limited access to clean water. The only communal borehole with a hand pump was often overcrowded, while open water sources—such as streams and scoop holes— had dried up, affecting water for drinking and other domestic uses, livestock, and crops. Recognizing the community's expressed interest in irrigation, the planning and implementation process was conducted through a locally led approach, facilitated by the first author of this report.

The timeline of the ACTION project on the ground was as follows:

- February 2023 to September 2023: Locally led planning, construction and handover of the solar-powered borehole.
- July 2024, after about ten months of system operation and water use: Assessment of (a) sustainable

operation and maintenance of the solar-powered borehole and (b) livelihood outcomes for climate resilience compared to the pre-project baseline.

1.3. Conceptual Approach

Polycentric governance describes the different layers of management systems, which have several overlapping authorities taking part in the decision-making process (Ostrom 2005; Ostrom et al. 1961). The process through which decision-making occurs within and across units in a lateral way is referred to as horizontal polycentricity. When decisions are passed on from the top authority to lower levels of the governance framework and vice versa, this is described as vertical polycentricity (Mulholland and Berger 2017).

Inclusive locally led processes to improve drought resilience are anchored in community-scale horizontal polycentricity. All livelihood dimensions and resources of all community members count. This integration shapes external support throughout the usual project cycle. Integrated participation starts from the earliest project phases onwards. Figure 1 highlights all six steps in the common project cycle that should be locally led: initiating collaboration, diagnosis, envisioning solutions, fitting the financial framework, implementation, and using the infrastructure. These steps were followed in Hanzila (Mweemba et al 2023b), demonstrating a shift away from the traditional top-down approach. This process avoids the conventional model of vertical planning and parachute projects, in which solutions are designed externally and handed over to communities after step five—just before the community is supposed to start using the results of the intervention. Active community participation from the first steps of the project cycle onwards, ensures interventions are adjusted to local conditions (Jiménez et al. 2019; UNESCO, UN Water and World Water Assessment Program 2003). Moreover, it opens opportunities to better recognize people's priorities. Both are key conditions for sustainability.

Local contextualization and prioritization by the people themselves are especially important measures to strengthen drought resilience. Both women and men in rural communities need water for domestic as well as one or more productive uses. While domestic water needs are universal and a well-recognized priority, as suggested in Sustainable Development Goal 6.1, basic productive uses are equally vital for life. However, productive water uses depend on the diverse livelihood strategies of different households and the local availability of water resources (Hellum et al. 2015).

The approach began by establishing contacts and conducting a baseline diagnostic to assess existing access to water and the challenges faced. This was followed by envisioning solutions that fit the financial framework, implementation, and use phases.

In vertical polycentricity, governments, NGOs, the private sector, and other support agencies should be able to respond to communities' integrated priorities—encompassing both domestic and productive water uses—within the framework of financial and technical support they are able to provide. However, vertical polycentric decision-making by governments from national to district to local levels is typically organized in sectors that bundle expertise and have their own mandates and funding earmarks. Even within the broader field of water-related services, the Water, Sanitation and Hygiene (WASH) sector tends to operate independently from departments of agriculture or environment. Within the department of agriculture, the irrigation and livestock units may work independently as well. As a result, water infrastructure is often designed to serve the needs of a single sector or unit. However, a widely observed response by rural communities is that they adapt these single use schemes to meet their multiple needs (Moriarty et al. 2004). Multipurpose schemes help prevent situations in which one sector implements water infrastructure for domestic use, while another implements separate systems for irrigation in the same community (Renwick et al. 2007). Upon realizing that multipurpose infrastructure is cost-effective, interest has grown for the planning of such multipurpose schemes (Jepson et al. 2023).

However, for the government and other sector-based institutions to respond to locally led design that meets all the basic water needs for life, some form of horizontal polycentric decision-making is required within the lowest tier of government. The units responsible for WASH, irrigation, and livestock need to communicate and be able to pool funding and expertise across their sectors. The ACTION project in Hanzila addressed this challenge.

Horizontal polycentric governance at the national level enables coordination between international initiatives, such as the ACTION Grant Program, and governments. As envisaged in the present study, this enables the operationalization of international support from the top down, embedded in existing or potential polycentric decision-making in the Monze District and the rest of Zambia. This, in turn, is a key condition for replicating and upscaling bottom-up innovations to strengthen climate resilience across Zambia and other rural areas in the Global South.

1.4. Objectives, Research Questions, and Report Structure

The study's overall objective was to facilitate and document a replicable, locally led approach to enhance drought resilience, and to evaluate its sustainable outcomes for multi-faceted livelihoods in the Hanzila

community. The findings aim to inform potential upscaling within Zambia's polycentric decision-making frameworks for climate adaptation.

The research questions and structure of the report are as follows:

- How were the six steps of the locally led ACTION project implemented from February to September 2023, and how was the solar-powered borehole operated and maintained by July 2024, almost a year later? (see Section 3)

- What were the project's multifaceted livelihood outcomes and challenges faced by July 2024? (see Section 4)

- What was the role of the Monze District local authority in vertical polycentric decision-making, and what does this imply for the potential upscaling of the locally led process and livelihood outcomes of the project in Hanzila? (see Section 5).

Section 6 presents conclusions and recommendations.

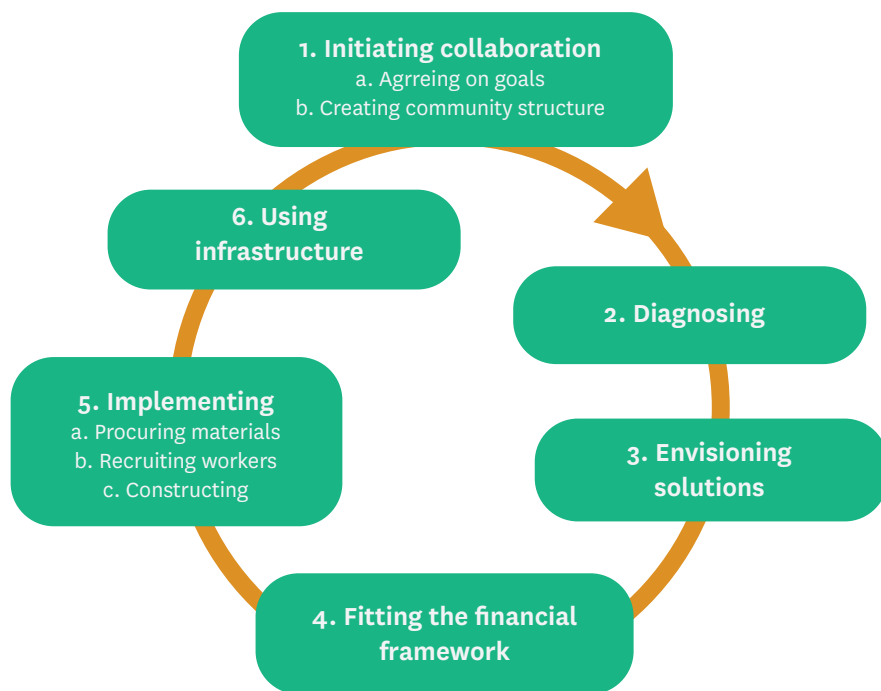


Figure 1. Stepwise participatory process for implementing community-led water infrastructure to enhance resilience and food security.

Source: van Koppen et al. 2020

- i) **Step 1: Initiating Collaboration:** The first step is to establish contact between project implementers and the community to initiate collaboration, set project goals, and create a structure for achieving those goals.
- ii) **Step 2: Diagnosing:** The second phase of engagement focuses on diagnosing the community's existing resources and challenges, which the project will try to resolve.
- iii) **Step 3: Envisioning Solutions:** Step three centers on understanding the challenges faced by the community in order to identify responsive solutions. The solutions are proposed by communities directly impacted by these challenges because they are better placed to recommend context-specific solutions.
- iv) **Step 4: Fitting the financial framework:** Once the preferred water solutions to address the impacts of climate change are identified, associated infrastructure costs are determined and financing is sourced to respond to community challenges.
- v) **Step 5: Implementation:** The next stage involves implementing the selected water infrastructure, which is undertaken with active participation from the local community as primary users.
- vi) **Step 6: Using infrastructure:** The last step includes monitoring and evaluating the project's impact to ensure that initial plans and the purpose for developing the project remain aligned.

2. Methodology

2.1. Selection of the Study Participants

The community-led process from February to September 2023 was documented by the facilitator, based on a literature review, focus group discussions (FGDs), interviews, and observations (Mweemba et al. 2023b). Section 3 provides a synthesis.

The study, conducted in July 2024 adopted a mixed quantitative and qualitative method. For the quantitative part of the study, 40 household respondents were sampled from members of the Hanzila community. The sampling ensured that there was representation of both men and women. An almost equal number of sexes was achieved (19 men and 21 women).

Almost all respondents used water for multiple uses, including drinking, other domestic uses, irrigation, and/or livestock watering. All 19 men in the sample tended to cattle or small livestock. Some women owned cattle but were not involved in tending to it, though they participated in tending to small livestock such as chickens, goats, and sheep. Part of the respondents (both men and women), were engaged in small-scale farming, particularly gardening. Further, women, children, and some young men collected domestic water from the solar-powered borehole for drinking, bathing, cooking, cleaning dishes, and other household needs.



For qualitative interviews, participants for the FGDs were selected using a purposive approach. The specific criteria used to identify eligible participants included individuals who regularly collected water from the borehole and engaged in agricultural activities. The criteria also included knowledge of the implementation process (i.e., participants with direct experience or knowledge relevant to understanding how the solar-powered borehole was implemented), current outcomes, and usage.

For this study, three FGDs were conducted. The first one comprised of 11 men and 10 women who provided insights into their water usage patterns, challenges encountered, and perceived benefits. In order to ensure diversity among research participants, the sampling strategy took into consideration factors such as age, gender, and those involved in different livelihood activities, such as small-scale farmers engaged in gardening, keeping cattle, and rearing small livestock. The aim of ensuring the diversity of participants was to understand how boreholes have influenced people's multifaceted livelihoods.

The second FGD meeting was open to a large number with no restriction on participation, provided participants were from the Hanzila community. A total of 72 men and women attended the meeting (see Figure 2). The discussion aimed to get as much insight as possible from people about how the solar-powered borehole influenced their lives and the challenges they faced.



Figure 2. Community members during the FGDs in the Hanzila Community. (photos: Agricom Media 2024)

The third FGD comprised water committee representatives selected to support the management and operation of the solar-powered borehole. A total of five males and five females were part of this FGD. The representatives provided insights into how they were managing the borehole and issues around the maintenance of the borehole. The sample also included 10 water committee members – five women and five men. They

provided insights into how they supported the borehole infrastructure's management and maintenance.

In addition to the FGDs, individual interviews were conducted with informants. Their selection was purposive. The first key informant was a local leader who helped facilitate community engagement during the project's implementation. Second, a local authority official from the

Monze Town Council was also selected to provide insights about the role of the local authority in enhancing access to the rural water supply.

2.2 Conducting Interviews and Data Collection

During the household interviews, respondents were asked questions regarding their access to water before the installation of the solar-powered borehole and any observed changes in livelihood opportunities since the borehole was implemented. Other questions asked were with regards to the operation and maintenance of the borehole. A structured interview questionnaire (see Annex 1) was used to ensure consistency and thoroughness in addressing questions related to both the rainy season and the dry season. Responses were recorded digitally to facilitate ease of analysis and interpretation.

The FGDs conducted with community members, i.e., ordinary members, pastoralists, small-scale farmers, and water committee members, gathered information about the impact of the solar-powered borehole on community water access and how water was used (see Annex 2). Similar interviews were conducted with committee members of the Hanzila borehole (see Annex 3).

Before each interview, the purpose of conducting the study was communicated to all participants. Providing accurate information was also emphasised to ensure that the data collected truly reflected what was on the ground. The researcher also encouraged groups to respect each other's opinions and value each contribution. A structured discussion guide (see Annex 2) was used with specific questions about the borehole's installation and its impact on the community.

Efforts were made to ensure that all interview participants had their voices heard. Recognising that there would be divergent views from men, women, and youth, the researcher ensured that all participants had equal opportunities to contribute their views. While some members seemed unwilling to participate, they were

encouraged to share their opinions based on their experiences since the installation of the borehole. Further, probing questions were also used deliberately to bring out specific issues that might not have been immediately apparent.

Interviews were recorded with the participants' consent. Recording devices were used to capture the conversations and interactions among participants during the FGDs to ensure accuracy.

The interview with the local authority investigated its general role in enhancing access to water supply in rural areas. The interview also explored how local authorities ensured the sustainability of existing water infrastructures in rural communities. Annex 4 provides details of the interview questions used to conduct the investigations.

2.3 Data Analysis

Quantitative data was analyzed using Statistical Package for the Social Sciences (SPSS) software to gain insights into the relationships and patterns within the dataset. Initially, the data was cleansed and checked for accuracy, with any missing values or outliers addressed. Descriptive statistics, such as frequency distributions, were computed to summarize the key characteristics of the data. Visualizations such as graphs and tables were generated to explore the distribution of the variables. Inferential statistics were then applied to test hypotheses and examine potential relationships between variables. The findings were carefully documented and presented, providing a comprehensive overview of the data's characteristics and the conclusions drawn from the analyses.

With regards to the information from the FGDs and key informant interviews, the data was coded by systematically categorising text into themes and developing concepts to show the outcomes of the discussions. Key issues highlighted during the interviews by research participants were included in the report as part of the research findings.

3. Horizontal Polycentricity: Locally led Integrated Planning and Implementation of the Solar-Powered Borehole

The borehole was implemented according to the six steps of the locally led process mentioned in Figure 1.

3.1. Step 1: Initiating Collaboration

In February 2023, the ACTION team of the CGIAR Research Initiative on Climate Resilience (ClimBeR) and government officials from the national and district level MOA conducted a field visit to Hanzila to initiate discussions on a project. This initiative aimed to create a platform where

community members could participate in developing an infrastructure suited to their context.

The first meeting with the Hanzila community was intended to understand the contextual issues and challenges they faced. Community members, including men, women, youth, and community leaders, highlighted a number of water-related challenges they experienced in relation to water for drinking, irrigation, and livestock (see Figure 3).



Figure 3. Initial engagement with community members, the ClimBeR Team, and government officials from the MOA. (photos: Agricom Media 2023)

3.2. Step 2: Diagnosis

A majority of the issues highlighted were similar to the challenges faced by most rural communities in Zambia. In rural communities that lacked adequate water infrastructure for storage and conveyance, people's lives revolved around searching for water for drinking, cooking, and cleaning. In the Hanzila community, people relied on multiple sources of water.

All water sources in the Hanzila community served multiple purposes: drinking, food preparation, cooking, cleaning, bathing, washing clothes, and productive activities such as watering livestock and crops and making bricks. Throughout the rainy season and into midyear, open sources like streams and scoop holes provided sufficient water. However, as the year progressed, these sources dried up, leaving many households with limited options for their needs.

Reduced rainfall and persistent droughts continued to compromise the quantity of water in these sources over the years. For example, open sources, which were once reliable all year round, began drying up by midyear, leaving the remainder of the year without natural water resources for people to use, affecting domestic and agricultural needs. This meant that when nearby open

sources dried up, men, both young and old, had to walk long distances to find bigger streams, rivers, or dams to provide water for their cattle. In addition, households that had small gardens near streams could no longer secure water for crops and were forced to stop their gardening activities.

The public borehole equipped with a hand pump in Hanzila remained the community's only and most reliable year-round water source when other sources had dried up. In addition, it provided clean water that was suitable for drinking compared to open sources that were vulnerable to contamination. At the nearby school there was another borehole, but this was primarily owned and managed by the school. The general public was restricted from accessing water from this borehole as it was reserved for school-going children and staff. At best, community members could be allowed access for drinking only, but even this was not always guaranteed.

Despite the public borehole being reliable all year round, it became overcrowded, creating a situation that reduced the quantities of water for each household. The borehole served approximately 500 households and animals in the village and provided water for irrigating gardens. Meeting the high demand for all water needs caused difficulties in access, especially during peak times when most people

needed to collect water to start cooking or bring livestock to drink water. This high demand also caused people to stay in queues for a long period of time, waiting their turn to get water. Women, primarily responsible for securing water for drinking and household needs, were increasingly under pressure to ensure their households had sufficient water. At times, they had to walk long distances to access water from other less congested sources, a situation that caused strain while carrying heavy buckets on their heads. Men also had to walk long distances to take their cattle to drink water or wait long hours at the borehole before their turn to water their livestock. This competition for water access led to conflicts at times, as some people grew impatient, and disputes became common. Additionally, during the dry season, water use for gardening was disallowed to prioritize essential needs like drinking and livestock watering. This limited opportunities for food and income from vegetable gardening.

Further, the borehole frequently broke down because it was used continuously without rest. When this happened, it caused further stress to the users because it meant the community was left without a reliable and clean water source that was within reach and had to travel to distant places to access water.

Following the discussions of the key challenges the community faced with available water sources, they mapped out existing water sources on paper to show what resources they had at the time. The meetings saw active participation from diverse community sectors, including pastoralists, crop farmers, local leaders, elderly individuals, and youth (Mweemba et al. 2023b). This inclusive process of ensuring participation from all groups and users of water in the community was intended to ensure a comprehensive understanding of water access points across the entire village, how they were used, and the challenges people faced in using all the mapped-out water resources.

On pieces of paper, participants highlighted points where scoop holes, open water sources, wells, and boreholes were found. They also specified which sources were used for specific water needs, such as drinking, other domestic uses, livestock, and crop watering.

3.3. Step 3: Envisioning Solutions

The objective of this step in the process was to allow community members to envision solutions that responded to the water challenges they identified for their community. Separate groups of men and women suggested ways to improve access to water that would respond to their unique needs. Men were more interested in having a solution that would improve access to water for livestock, such as dams, weirs and solar-powered boreholes. Women were more interested in improving access to water for drinking and other domestic uses, reducing the need to queue for long hours. They also proposed water access for crop irrigation in small gardens and were more interested in having a

solar-powered borehole along with an additional borehole fitted with a hand pump.

After thorough discussions and guidance by the ACTION team on the technical options and cost implications for each of the proposals brought forward, the community settled for a solar-powered borehole as the most plausible option that would meet the community's primary water needs. The solar-powered borehole was likely to be best because it was seen as a solution to water for drinking and other domestic uses, while also reducing the challenges of congestion when accessing water. It was also seen as a viable solution to enhance access to water for irrigating gardens, and providing adequate water for livestock watering.

3.4. Step 4: Fitting the Financial Framework

The ACTION team secured funding totaling ZMW 438,688.80 (approximately USD 17,548) for the entire project. This included the development of the solar-powered borehole and its associated infrastructure, such as pipes, taps, tank stand, solar panels, and other accessories.

The project invited qualified vendors to bid for the construction of the borehole in Hanzila. As proposed by the ACTION Grant Program in the Terms of Reference (ToR) for bidders, this borehole was designed to have an approximate depth of 100 m into the ground and a solar-powered pump system. In addition, the borehole was to have a 10,000-liter storage tank and an elevated tank stand to ensure good gravity flow of the water supply.

Regarding pipelines, the ToR recommended a 1 km network of pipes connecting the borehole to 10 strategically located taps. The distribution of the taps mostly covered the area allocated for irrigation, and some areas situated closer to people's homesteads.

Potential bidders submitted their proposals showing details of the bill of quantities and the cost estimate required to complete the work.

During the selection process, emphasis was placed on evaluating bids with the most competitive costs. In addition, bidders who showed experience in working on similar projects in collaboration with the community as well as in executing similar projects funded by multilateral donors, were also considered.

Following the evaluation of the bids, the project to develop the solar-powered borehole was awarded to one contractor, who subsequently entered into an agreement to commence work on the borehole. The contractor committed to executing the project by strictly following specified standards and ensuring quality implementation of the borehole. They also committed to adhere to the timelines outlined in the project plan.

Although the contractor initially did not follow the agreed upon depth of the borehole, this was corrected amicably before community members started using the borehole.

3.5. Step 5: Implementation

Determining the precise site for the implementation of the borehole began in June 2023 when the ACTION Grant Program facilitator convened a meeting with the contractor and community members to agree on the location. Ensuring community participation in this process was vital to promoting fair access to water for all groups—women, men, children, small-scale farmers, and livestock keepers—and as many community members as possible. This collaboration was also essential to preempt any future disputes over ownership privileges as well as any cultural considerations.

During the initial gathering, it was agreed that the site was to be centrally located and accessible to everyone, in order to meet all water needs prioritized by community members. Fortunately, the Hanzila village already had three hectares of land under joint community ownership. The land was allocated by the local chief as a designated area that could be used for any project proposed by the community. Previously, community members had submitted a request to use this land for various initiatives, including a dairy milk project. The land allocation was also formally documented in a letter addressed to the Hanzila community, in which the chief granted permission for communal use. This implied that the land identified for drilling the borehole was already the property of the entire community. Hence, there was a clear understanding among community members that a borehole would be installed on publicly owned land and meant that no individual could claim ownership of the land and the water infrastructure once it was developed. Everyone would have equal access to land and water resources. Therefore, by default, communally owned land was considered the first choice as the location for where the borehole could be implemented. With regards to gardening activities, the land had sufficient space to accommodate all those who wished to use the space for small-scale gardening. The area also had enough room for livestock watering, provided a watering trough would be constructed to support it.

Further siting criteria were implemented to ensure optimal land use within the publicly owned area. This included locating the borehole closer to people's homesteads. Installing it further away would have increased the risk of theft as some of its significant components would be vulnerable and exposed in isolated areas.

The other consideration for site selection was a location that could provide sufficient water yields. Geophysical surveys were conducted to ensure that the site selected had adequate groundwater reserves that could sustain a consistent water supply throughout the year. During

transect walks involving community members, the ACTION Grant Program facilitator, and contractors, three out of the four preselected sites qualified under geophysical surveys and met the suggested criteria of having adequate water reserves. Although three sites showed potential for sufficient water yield, one of them was immediately disqualified due to its unfavorable distance from people's homesteads.

The remaining two locations were subjected to a final criterion which was to have a site that would be at an adequate distance from most households to ensure that people did not have to walk far to access water, particularly for drinking and other domestic uses. Despite these considerations, some households were still situated further from the sites. As has always been the case for communal water resources, some homesteads would fall outside advantageous locations especially when spread across a vast area.

After careful deliberation and technical evaluation, a site located approximately 100 m from a few homesteads was chosen as it met the proposed criteria.

The drilling of the borehole began in July 2023, after the contractor obtained all the necessary permits from the local authority. During the entire borehole implementation process, community members—including groups of young men who monitored the drilling process closely—participated actively. Their involvement was important to ensure that what had been agreed upon in the contract was adhered to. For example, community members monitored the area to ensure that the correct depth of the borehole was reached and that the materials used were of good quality.

Once drilled at the agreed upon location, it was also essential to establish how the supply lines would be laid to discharge water outwardly to cover a radius of 1 km, as agreed in the contractor's ToR. Taps were strategically installed in selected parts of the village where community members suggested, ensuring reasonable access to water resources. The three-hectare plot proposed for gardening activities received the highest concentration of taps. This was intended to facilitate widespread public use and maximize the utility of the infrastructure for agricultural purposes.

To further enhance accessibility to water for drinking and other domestic uses, some taps were put up near people's homesteads in various directions within the village. However, because some households were situated much further from the 1 km radius where the taps were installed, some of those households decided to invest in extending the water supply closer to their homes using their own money. Nonetheless, those without sufficient resources to extend supply lines closer to their homesteads lost out on this. This meant that they covered a longer distance to carry water from the taps to their homes compared to other people within the village.

Throughout the development and implementation phases, officials from the Department of Rural Water Supply at the Monze Town Council were on hand to oversee and supervise the construction of the infrastructure. Their participation was essential to ensure that the contractor adhered to the government's recommended standards for drilling boreholes in rural areas.

3.6. Step 6: Using the Infrastructure

The solar-powered borehole (see Figure 4) was handed over to the community in September 2023 after its implementation was completed. Since then, it has served the community, providing water for all primary needs – drinking and other domestic uses, livestock and crop watering.

A water committee was voted in by the community to monitor how the borehole was being used and to support its use and management.

3.6.1 Water committee for the Hanzila solar-powered borehole

Following the implementation of the borehole, it became essential to discuss and ensure that the community would maintain and sustain the borehole over time, for current and future generations.

Through a participatory process, community members identified individuals who exhibited the necessary dedication to effectively manage water and other community resources as well as enforce communal rules. Understanding the nominee's capability was guided by their active contribution towards other community projects, where they asserted themselves and provided

leadership for the community's wellbeing. Both men and women were nominated based on these qualities and their commitment to enhancing the borehole's sustainability. Some nominees were selected for their practical knowledge of maintaining previously used hand pumps.

The candidates underwent a voting procedure following a nomination process to select ten members and form the Hanzila Solar-Powered Borehole Committee. The committee chosen comprised five males and five females selected to run the affairs of the borehole. Within the Hanzila Solar-Powered Borehole Committee were a female chairperson, a male vice chairperson, a female secretary, a female treasurer and additional committee members. Each of these designations came with different responsibilities. For example, the chairperson was responsible for presiding over community meetings related to the water points and for holding meetings with community members using the borehole. In the chairperson's absence, the vice chairperson fulfilled these duties. On the other hand, the secretary was responsible for taking meeting minutes related to borehole management, supported by the vice secretary. The two were also responsible for taking care of all relevant correspondence within the village and assisted the chairperson to ensure that word reached community members about any proposal or agreement on the borehole.

The treasurer received all monetary contributions related to the borehole and also maintained records that showcased savings from community contributions towards its maintenance. Other committee members participated as caretakers of the borehole and oversaw that the rules related to the borehole were enforced.



Figure 4. Handover of the solar-powered borehole developed for the Hanzila community. (photo: Agricom Media 2023)

3.6.2 Management for the efficient use of the solar-powered borehole by the water committee

The water committee was responsible for managing and maintaining the solar-powered system in Hanzila. On a day-to-day basis, the committee oversaw how the borehole operated and had certain measures put in place to ensure that it functioned well.

The first measure was to guarantee the safety of essential components, such as the submersible pump and the control box, which had previously been stolen. Since then, committee members have implemented stringent measures to ensure that theft does not recur. For example, the control box was shifted from the earlier location at the borehole site and placed in one of the houses belonging to a committee member nearby, to safeguard it. The turning on and off to operate the borehole was done from the house, powered through an extension cord placed to reach the borehole from the house. Further, on top of the submersible pump, the committee and the contractor placed concrete above the opening to make it difficult for anyone wishing to access it. This measure contributed to the safety of the borehole parts. Other hard-to-steal parts placed at the borehole's site were monitored regularly to prevent anyone from tampering with the parts, or in the event this occurred, someone from the community would quickly notice. The location of the borehole also had a security light equipped with motion sensors to light up at night when the sensors pick up any movement. This feature allowed people to be alerted whenever the security light switched on.

The second measure was to have the committee manage water access by implementing and enforcing schedules for various water uses. For example, to ensure equitable access to water for drinking, other domestic uses, livestock and vegetable gardens per household, the Hanzila community implemented a rotating schedule. Accordingly, each household took turns using water from the borehole for irrigation purposes. The gardens were divided into different sections for watering. If households from the first section watered their crops on day one, they voluntarily abstained from using water for irrigation the following day until it was their turn again on the third day. Though skipping out on watering crops posed temporary wilting, it did not lead to any dramatic effects on crops because this was done to well-established crops, and the conditions were favorable. During the days where watering did not take place, other households in another section of the community would step in to use the water for their own gardening needs. A female respondent from one of the FGDs offered the following comments:

"... to ensure that we all have adequate water for watering our vegetable gardens, we give each other turns. If a household waters its crops on day one, it will not water its crops for the next day until the third day. In the meantime, on the days they don't

water, other households will take turns to water the crops. All this is done to avoid straining the pump and ensure adequate water for all uses." — A female participant of the FGD

Furthermore, livestock were given a dedicated two-hour window from 12.00–14.00 daily to access water from the solar-powered borehole. This arrangement was planned to guarantee enough water for other critical purposes within the community. In contrast, access to water for drinking and other domestic needs was available without any time restrictions throughout the day.

This rotation system for accessing water in the Hanzila community was important for many reasons. First, it prevented overburdening of the borehole pump, ensuring it operated efficiently. Without rules that governed the rotation of water usage, allowing community members to access water simultaneously would have led to the pump operating continuously, day and night. This relentless use could have damaged the infrastructure over time. Further, the rotational system allowed for adequate time to replenish groundwater levels. For example, no water pumping was done after midday once the tank was full to allow groundwater resources to regain adequate levels. In addition, spacing out usage ensured that the community maintained a sustainable water supply that met the needs of all households, not just for gardening but also for other essential uses such as drinking, cooking, and hygiene.

Second, the rotation schedules helped foster essential community cooperation and unity. It encouraged households to work together and support one another in managing shared resources responsibly. This collaborative approach created a sense of unity and collective responsibility among community members towards their common resource, as everyone understood the importance of conserving and using water prudently.

Moreover, this system helped optimize water usage for agricultural purposes. By allowing each household to irrigate their crops in a structured manner based on a predefined schedule, it ensured that all gardens received sufficient water without straining the borehole or compromising water availability for other crucial activities. The rotation schedule for watering vegetable gardens exemplified the Hanzila community's commitment to sustainable resource management. As indicated by one of the community members:

"We know that we need to preserve our water, and therefore, we have adopted this rotational method of water usage also to safeguard the groundwater resource whilst saving our community's well-being for the long term." — A male respondent from the FGD

A few committee members had been given the responsibility of overseeing adherence to the above measures to ensure that everyone followed agreed upon rules.

Lastly, the water committee was responsible for collecting financial contributions from community members that were used as contingency funds to cover any eventuality of the borehole breaking down or if some parts needed to be replaced. On a monthly basis, they collected ZMW 30 (USD 1.20) from each household. The pooling of finances through regular monetary contributions and the availability of funds in the coffers was expected to ensure a quick turnaround in fixing the borehole if maintenance was necessary. As of July 2024, the water committee members had collected a sum of ZMW 5,800 (USD 224). This was collected over a period of eight months from some of the water users. It was also mentioned that some households had missed contributions on certain months however, the exact number was not disclosed. Such contributions were vital towards fostering a sense of ownership and stewardship among the facility users.

3.6.3 Challenges in maintaining a solar-powered borehole by the water committee

The installation of the solar-powered borehole represented a significant advancement for the Hanzila community, marking the first introduction of such a technology. Unlike traditional hand pumps, which community members were accustomed to maintaining as pump minders, the operation and troubleshooting of solar-powered equipment demanded specialized knowledge and training, lacking among community members at the time. During the FGD with water committee members, it was mentioned:

"We are so happy to have a borehole of this nature because it does a lot for us, and we are the envy

of our neighboring villages. However, we do not have the skills to know what needs to be done to repair the parts should we face problems in the future. We have pump minders who were trained to maintain the hand pumps. Still, this borehole needs specialized skills, which none of us possess." — A male respondent from the FGD

This showed that transitioning to solar-powered systems from traditional hand pumps introduced new complexities. Community members familiar with manual pumps had to adapt to managing and understanding the precise positioning of solar panels for maximum sunlight exposure and to troubleshoot electrical faults, which required technical skills beyond the mechanical expertise they possessed at the time. There was an essential need for training programs to equip community members, particularly water committee members, with the necessary skills to operate and maintain the solar-powered borehole effectively. However, such training had not yet been initiated for the Hanzila community. Instead, there were plans within the community to reach out to the local authority responsible for rural water supply development to receive training on the operation and maintenance of the solar-powered borehole. As indicated by one community member:

"We have decided to contact the local authority because they are responsible for rural water supply programs in this district. We wish to ask them to provide us with training on maintaining this kind of borehole or provide us with the basics that we will need should we encounter a breakdown of parts in the future." — A male respondent from the FGD

4. Livelihood Outcomes

This section presents findings from the July 2024 evaluation of health and livelihood outcomes, nearly one year after the installation of the solar-powered borehole. It compares access to water sources, their uses, and the related livelihood impacts before the project with improvements seen such as enhanced access to water for drinking and other domestic uses, irrigation, and livestock watering among households within the Hanzila community.

4.1. Outcomes of the Solar-Powered Borehole on Drinking and Domestic Water Use

4.1.1. Drinking, other domestic water uses, and livelihood benefits

To understand the impact of the solar-powered borehole on drinking and domestic use, the study began by evaluating the primary water sources used for drinking and domestic use in the Hanzila

community before and after the installation of the new borehole.

Before installing the solar-powered borehole, most respondents, accounting for 67%, relied on the borehole equipped with a hand pump to access water for drinking and other domestic uses. Results further show that 20% of respondents reported accessing water from open sources such as streams and scoop holes, whereas 13% indicated that they accessed water from deep wells (see Figure 5).

After the development of the solar-powered borehole, 86% of respondents reported using water from the solar-powered borehole from their homesteads or taps situated closer to their homes for drinking and domestic use. Results further show that 8% continued to rely on water from deep wells for drinking and domestic use because of the long distance to the solar-powered borehole, whereas 6% indicated that they used the borehole equipped with a hand pump. No household reported using water from open sources such as streams and scoop holes for drinking and domestic use (see Figure 5).

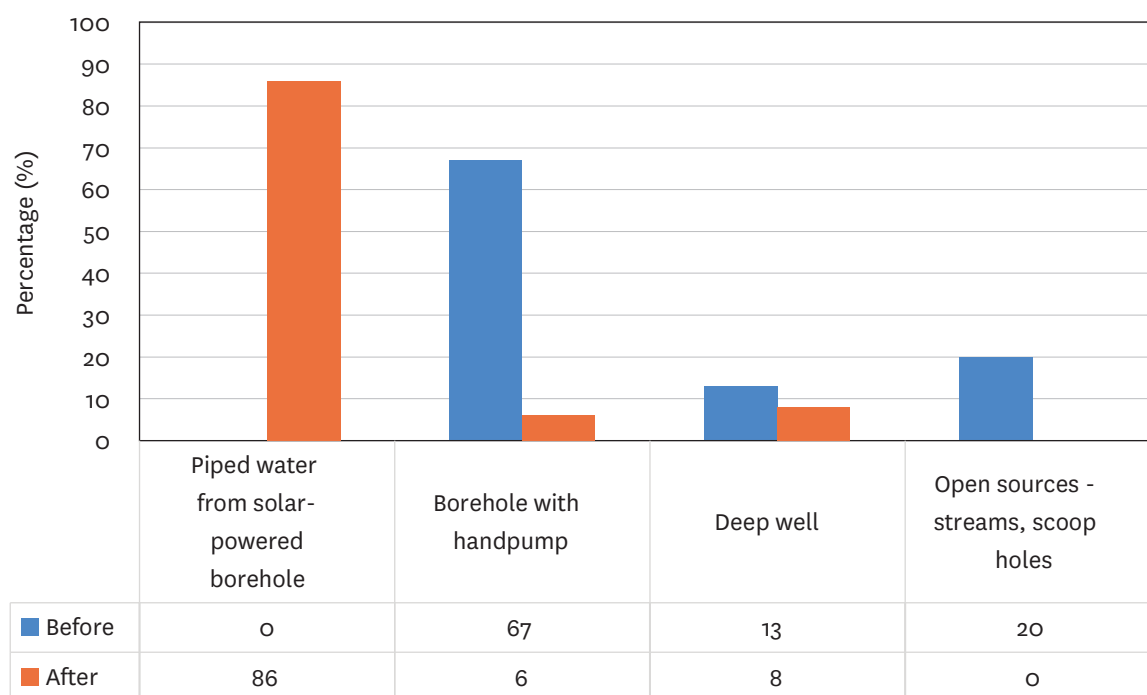


Figure 5. Primary sources of water relied on for drinking and other domestic uses by respondents (percentage) before and after the implementation of the solar-powered borehole (N=40)

Source: Household Survey 2024

The survey found that in terms of the distance traveled to access water before the installation of the solar-powered borehole, 63% of respondents indicated that they covered over 500 m to access water for drinking and other domestic uses (see Figure 6).

On the other hand, only 13% of respondents indicated they travelled over 500 m to access water needed for drinking and other domestic uses after the implementation of the borehole (see Figure 6). Further, results show that 37% of respondents interviewed travelled between 100 and 200 m to access water after the borehole was installed. Additionally, 20% of respondents reported having water available within their households, while another 20% travelled between 50 to 100 m to obtain water for drinking.

The results indicate that the distances covered to collect water for drinking and other domestic uses have reduced for a large proportion of the community since they began using the solar-powered borehole.

The new solar-powered borehole has modernized drinking and domestic water access for the Hanzila village in other ways as well. Women and children no longer endure long queues and spend long periods waiting to fetch water. While 54% of the interviewed households reported that it took more than one hour to queue up and wait to access water for drinking and other domestic uses before the borehole was fixed, there are no households queuing for more than 30 minutes at the solar-powered borehole since its installation (see Figure 7).

Results show that most respondents, accounting for 70%, reported spending less than 30 minutes to access water, whereas 25% reported that they spent only a few minutes or did not need to queue up because water was available within their compound. Only 5% indicated they spent half an hour to access water after the implementation of the borehole (see Figure 7).

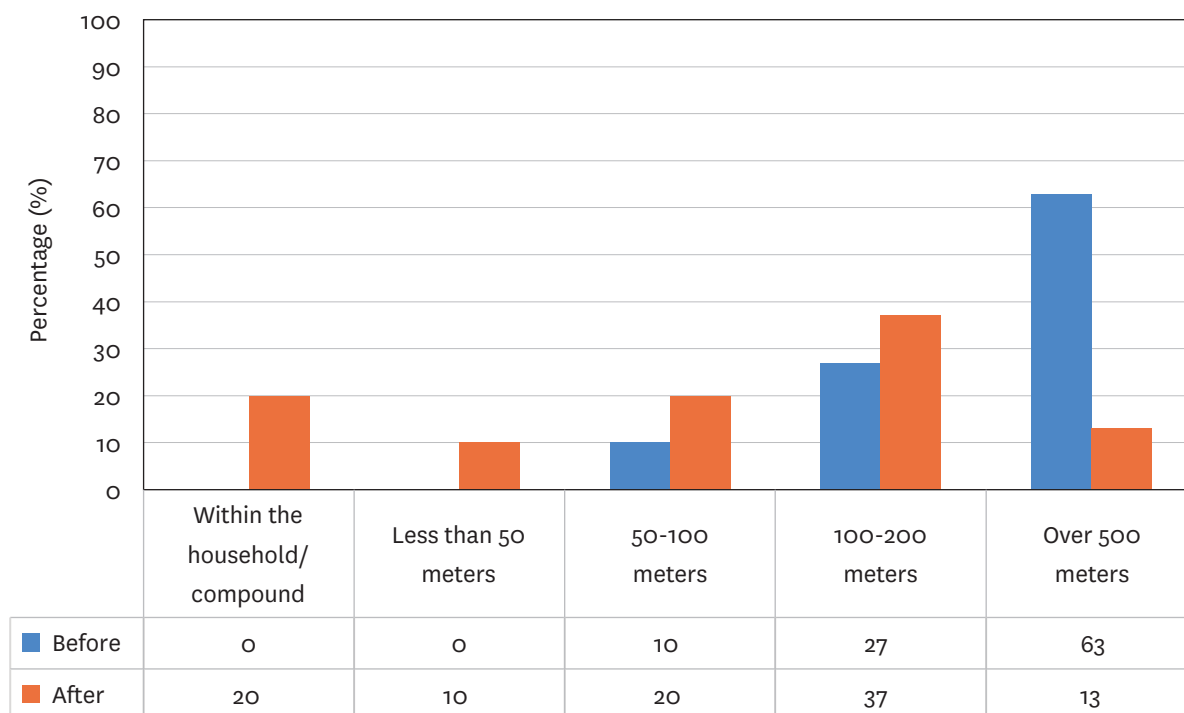


Figure 6. Distance to primary sources of water used for drinking and other domestic uses by respondents (percentage) before and after the implementation of the solar-powered borehole (N=40).

Source: Household Survey 2024

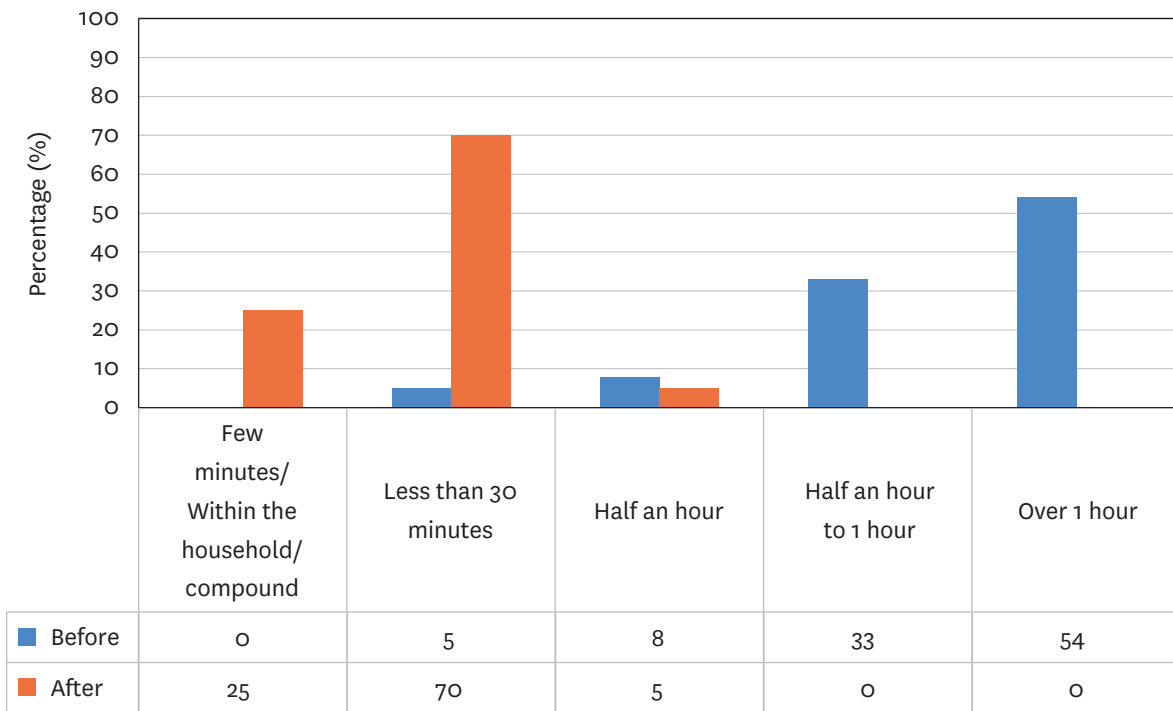


Figure 7. Time spent to access water for drinking and other domestic uses by respondents (percentage) before and after borehole implementation in Hanzila (N=40).

Source: Household Survey 2024



Figure 8. One of the taps installed in the village, ensuring quick and easy access to water. (photo: Agricom Media 2024)

The installation of 10 taps spread across various locations within the village allows multiple people to access clean water simultaneously without queuing. Figure 8 shows an example of one of the installed taps.

With the 10 taps that were put up in different locations, it allowed many people to access clean water easily within the community. This convenience, which eliminated long waiting periods, allowed women to dedicate more time to their families and household chores without the fatigue of fetching water from overcrowded sources. One respondent also noted this during the FGD:

"Nowadays, we have plenty of time to focus on other tasks like cooking and even find time to relax and spend with family. We no longer worry about searching for water or enduring long queues to fill just one or two containers that wouldn't suffice for all our household needs. Within minutes, we can fill all the containers in our home with water for drinking, cleaning dishes, and washing clothes. This allows us enough time to clean our homes and dishes promptly." — A female respondent from the FGD

4.1.2 Challenges of unequal access to water for drinking and other domestic uses

The following are some of the challenges noted in relation to accessing water for drinking and other domestic uses.

Some community members who resided further from the piped water supply lines and the installed taps experienced difficulties accessing water. For example, community members living in the northern and southern parts of the village had to spend extra money from their own funds to extend the supply lines. For an infrastructure that was provided to the community at no cost, this arrangement did not seem fair to those who had to pay for supply lines, as this cost only affected this segment of the community. Moreover, households that resided more than 1 km from the solar-powered borehole—and could not afford to extend the supply lines beyond that limit—continued to face challenges accessing water for drinking and other domestic uses at locations closer to their homesteads. This situation highlights that poverty can still impact how people gain access to public water resources within a community, even when such resources are intended to benefit everyone, including the vulnerable. According to one community member:

"We know that it is okay for us to extend the pipes to our homes or at least closer to our homes, but due to limitations in funds, we can't afford to do this, and therefore, we fail to fully utilize water from the borehole like those households that are situated closer to the borehole." — A female respondent in the FGD

This challenge meant that while some households experienced improved access to water after paying for the extension and others enjoyed closer access to the infrastructure without making any investment, others remained disadvantaged in terms of distance because they were unable to afford to pay for the extension of the infrastructure. As opposed to bringing equality, the development of the solar-powered borehole reinforced some inequalities because certain groups within the community were disadvantaged in accessing the public water infrastructure. In this case, having limited financial resources to pay for the extension contributed to some segments of the community being excluded from the benefits of having close access to the borehole. This showed how poverty and vulnerability could prevent marginalized groups from enjoying shared community resources.

Further, those who still found themselves far away from the borehole continued to face challenges and complications. They still relied on old sources such as wells and sometimes hand pumps. Some of these sources were shared with nearby villages and still led to increased time and effort spent fetching water, a challenge the solar-powered borehole intended to solve. Moreover, the physical strain of transporting water from distant sources continued to be a burden, especially for the elderly and school-going children. However, with a significantly lower number of people using the hand pump, compared to how it was previously, queuing long hours for water has reduced for those still relying on such sources.

4.1.3 Outcomes of the solar-powered borehole on health and wellbeing

The participatory diagnosis highlighted some unclean water sources, such as scoop holes used as alternative water sources, particularly during peak congestion periods. According to the household survey, such water sources contributed to diarrheal diseases. In response to the question of whether respondents had perceived any health benefits since they began using water from the solar-powered borehole, 80% reported that the cleaner and safer water they consumed had led to a reduction of waterborne diseases—previously common when people had to rely on unclean sources to access water for drinking and other domestic uses. The other 19% of respondents did not report reduced incidences of waterborne diseases (see Table 1).

As can be seen from the study findings, most respondents reported that the installation of the solar-powered borehole was instrumental in enhancing community health as it eliminated the need to fetch water from contaminated sources such as scoop holes, previously used for drinking. This improvement was particularly beneficial for children, ensured good digestion and prevented diarrheal diseases that could have had both physical and mental repercussions. As noted by a female respondent during the FGD:

Table 2. Perceived benefits of using the solar-powered borehole for vegetable growing (N=40).

Perceived benefits	Response	Percent
Reduced reliance on rainfall	Yes	69
	No	0
	N/A – Do not own a garden	31
Can cultivate crops during drought periods	Yes	69
	No	0
	N/A – Do not own a garden	31
Able to produce crops throughout the year due to water availability	Yes	59
	No	10
	N/A – Do not own a garden	31
Increased income from selling vegetables	Yes	54
	No	15
	N/A – Do not own a garden	31

Source: Household Survey 2024

"We no longer experience diarrheal diseases, and our children no longer suffer from such diseases since we started using this borehole water. We always have access to clean water and don't complain of accessing water at unclean sources as we did previously when we had no choice but to rely on water from scoop holes, which was contaminated and also accessed by livestock."
— A female respondent in the FGD.

Further, results showed that 74% of respondents indicated that personal hygiene at the household level had improved, with people taking regular baths and practicing handwashing since the installation of the solar-powered borehole (see Table 1). Findings of the household survey were also highlighted during the FGD where respondents reported that:

"We now bathe every day because we have reliable water that can be accessed without much effort. Even a quick look at the children can tell you that they are bathed every day and do not have dirt accumulated on their skin for many weeks."
— A male respondent from the FGD

"Our children's skin also looks healthy due to regular baths that are now taken more often than before, when they used to have skin diseases such as scabies. Clothes are no longer smelly as they are washed whenever they are dirty instead of wearing

dirty clothes for many days." — A male respondent from the FGD

In addition, school-going children started wearing clean uniforms and bathing before going to school. This marks a significant improvement from past experiences when children had to queue for water, often causing delays that impacted their punctuality and school performance.

Furthermore, as mentioned during the women's FGDs, chores like washing clothes, which were previously done using water from scoop holes and sometimes not done at all due to inadequate water supply, have since been performed regularly and closer to people's homes because water was readily available.

Women also reported that the increased water supply had significantly enhanced hygiene practices at the household level. An example was given where women indicated that previously, multiple people would share a single cup without washing it between uses, as they avoided 'misusing' water by washing utensils continuously. After the implementation of the borehole, people washed their cups before reusing it because sufficient water was available. Furthermore, storage containers were thoroughly cleaned with soap before being filled with clean drinking water. There was also a renewed focus among the community on food hygiene. Fruits and vegetables were regularly washed with clean water before consumption or cooking.

4.2. Outcomes of the Solar-Powered Borehole on Enhancing Agricultural Practices

4.2.1. Water uses for cultivation and livelihood benefits

In the Hanzila community, like most Zambian rural communities, vegetable gardening is primarily done in the dry season. In contrast, the rainy season is reserved for growing staple foods—such as maize, cassava—and cash crops such as groundnuts, tobacco, and cotton. These are grown on a larger scale and cannot rely on shared borehole water for irrigation. Moreover, such crops are grown away from villages, and resources such as solar-powered boreholes cannot conveniently supply water without investments into supply lines. Therefore, this study only assessed water access for vegetable gardens during the dry season, when it was most relevant.

To evaluate current practices in vegetable gardening, the study examined the proportion of respondents who had gardens they tended to during the dry seasons before and after the implementation of the solar-powered borehole.

Before the implementation of the borehole, some households had gardens near public water sources such as the borehole equipped with a hand pump, wells, and near open sources. As can be seen from the results, only 23% of respondents indicated owning gardens where they grew crops before the borehole was implemented (see Figure 9). After the implementation of the solar-powered borehole,

results showed that 69% of the interviewed households reported owning a garden where they grew crops.

Results shown in Figure 9 highlights that the number of people growing crops in their gardens had increased by 200% since the installation of the solar-powered borehole. This rise in gardening activities within less than a year can be attributed to the availability of piped water from the borehole, which provided a significant proportion of households with improved access to water and land for their gardens.

Regarding sources of water used for gardening, Figure 10 shows that 51% of respondents reported using piped water from the solar-powered borehole to irrigate their garden crops. Other water sources used to irrigate crops in gardens were from open sources, such as streams, weirs, and dams, accounting for 12% of responses, and water from wells, accounting for 6% of responses. No households reported using water from the community public hand pump or harvesting rainwater for their gardens. As depicted in Figure 10, 31% of respondents did not participate in gardening activities.

When comparing results obtained among water sources used for gardening before introducing the solar-powered borehole, 9% of respondents who owned gardens indicated that they used open sources, i.e., streams, weirs or dams, to water their gardens. Further, the study found that only 8% of respondents used the public borehole equipped with a hand pump, and 6% relied on wells (mostly private) to water crops in their gardens (see Figure 10).

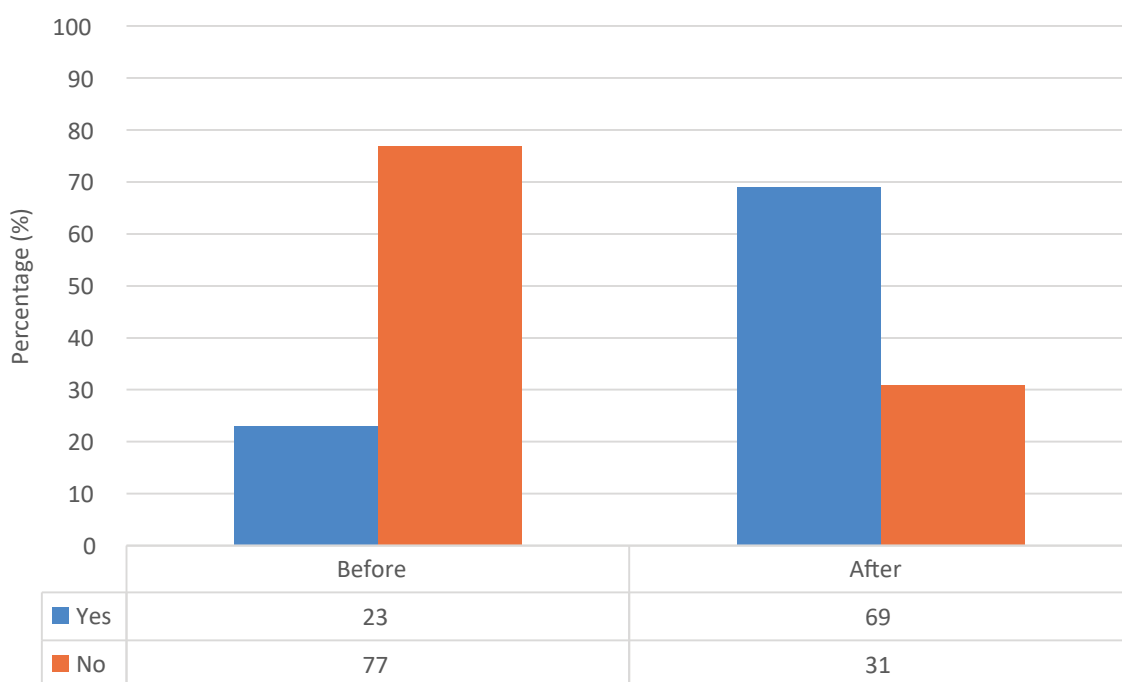


Figure 9. Proportion of households (percentage) that were engaged in growing crops in gardens before and after the installation of the solar-powered borehole (N=40).

Source: Household Survey 2024

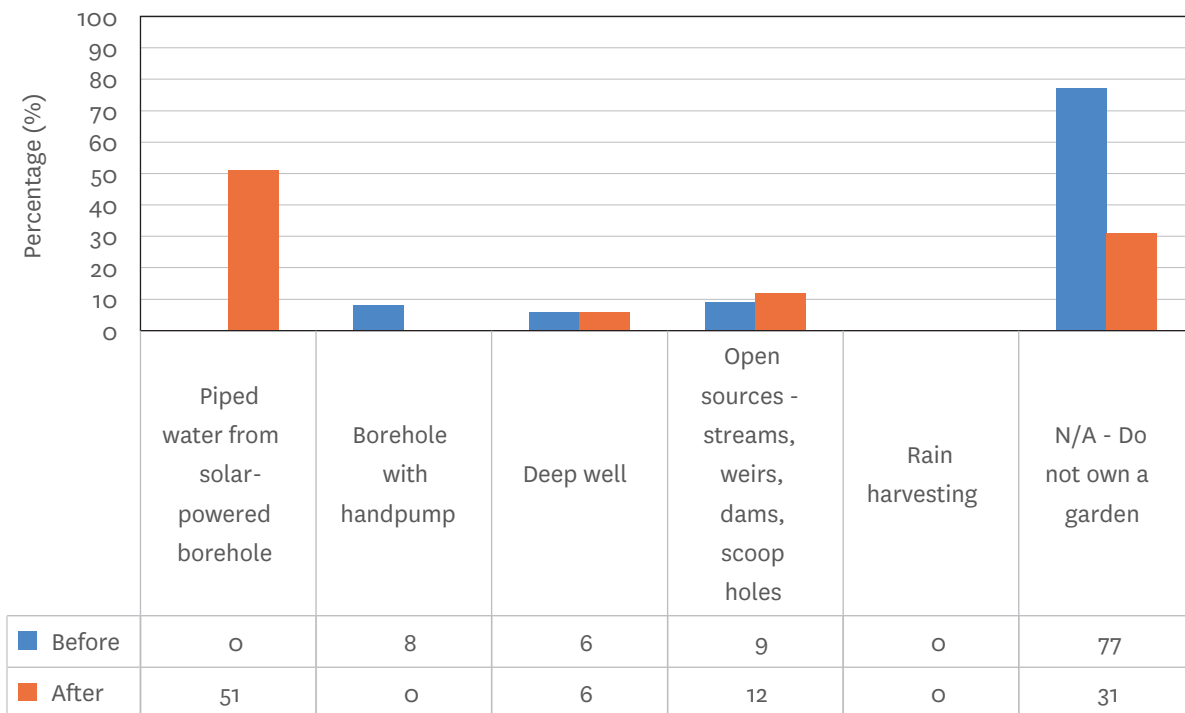


Figure 10. Primary sources of water used for gardening by respondents (percentage) before and after the implementation of the solar-powered borehole (N=40).

Source: Household Survey 2024

A separate discussion was held with the women involved in gardening activities. They reported that by installing the solar-powered borehole in the Hanzila community, they were able to cultivate various crops such as maize, tomatoes, cabbage, kale, sweet potatoes, onions, chillies, and Chinese cabbage, among others. Before the installation of the borehole, however, a few households that were involved in gardening only produced tomatoes and kale because these were mainly for home consumption. From the produce, very little was sold to earn an income because people faced limitations in accessing water to irrigate. One respondent noted that:

"Currently, we grow several crops in our gardens, such as maize, tomatoes, cabbage, kale, sweet potatoes, onions, chillies, and Chinese cabbage. Most of these are only grown now because previously, we did not have sufficient water to grow them. A few people who could access water

mostly grew kale and tomatoes for household consumption. There was also very limited produce that was sold." — A female participant from the FGD

The women further highlighted that the crops grown since the borehole's installation had become crucial in supplementing household food needs and generating an income through local markets, primarily in Monze town. This contributed to enhanced food security at the household level.

The study established that the solar-powered borehole had reduced the community's dependence on seasonal rainfall, which is unpredictable. Of the 69% of respondents who indicated owning a garden where they were currently growing crops, all indicated that the solar-powered borehole allowed them to reduce their reliance on rainfall and allowed cultivation during the drought period (see Table 2).

Table 2. Perceived benefits of using the solar-powered borehole for vegetable growing (N=40)

Perceived benefits	Response	Percent
Reduced reliance on rainfall	Yes	69
	No	0
Can cultivate crops during drought periods	N/A – Do not own a garden	31
	Yes	69
	No	0
Able to produce crops throughout the year due to water availability	N/A – Do not own a garden	31
	Yes	59
	No	10
	N/A – Do not own a garden	31
Increased income from selling vegetables	Yes	54
	No	15
	N/A – Do not own a garden	31

Source: Household Survey 2024

During the FGDs with both men and women, participants noted that vegetable farmers were able to plan their crop planting and harvesting more effectively due to the consistent availability of water from the solar-powered borehole. One participant gave the following comment:

"With the drought that we experienced this last season, we are not in a terrible place anymore because we now have a reliable source of water that has allowed us to continue farming activities within this community. This could not have been possible without the solar-powered borehole, and we would have continued suffering like the rest of the people in this part of the country." — A male respondent from the FGD

With reliable access to water throughout the year, farmers were able to irrigate their vegetable crops consistently. This newfound capability of being able to irrigate crops using water from the borehole infrastructure has increased agricultural productivity. It has also improved crop yields across the village. Fields that were once dormant due to a lack of adequate water, began to flourish with lots of crops. Moreover, the land allocated for crop production enabled farmers in the Hanzila community to cultivate more diverse crops and expand their agricultural activities. Figure 11 is an example of a vegetable garden in the Hanzila community with multiple crops.

Beyond mere sustenance, the surplus produce from these gardens became a source of local economic activity as it found its way to markets in the nearby town. The household survey indicated that 54% of the 69% engaged in vegetable growing reported earning an income from the sales of vegetables from their gardens (see Table 2).

Once their crops were ready for harvest, small-scale farmers sold their produce in the Monze town market, earning an income to meet their household needs (see Figure 12). Daily sales ranged from ZMW 250 (USD 10) to ZMW 1,000 (USD 40). A box of tomatoes sold for anywhere between ZMW 250 (USD 10), with many people often carrying multiple boxes at a time. This has improved household incomes and boosted the community's resilience against food shortages and financial instability. As a result, families were to a greater extent able to use incomes from the sale of vegetables to purchase other household requirements and foods that could not be grown in their gardens, such as maize meal. Moreover, this financial stability enabled them to afford a balanced diet, contributing to the health and well-being of children and the rest of the family. One such example provided by a community member is as follows:

"Once I sell my vegetables at the market in Monze town, I use the money I have earned to buy what I do not have at home, such as soap, sugar, and cooking oil. This helps to continue sustaining the household, and we don't lack some of these essential foods and groceries that we cannot grow in our gardens." — A female respondent from the FGD

Further, earnings from the sale of crops were reinvested into various other income-generating activities. For example, some households used these funds to purchase goods they resold within the community and neighboring villages. They bought basic household necessities like soap, sugar, salt, and cooking oil, then sold them to community members who hardly travel to Monze town to purchase household necessities. This initiative enabled people to have an additional income for home use, which enhanced the economic status of the household and the community at large.



Figure 11. Women farmers in their newly established garden after gaining access to solar-powered borehole water. (photo: Agricom Media 2024)



Figure 12. Ripening tomato fields to be harvested and sold at the market. (photo: Agricom Media 2024)

Further, placing water taps in locations near the allocated fields for vegetable gardening facilitated community gardening activities for both men and women. This reduced the physical strain of fetching water from distant places to water gardens. Community members were able to spend more time cultivating their gardens without getting overly tired from long walks to access water. As a result, they grew various crops at a larger scale, which improved their overall livelihoods. As indicated by one male during the FGD:

"Our water source is very close to our gardens. It has become very easy for us to grow vegetables and water them adequately without having to exert all our energies to obtain water like we did when we had to pump water from the hand pump manually."
— A male respondent from the FGD

During the FGDs participants noted that having gardens where parents grew vegetables allowed them to teach their children the skill of gardening. They also reported that such skills were important for all children to learn because they prepared them to be productive in the future. These skills empowered children to be able to support themselves as they grew up and reduced the burden on families of having young adults who remained dependent on their parents for survival.

Due to this ease of access to water in the community, youth also became interested in gardening. This led to them spending most of their days working in their gardens, turning them into responsible young men and women. During the FGD, participants mentioned that those who previously spent time drinking beer

and engaging in other illicit activities had shifted their attention to farming and were now earning an income that they used to support themselves and contribute to their household's well-being.

4.2.2 Challenges of access to water for enhancing agricultural practices

While the solar-powered borehole in the Hanzila community was seen as a cornerstone of sustainable climate adaptation, namely for its ability to empower farmers to diversify their agricultural practices, increase their yields, and secure their livelihoods, the survey also probed whether respondents faced specific challenges in accessing water to enhance agricultural activities. The two most notable challenges reported were: (i) some fields situated further away from the main supply lines and taps lacked conveyance—such as pipes—to facilitate irrigation, as indicated by 40% of respondents; and (ii) about 39% of respondents lacked gardening equipment, such as sprinklers (see Table 3).

For farmers whose fields were located farther away from supply lines and taps, the lack of adequate conveyance pipes created difficulties in delivering water to crops in the gardens. This contributed to widening inequalities in agricultural productivity compared to those whose gardens were situated in more advantageous locations where they were closer to the taps and supply lines. The same goes for those individuals who lacked gardening equipment, such as drip irrigation or sprinklers, which meant that they relied solely on the conventional method of carrying buckets from taps across the fields, which was tedious and labor intensive.

Table 3. Challenges in accessing water from the solar-powered borehole for enhanced agricultural activities (N=40).

Challenges	Response	Percent
Limited solar energy to run the pump	Yes	11
	No	58
	N/A – Do not own a garden	31
Lack of proper conveyance for fields further away from supply lines and taps	Yes	40
	No	29
	N/A – Do not own a garden	31
Lack of gardening equipment, e.g., drip irrigation or sprinklers	Yes	39
	No	30
	N/A – Do not own a garden	31
Denied access to use water from the borehole	Yes	0
	No	69
	N/A – Do not own a garden	31

Source: Household Survey 2024

Only 11% reported that limited solar energy posed a challenge to running the pump (see Table 3). Despite this figure, the issue was still highlighted during the FGD among men and women. Respondents highlighted that cold or cloudy days were not favorable for gardening activities because water output from the borehole was inadequate. Farmers expressed dissatisfaction with how much water could be generated using solar energy when the weather was cold or cloudy. This meant that crop watering was not achieved at the optimal capacity. According to an observation by an FGD participant:

"We noticed that around May and June, when the temperature dropped and we experienced rainfall only a few times, the borehole was not working optimally to pump the needed water. We concluded that this was due to limited sunlight that was causing the solar panels not to have sufficient sunlight to provide us with energy to run the borehole." — A male respondent from the FGD

No respondents reported being denied access to water from the solar-powered borehole for crop irrigation.

4.3. Hanzila's Role in Seed Production and Community Development

Because of the availability of water throughout the year following the installation of the solar-powered borehole, 13 farmers in the Hanzila community were identified by the MOA to experiment with producing maize seeds that could be used as seed crops during the rainy season. Selected community members were approached to dedicate some of their fields to produce maize seeds for the rainy season. According to one of the participants from the FGD:

"The Ministry of Agriculture, through its local camp officers operating in our rural communities, has extended an opportunity for us to grow maize specifically for seed production, which will be sold to other farmers come the rainy season when rainfed agriculture is practiced. This promises significant development for the village because we see that we are now recognized and seen, and this will mark a new phase in agricultural entrepreneurship." — A male respondent from the FGD

Community participation in growing maize for seed had several benefits for the people in the Hanzila village. First,

it boosted agricultural activities within the community by ensuring that maize seeds were available for the community when the time arrived to begin farming. Second, it opened economic opportunities for the community because once they sold the maize seed to the government after harvesting, they generated an income from it. Third, working with the MOA put the Hanzila community in the spotlight as a potential partner that the Ministry may consider working with even in the future. In sum, the community now has the potential to enhance its food security by participating in seed production and strengthening its resilience against climate variability and economic uncertainties.

4.4. Outcomes of the Solar-Powered Borehole on Water for Livestock

4.4.1. Water uses for livestock and livelihood benefits

To contextualize issues related to livestock watering within the Hanzila community, the study began by understanding the proportion of respondents who owned cattle and small livestock such as goats, pigs, sheep and chickens. Further, the study tried to understand the water sources used for livestock watering in the Hanzila community before and after the implementation of the solar-powered borehole. Two sets of questions were asked: one about watering cattle and another about watering small livestock. Further questions were asked concerning the different seasons of livestock watering.

The survey indicated the proportion of respondents who owned cattle before and after the implementation of the solar-powered borehole. Findings showed that 52% of households in the Hanzila community owned cattle after the borehole was introduced for livestock watering (see Figure 13). The same respondents reported owning cattle before the implementation of the solar-powered borehole.

Regarding ownership of small livestock such as goats, sheep, and chickens, 93% of respondents reported having at least one of these animals (see Figure 14). On the other hand, 7% of respondents indicated that they did not own small livestock in the Hanzila community.

During the dry seasons, particularly before the borehole was implemented, 48% of respondents watered their cattle using open sources such as streams, scoop holes, and dams. Furthermore, 4% reported using wells to water their cattle, while 48% of respondents did not own any (see Figure 15).

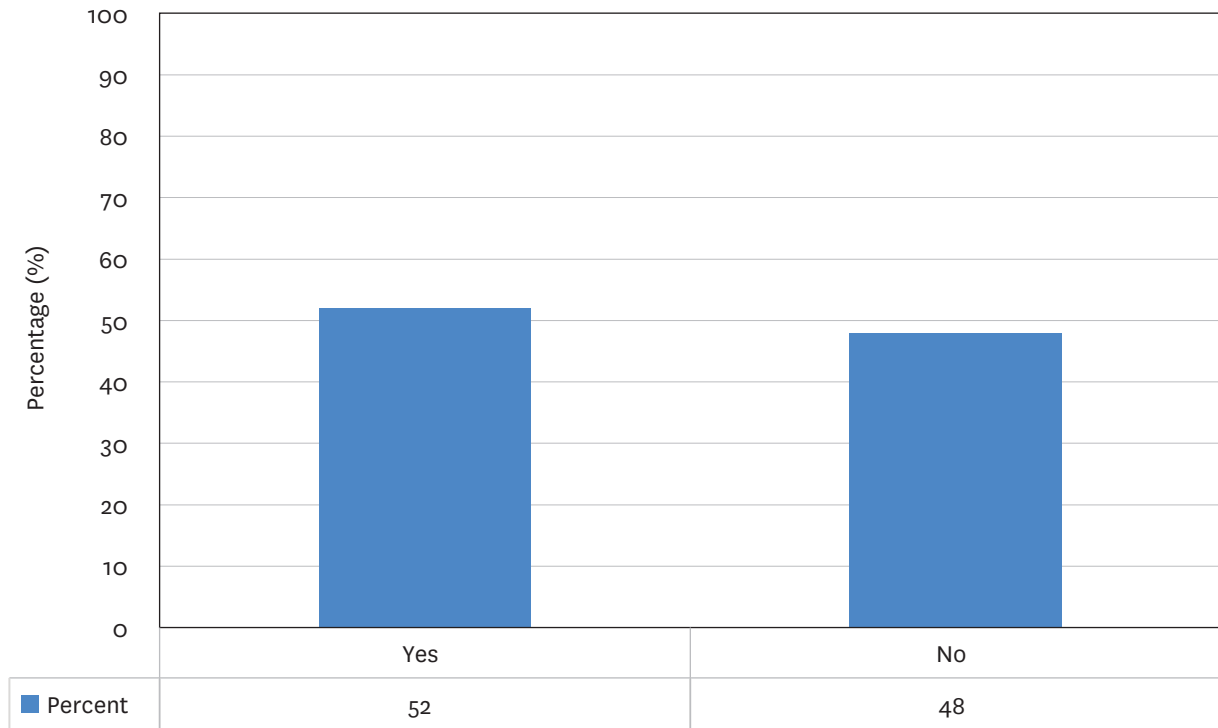


Figure 13. Proportion of households that owned cattle before and after the implementation of the solar-powered borehole (N=40).

Source: Household Survey 2024

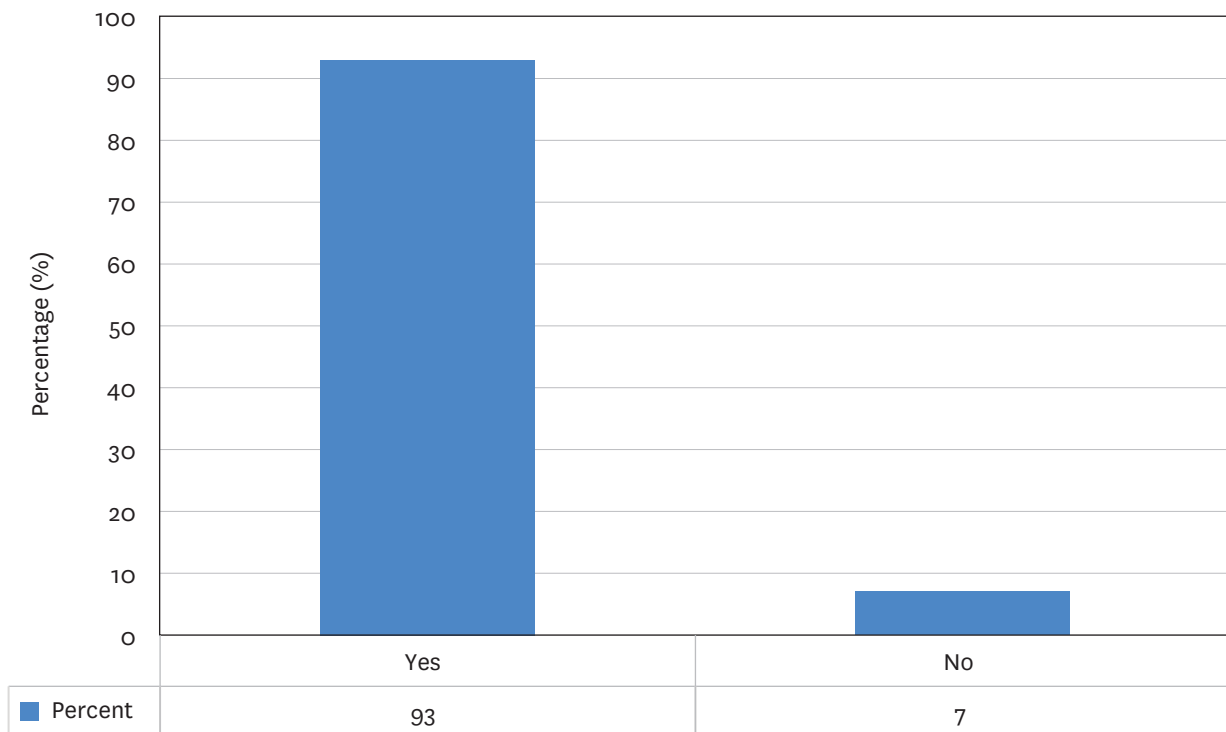


Figure 14. Proportion of households that owned small livestock before and after the implementation of the solar-powered borehole (N=40).

Source: Household Survey 2024

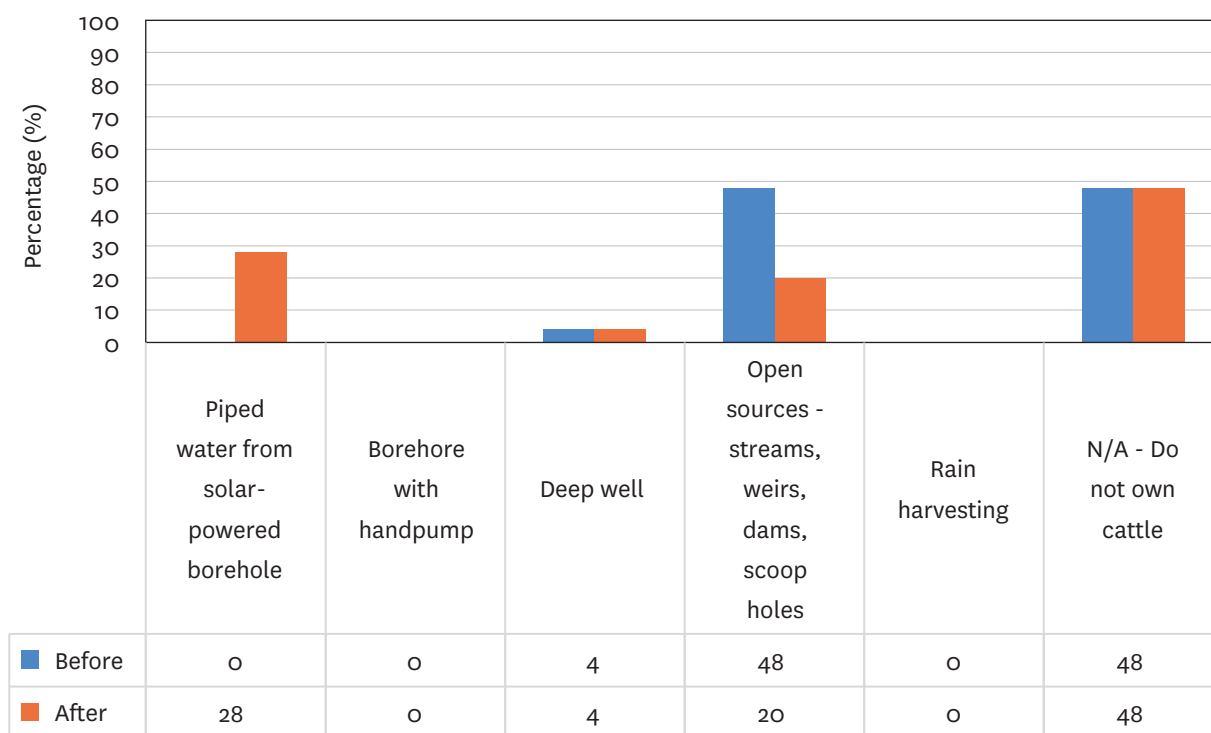


Figure 15. Primary source of water used during the dry season for cattle watering before and after the implementation of the solar-powered borehole in the Hanzila community (N=40).

Source: Household Survey 2024

During the dry season, a slight shift in the types of water sources used for cattle watering was observed. The study established that piped water from the solar-powered borehole emerged as the primary water source, accounting for 28% during this season, while 20% opted to continue watering their livestock at open sources such as streams, weirs, dams, and scoop holes (see Figure 15).

As opposed to struggling to find water when open sources dried up, cattle keepers with limited access in the Hanzila community have since benefitted from the installation of the solar-powered borehole. The study indicated that livestock were reliably provided with water through large basins. Community members improvised by using large basins to give water to their livestock because they had not yet built water troughs. The initial planning and budgeting for the borehole did not include the construction of water troughs for livestock. Using the basins reduced the burden on men who previously had to take their cattle to distant streams for watering. With ample water available within the community, animals had consistent access to clean water, which, in turn, was likely to improve the production of high-quality milk. When livestock produced large quantities of milk, the surplus was sold, which enhanced income at the household level. This was further highlighted during the FGD:

"Our routine for livestock watering has changed. Some of us no longer need to move the cattle to distant streams to have water for drinking. We now just use hosepipes connected to the taps and put water in large basins where all our animals can get the water they need to drink." — A male respondent from the FGD

Further, respondents during the FGDs mentioned that the presence of water within the community has reduced the need for animals to come into contact with cattle from neighboring communities during watering. They indicated that contact with other animals previously increased the transmission of diseases among livestock. This resulted in high veterinary costs. One community member noted that:

"For some of us who now have water from the solar-powered borehole, we don't necessarily need to take our animals to the public dams where they mix with other animals and catch diseases. Our costs for treating animals have also reduced because the animals don't mix a lot with other animals that may have diseases." — A male respondent from the FGD

The Hanzila community had planned to construct water troughs specifically for animal watering to ensure an

adequate water supply for the animals' wellbeing and to continue providing sustainable solutions for livestock watering for the village. Community members, particularly men, voluntarily engaged in making bricks, which served as building materials for the planned reservoirs. As per comments from an FGD participant:

"We have already started making bricks to construct a communal water reservoir where we will pump water to water our livestock. This is something that everyone in the community will use, so men are contributing their labor to make the bricks to build the reservoir." — A male respondent from the FGD

Several benefits were anticipated from the construction of the water trough. First, the water trough was expected to provide reliable water for livestock, which would have ensured that all livestock in the community remained well-hydrated throughout the year. In turn, this was expected

to enhance the quality and quantity of milk produced by dairy animals and contribute to increased household incomes and food security. Second, the water troughs were expected to mitigate the challenges posed by the drying up of water sources during the drought season, providing animals with an adequate supply of water. This collective effort demonstrated the community's commitment to improving water management for animals. It also reflected their hands-on initiative to improve animal husbandry within the community.

For small livestock (e.g., chickens, goats, sheep), almost all respondents provided water in basins to water their livestock during rainy and dry seasons. The study established that 89% of respondents used piped water from the solar-powered borehole to put water in basins, whereas 4% watered their small livestock using a well. Results also showed that 7% of respondents indicated they did not own small livestock (see Figure 16).

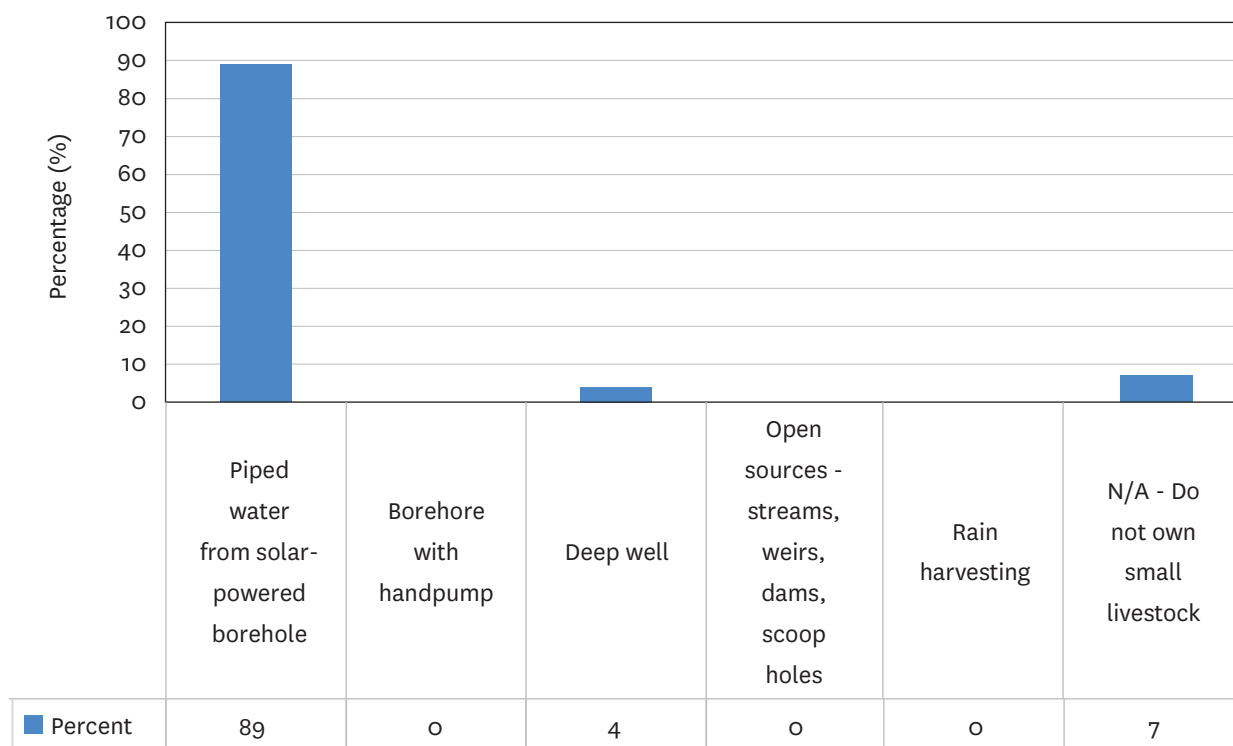


Figure 16. Primary source of water used for watering small livestock by respondents (percentage) after the implementation of the solar-powered borehole during the dry and rainy seasons (N=40).

Source: Household Survey 2024

4.4.2 Challenges of accessing water for livestock

Despite the presence of a solar-powered borehole in the community, many cattle keepers continued to move their herds to distant natural water sources like streams, rivers, or ponds. Moving cattle to rivers or streams is a cultural practice among cattle herders. However, the lack of water troughs in the area that were capable of storing clean and sufficient water also contributed to this continued reliance on natural sources. During periods where such nearby open sources dried up, herders faced challenges as the distance they had to travel in search of water increased. The study revealed that 33% of livestock owners cited the absence of water troughs as a significant challenge (see Table 4).

Additionally, 28% of respondents (cattle owners) noted that the designated two-hour watering times (see Section 3.6.2) were insufficient to meet their cattle’s water needs.

As a result, some cattle owners had to transport their animals to faraway streams, rivers, or ponds to ensure they had an adequate supply of water.

Only 9% reported that limited solar energy posed a challenge when running the pump to get the required water for livestock watering. Further, no respondents reported facing the challenge of being denied access to water from the solar-powered borehole to water their cattle (see Table 4).

Regarding the watering of small livestock, no significant challenges were reported with accessing water from the solar-powered borehole. This was mainly because traditional methods of collecting water for small livestock have been in use for a long time, such as owners using basins to water small livestock. Unlike cattle, which require large amounts of water—estimated at 30 to 80 liters per day—small livestock have lower water needs, making existing methods sufficient for their requirements.

Table 4. Challenges in accessing water for cattle watering from the solar-powered borehole (N=40).

Challenges	Response	Percent
Limited solar energy to run the pump	Yes	9
	No	43
	N/A – Do not own cattle	48
No trough to water livestock	Yes	33
	No	19
	N/A – Do not own cattle	48
Inadequate time allocated for livestock watering	Yes	28
	No	24
	N/A – Do not own cattle	48
Denied access to use water from the borehole	Yes	0
	No	52
	N/A – Do not own cattle	48

Source: Household Survey 2024

5. Horizontal and Vertical Polycentricity and Upscaling: The Role of the Local Authority in Supporting and Sustaining Locally Led Water Infrastructure Projects

5.1. Local Authority's Key Role in Partnering with the ACTION Grant Program

The positive outcomes of community-scale horizontal decision-making in the foregoing sections underscore the relevance of the last research question addressed in this section: What was the role of the Monze local authority in vertical polycentric decision-making and what does this imply for the potential upscaling of the locally led process, livelihood outcomes, and lessons learnt from the project in Hanzila?

In Zambia, the local authorities, i.e., the councils, play a key role in collaborating with external partners through vertical polycentric decision-making. They typically participate in assessing the needs of their communities and identifying areas where water infrastructure is lacking or insufficient. They provide crucial technical, financial, and institutional support during implementation and post-construction phases. This was also evident in the ACTION project, where early interactions with the local authority of Monze proved instrumental in bringing the Hanzila community to the attention of the ACTION facilitator. They highlighted Hanzila as a community with strong development aspirations that were not being achieved due to limited access to water resources. During the locally led planning and implementation process, the local authority provided information on their understanding of the community's needs and provided insights into various projects that the community was already undertaking.

The local authority was also invited to be part of the initial meeting with the community and was represented by the MOA. This involvement ensured that the integrated scope of the ACTION Grant Program aligned with ClimBeR's vision and goals, and also ensured that the government guidelines for rural water development were adhered to.

The Monze local authority continued to play a supportive role in the implementation process of the solar-powered borehole by issuing permits to the contractor for drilling after confirming that the selected site met the necessary criteria for rural water supply. Since the borehole's capital costs were fully funded, the community was not required to make any upfront payment to receive the borehole. However, it remains the local authority's responsibility to ensure that the community can sustain the water infrastructure and that they maintain ownership and control over it. It is within the local authority's mandate to ensure that existing water supply systems such as boreholes, wells, dams, and other water infrastructures are functional and sustainable. A key informant described this as follows:

"Part of our work is to ensure that we maintain and sustain all water infrastructure in our catchment, be it hand pumps, dams, wells, so that community beneficiaries can access such facilities over a long period and even for generations to come." — Key informant, Monze Town Council.

Part of the sustainability plans initiated by the local authority responsible for Hanzila and surrounding areas entailed providing local communities with training on how best to use and maintain the water infrastructure. They also worked to raise awareness among community members on the importance of safeguarding water resources to enhance the lifespan of the water infrastructure. Additionally, the local authority developed mechanisms for reporting any incidents affecting the water system so that corrective measures could be implemented within the shortest possible time. This helped prevent any inconvenience to communities and reduced the risk of deterioration to the water infrastructure that could arise with prolonged downtime.

Hence, the local authority was responsible for supporting Hanzila community members with a training program that would help them obtain basic knowledge about maintaining the solar-powered borehole effectively. During the interviews, the representative from the Monze Town Council indicated that:

We do not have many communities that have solar-powered boreholes in the district, so we do not have routine training programs for such boreholes as we do for boreholes equipped with hand pumps. However, for those that have hand pump borehole infrastructure, we provide them with the necessary skills to troubleshoot common problems that are easy to manage. We also ensure that selected users of the borehole infrastructure understand the technical aspects of the solar-powered system so that community members are well-equipped with the knowledge and skills needed to operate and sustain the water infrastructure independently. — Key informant, Monze Town Council.

5.2. Local Authority's Key Role in Replicating and Upscaling Cross-Sectoral Locally Led Rural Water Development for Drought Resilience

After the ACTION project implemented its cross-sectoral step-by-step participatory planning for the execution of the solar-powered borehole, the local authority expressed interest in adopting this method for scaling up future water projects. This model involves engaging communities

from the start to identify their multiple water-related challenges and develop solutions collaboratively.

Local authorities in Zambia already implement community engagements when identifying water challenges, but this is typically focused on domestic uses, which need to be resolved first. In terms of a formal process, the application for developing and implementing a water infrastructure is first initiated by the community. According to government guidelines (MLGH 2010), community members are required to sit together through a participatory process and highlight the key water challenges they face. This is followed by a formal application submitted to the local authority requesting approval and support for the implementation of the water infrastructure. Once received, the local authority assesses applications from various communities and conducts field visits to verify the information provided. At this point, several communities that have applied may be visited as part of the verification process. Once this is complete, the local authority convenes a meeting to prioritize which communities have the most urgent water needs. Priority is generally given to domestic use infrastructure, with limited consideration for basic agricultural uses. The local authority then holds meetings with the communities that qualify for support in water supply. This is intended to understand the contextual issues in those communities before the boreholes are implemented. Previously, there were challenges when local authorities or any other developer implemented water projects without community involvement and an understanding of local knowledge. For instance, boreholes were sometimes placed near graveyards or on sites deemed sacred by community members, which resulted in a reluctance to use the infrastructure despite significant investment. Another problem that would occur was when the water supply was constructed on land that was already claimed as private property. Despite the land holders' initial promises that the water supply would remain open to everyone, they increasingly saw the water infrastructure as private property. These experiences showed the importance of integrating inclusive local perspectives to avoid such hinderances. By learning from the community about the uniqueness of different sites and their cultural significance, local authorities have better aligned how they

develop water infrastructure projects to local contexts and priorities. This enhances ownership of the infrastructure by all and ensures the successful use of the resources provided. Once these matters have been resolved, the implementation phase is initiated, and post-construction support is provided accordingly.

It is important to note that the implementation of water infrastructure is also dependent on the availability of funding, which is often insufficient to meet the full scope of water demands coming from the community. Interviews with the local authority showed that despite the government's interest in enhancing access to water for rural communities, local authorities usually faced challenges in supporting many communities due to limited budgets.

However, with the extreme and recurrent effects of climate change, local authorities need to proactively find financiers to support rural water supply for enhanced livelihoods, not only to improve access to water for drinking and other domestic uses, but also for crop production and livestock watering. Although, multipurpose infrastructure is more cost-effective than two separate single-use systems, advanced technology—such as solar-powered boreholes for domestic and productive uses—is likely to be a solution of choice for rural communities to enhance their resilience to climate change, as it was in Hanzila. The readiness of local authorities to replicate the ACTION project's approach to ensure a reliable and consistent water supply for multiple uses, especially in areas with erratic rainfall, is reflected in the following statement:

"Where such boreholes are, we have seen how communities transform and use water for many purposes, such as growing vegetables that help them earn an income. It is time that we start making use of such investments to improve the lives of the people because we see that the impacts of droughts are many, and therefore, we need to reduce people's dependence on unreliable water sources, most of which dry up." — Key informant, Monze Town Council.

6. Conclusions and Recommendations

The study analyzed benefits and challenges encountered during the process to assess their impact on project effectiveness. These challenges included limited technical expertise, funding constraints that prevented pipeline extensions for some community members, and unforeseen construction obstacles.

Like many countries in the Southern African region, Southern Province in Zambia faces heightened vulnerability to climate variability, including prolonged droughts and unpredictable rainfall patterns. Rainfall during 2023/2024 was extremely limited. The ACTION Grant Program partnered with the national and district-level tiers of the Zambian government to demonstrate innovative climate adaptation measures. Both at the national level and the district level, horizontal decision-making crossed sectoral silos and fostered openness in vertical decision-making with local communities. This inclusive approach enabled government stakeholders to listen and identify integrated pathways towards climate resilience that reflected local priorities and holistic contexts.

The Monze local authority proposed Hanzila, a community of 500 households, as a demonstration village. Like many communities in this area, Hanzila had only one borehole with a hand pump, which was overcrowded and regularly broke down. The streams, scoop holes, and wells that were used as an alternative means to meet basic domestic needs and water for livestock, increasingly ran dry.

The six-step participatory process from February 2023 to September 2023 proved to be effective. Engagement from the start of the project allowed community members to fashion an infrastructure that responded to the drought challenges and was true to their holistic context. As the drought affected both domestic and productive water uses, women and men opted for an infrastructure that met all their needs. The solution fitted the funding and financial framework that the local authority and the ACTION project were able to offer. Given that the area received plenty of sunlight, all parties—and the selected contractor—agreed on a solar-powered borehole system which included a pump, reservoir, and reticulation consisting of 10 taps at a maximum radius of 1 km.

As a next step, the Hanzila community participated in identifying the sites that were most feasible to implement the borehole and reticulation, and that would meet different water needs within the community, including drinking, other domestic uses, livestock watering, and gardening year-round for those with fields. However, the 1 km radius of taps, as agreed with the contractor, implied that it was impossible to reach all households. Some wealthier households financed and connected a pipe to the nearest tap. However, poorer households could not afford this. Additionally, a water committee was elected to operate and maintain the system and collect contributions.

The solar-powered borehole was a new technology to the community, unlike traditional boreholes with hand pumps that were common in most rural areas and the use of other sources such as deep and shallow wells. Although water committee members used to be trained in maintaining and repairing boreholes with hand pumps, the capacity to operate, maintain, and repair solar systems was still lacking.

The solar-powered borehole tangibly improved access to water for health, food security, and drought resilience. This was found in the study that was initiated in July 2024 to assess the livelihood outcomes of the solar-powered borehole. Year-round access to water for drinking and other domestic uses became easier.

The distance to the 10 taps instead of the one borehole with a hand pump or alternative sources reduced. Crowding and time spent in queuing were reduced as well.

Reliance on unsafe water sources for drinking, such as scoop holes, had ended. Increased access also led to more frequent washing and bathing, contributing to improved hygiene.

The solar-powered borehole also provided water for year-round irrigation of vegetables. Where only 23% of respondents irrigated gardens before the new borehole, this figure became 69% after its installation. The harvested produce primarily used to be for consumption, but since the project, most gardeners sold part of their produce as well. This contributed to food security and economic stability even during the dry season or in years with limited rainfall, as seen in 2023/2024.

The taps also provided water for small livestock, a benefit reported by almost all respondents. For the 52% of respondents who owned cattle, slightly more than half moved away from the open sources they used before (streams, dams, scoop holes) to basins that they had connected to the new taps.

For all uses, community members transported water from the taps to their homesteads, fields or livestock basins.

These positive livelihood outcomes, as a result of improved year-round access to water, highlighted how community-led participatory approaches strengthened drought resilience and adaptation to climate change. The project was embedded in horizontal and vertical polycentric decision-making of Zambia's government. The Monze local authority welcomed cross-sectoral water management for both domestic and productive water uses and underlined its replicability and potential for upscaling.

The following recommendations are derived from these findings:

a) Replicate and upscale cross-sectoral locally led drought resilience approaches

In any community project, the voices of community members can bring to light real issues that the project should address, while also helping to meet the diverse needs of their multifaceted livelihoods. This is especially relevant for water and drought-resilience projects. Multi-purpose water infrastructure is a cost-effective way to provide water for all the water uses of both women and men.

b) Ensure the inclusion of marginalized community members from the first steps onwards, including the detailed technical design and infrastructure financing, to ensure equitable benefits.

Despite the positive outcome that the borehole brought to most members of the Hanzila community, water challenges for other community members were not resolved, particularly affecting people living farther from the piped water lines and installed taps. In the initial contract agreement for installing the borehole, it was agreed that the borehole would only cover a radius of 1 km, and taps would be installed within this recommended radius. Those that were situated farther had a choice to extend the supply lines to their homes at their own cost. This was done by those who could afford it. Some community members could not afford to pay for the extension of supply lines and, therefore, continued to cover the same long distances to access water from the new borehole, just as they had to do before the installation of the solar-powered borehole. Others opted to continue accessing water from wells and other open sources closer to their homesteads. This situation falls short of what the borehole was trying to achieve—ensuring that no one was left behind in the pursuit of improved access to water. The disparity also indicates a broader issue of inequality in water access, where more affluent individuals within a community can benefit from infrastructure that is provided free of charge if an additional investment is made.

Installing more taps or water points near those homesteads situated farther from the borehole could have helped prevent unequal access. For future projects, one viable approach is to request initial financial contributions from community members to ensure that funds raised can be used in combination with resources from external donors to develop larger and more effective water distribution systems. Involving the community to fund their local water project would mean enhancing the overall infrastructure and improving water access for a greater number of community members.

Where project funding is limited, another option is that community members could agree on equal contributions toward installing additional water access points that serve all households. This can be a community initiative to complement what was provided by the

donor. Alternatively, local authorities can take on the responsibility for balancing water access by funding such efforts, helping to ensure equitable access to water for all community members.

c) Develop local capacities for new solar-powered technologies

Considering the technical infrastructure for solar-powered boreholes was new for most people in rural areas, it is recommended that these community members be trained with the relevant knowledge and skills on monitoring and maintenance. The Hanzila community recently transitioned from using a traditional hand pump that they had relied on for many years to a much more sophisticated solar-powered system. This meant that the new solar-powered borehole introduced new technical complexities that require specialized knowledge and skills to operation and maintenance. There were a few people within the community who were trained by the local authority to operate and maintain boreholes equipped with hand pumps. However, there was no one at the time who possessed the skills to fix the solar-powered borehole, should such a need arise. Priority should be given to training a new cadre of people who can fix the borehole. In addition, training should be tailored to the local context of the Hanzila community, taking into consideration people's comprehension and literacy levels. Community members should also be informed to seek help from the local authority for challenges that cannot be handled or resolved among themselves, and to ensure a quick turnaround of borehole repairs should there be a breakdown.

d) Scale up solar-powered boreholes for multiple uses through the government's polycentric decision-making frameworks

With the experience gained from implementing a solar-powered borehole in a remote area such as Hanzila—and its documented benefits for irrigation, livestock watering, food security, and economic development that enhances resilience to climate change—replication and upscaling are strongly recommended. Local authorities in Monze along with higher government tiers were instrumental to the project's success. It is therefore recommended that local authorities across Zambia develop similar water project proposals targeting provincial and national governments, as well as external financiers. These proposals should prioritize systems—such as the solar-powered boreholes—that respond to both domestic and agricultural water needs. This will strengthen resilience to climate change, including reduced rainfall patterns and recurring drought conditions on a much broader scale.

Solar-powered boreholes are particularly well-suited for replication by the local government. It is technically feasible to implement these in remote areas and Zambia has sufficient sunlight to power the pumps and other parts. Using solar energy is environmentally friendly and contributes to mitigating the impacts of climate change.

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Annex 1. Household Interview Questionnaire.

Household Questionnaire	
INTRODUCTION	
<p>Good morning/afternoon/evening. My name is, and I am evaluating the solar-powered borehole installed in the Hanzila community. This research aims to understand how the borehole has impacted your life, household, and community since its installation. We want to gather insights into various aspects of the project, including the installation process, stakeholder satisfaction, maintenance needs, and critical lessons learned.</p> <p>Your household has been chosen for the interview because you reside in the Hanzila community and could benefit from the borehole in some way. We are interested in learning about the impact of the borehole on you and your household.</p> <p>I appreciate your cooperation and your valuable insights. May I begin the interview now?</p> <p>Yes <input type="checkbox"/> (Proceed with details below) <input type="checkbox"/> No (Thank the respondent & leave)</p>	
1. QUESTIONNAIRE IDENTIFICATION	
1.1 Questionnaire number	
1.2 Survey date (dd/mm/yy)	
1.3 Start time	
2. DEMOGRAPHIC INFORMATION	
2.1 Respondent's gender <i>(Don't ask, just take note)</i>	<input type="checkbox"/> 1. Male <input type="checkbox"/> 2. Female
2.2 Age range of respondent <i>(Only interview adults within the household – 18 years and above)</i>	<input type="checkbox"/> 1. 18 years old <input type="checkbox"/> 2. 19 to 24 years old <input type="checkbox"/> 3. 25 to 30 years old <input type="checkbox"/> 4. 31 to 40 years old <input type="checkbox"/> 5. 41 to 50 years old <input type="checkbox"/> 6. 51 to 60 years old <input type="checkbox"/> 7. Above 60 years old
3. DRINKING AND DOMESTIC WATER USES	
3.1 What sources of water do you currently use for drinking and other domestic uses? <i>(Tick all that apply)</i>	<input type="checkbox"/> 1. Solar-powered borehole <input type="checkbox"/> 2. Borehole with hand pump <input type="checkbox"/> 3. Well <input type="checkbox"/> 4. Open sources – streams, scoop holes <input type="checkbox"/> 5. Other (specify) _____
3.2 Do you use alternative sources of water for drinking and other domestic uses?	<input type="checkbox"/> 1. Yes <input type="checkbox"/> 2. No <input type="checkbox"/> 3. I don't know
3.3 What water sources were you using for drinking and domestic uses before the installation of the solar-powered borehole? <i>(Tick all that apply)</i>	<input type="checkbox"/> 1. Borehole with hand pump <input type="checkbox"/> 2. Well <input type="checkbox"/> 3. Open sources – streams, scoop holes <input type="checkbox"/> 4. Other (specify) _____
3.4 As a household, do you have adequate access to water throughout the day for drinking and other domestic uses from the solar-powered borehole?	<input type="checkbox"/> 1. Yes <input type="checkbox"/> 2. No <input type="checkbox"/> 3. There is an allocated period to access water for drinking and domestic uses <input type="checkbox"/> 4. I don't know

<p>3.5 Are you denied access to water for drinking and other domestic uses from the solar-powered borehole? (If not denied, proceed to question 4.1)</p>	<p><input type="checkbox"/> 1. Yes <input type="checkbox"/> 2. No <input type="checkbox"/> 3. I don't know</p>
<p>3.6 If you are denied access to the solar-powered borehole for drinking and other domestic uses, what causes you to be denied access? (Tick all that apply)</p>	<p><input type="checkbox"/> 1. That the borehole belongs to select people in the community <input type="checkbox"/> 2. That we haven't paid the maintenance fee to use it <input type="checkbox"/> 3. That we belong to another community <input type="checkbox"/> 4. Other (specify) _____</p>
<p>4. PERCEIVED IMPACTS OF SOLAR-POWERED BOREHOLES ON DRINKING WATER AND DOMESTIC USES</p>	
<p>4.1 What is the current distance to your primary water supply for drinking and other domestic uses?</p>	<p><input type="checkbox"/> 1. Within the household/compound <input type="checkbox"/> 2. Less than 50 meters <input type="checkbox"/> 3. 50-100 m <input type="checkbox"/> 4. Between 100-200 m <input type="checkbox"/> 5. Over 500 m <input type="checkbox"/> 6. I don't know</p>
<p>4.2 What was the distance to your main source of drinking and other domestic water supply before you started using the solar-powered borehole?</p>	<p><input type="checkbox"/> 1. Within the household/compound <input type="checkbox"/> 2. Less than 50 m <input type="checkbox"/> 3. 50-100 m <input type="checkbox"/> 4. Between 100-200 m <input type="checkbox"/> 5. Over 500 m <input type="checkbox"/> 6. I don't know</p>
<p>4.3 How long does it take to access water on a round trip? (Exclude time used to do other household errands)</p>	<p><input type="checkbox"/> 1. A few minutes or within the household/compound <input type="checkbox"/> 2. Less than 30 minutes <input type="checkbox"/> 3. Half an hour <input type="checkbox"/> 4. Half an hour to 1 hour <input type="checkbox"/> 5. Over 1 hour <input type="checkbox"/> 6. I don't know</p>
<p>4.4 Before installing the solar-powered borehole, how long did it take to access water for drinking and other domestic uses a year ago?</p>	<p><input type="checkbox"/> 1. A few minutes or within the household / compound <input type="checkbox"/> 2. Less than 30 minutes <input type="checkbox"/> 3. Half an hour <input type="checkbox"/> 4. Half an hour to 1 hour <input type="checkbox"/> 5. Over 1 hour <input type="checkbox"/> 6. I don't know</p>
<p>4.5 Have you perceived any health benefits since you started using water from the solar powered borehole? (Tick all that apply)</p>	<p><input type="checkbox"/> 1. Yes, cleaner and safer water, and reduced incidents of waterborne diseases. <input type="checkbox"/> 2. Yes, personal hygiene has improved (regular bathing and hand washing) <input type="checkbox"/> 3. No <input type="checkbox"/> 4. Other (specify) _____</p>
<p>4.6 How was your health and hygiene before using water from the solar-powered borehole? (Tick all that apply)</p>	<p><input type="checkbox"/> 1. We did not bath every day because of inadequate water supply <input type="checkbox"/> 2. We sometimes drink water from open sources (streams and scoop holes), which causes diarrheal diseases <input type="checkbox"/> 3. Nothing has changed <input type="checkbox"/> 4. Other (specify) _____</p>

5. WATER FOR CROP GROWING/GARDENING		
5.1 Do you have a garden where you are currently growing crops? <i>(If they do not have a garden, skip to question 8.1)</i>	<input type="checkbox"/> <input type="checkbox"/>	1. Yes 2. No
5.2 Did you own a garden before the borehole installation where you regularly grew crops?	<input type="checkbox"/> <input type="checkbox"/>	1. Yes 2. No
5.3 What sources of water do you currently use for vegetable gardening? <i>(Tick all that apply)</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	1. Solar-powered borehole 2. Borehole with hand pump 3. Well 4. Open sources – streams, weirs, dams, scoop holes 5. Rain harvesting 6. Other (specify) _____ 7. N/A – Do not own a garden
5.4 Do you use alternative sources of water for vegetable gardening?	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	1. Yes 2. No 3. I don't know
5.5 What water sources were you using for vegetable gardening before the installation of the solar-powered borehole? <i>(Tick all that apply)</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	1. Borehole with hand pump 2. Well 3. Open sources – streams, weirs, dams, scoop holes 4. Rain harvesting 5. Other (specify) _____ 6. N/A – Did not own a garden
6. CHALLENGES OF ACCESSING WATER FOR CROP GROWING/GARDENING		
6.1 Do you have adequate access to water from the solar-powered borehole for agricultural purposes?	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	1. Yes 2. No 3. There is an allocated period to access water for drinking and other domestic uses 4. I don't know
6.2 What challenges do you face in accessing water from the solar-powered borehole? <i>(Tick all that apply)</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	1. Limited power to run the borehole 2. Lack of proper conveyance for fields further from supply lines and taps 3. Lack of gardening equipment, e.g., drip irrigation or sprinklers 4. Denied access to use water from the borehole 5. Other (specify) _____
7. PERCEIVED IMPACTS OF SOLAR-POWERED BOREHOLES ON VEGETABLE GARDENING		
7.1 Ask respondents to list the perceived benefits of using the solar-powered borehole for their gardening. <i>(Tick all that apply)</i>	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	1. Able to produce crops throughout the year because of the availability of water 2. Increased income from vegetable sales 3. Reduced reliance on rainwater 4. Cultivate during drought periods 5. Other (specify) _____
8. WATER FOR LIVESTOCK WATERING		
8.1 Do you own cattle? (If they do not own cattle, skip to the end of the interview)	<input type="checkbox"/> <input type="checkbox"/>	1. Yes 2. No

<p>8.2 What sources of water do you use for cattle watering during the rainy season? (Tick all that apply)</p>	<input type="checkbox"/> 1. Solar-powered borehole <input type="checkbox"/> 2. Borehole with hand pump <input type="checkbox"/> 3. Well <input type="checkbox"/> 4. Open sources – streams, weirs, dams, scoop holes <input type="checkbox"/> 5. Rain harvesting <input type="checkbox"/> 6. Other (specify) _____
<p>8.3 What water sources do you use to water cattle during the dry season? (Tick all that apply)</p>	<input type="checkbox"/> 1. Borehole with hand pump <input type="checkbox"/> 2. Well <input type="checkbox"/> 3. Open sources – streams, weirs, dams, scoop holes <input type="checkbox"/> 4. Rain harvesting <input type="checkbox"/> 5. Other (specify) _____
<p>8.4 Do you own small livestock, i.e., chickens, goats, sheep, etc.? (If they do not own small livestock, skip to question 9.1)</p>	<input type="checkbox"/> 1. Yes <input type="checkbox"/> 2. No
<p>8.5 What sources of water do you use to water small livestock, such as chickens, goats, and sheep, during the rainy season? (Tick all that apply)</p>	<input type="checkbox"/> 1. Solar-powered borehole <input type="checkbox"/> 2. Borehole with hand pump <input type="checkbox"/> 3. Well <input type="checkbox"/> 4. Open sources – streams, weirs, dams, scoop holes <input type="checkbox"/> 5. Rain harvesting <input type="checkbox"/> 6. Other (specify) _____
<p>8.6 What sources of water do you use to water small livestock, such as chickens, goats, and sheep, during the dry season? (Tick all that apply)</p>	<input type="checkbox"/> 1. Solar-powered borehole <input type="checkbox"/> 2. Borehole with hand pump <input type="checkbox"/> 3. Well <input type="checkbox"/> 4. Open sources – streams, weirs, dams, scoop holes <input type="checkbox"/> 5. Rain harvesting <input type="checkbox"/> 6. Other (specify) _____
<p>9. CHALLENGES OF ACCESSING WATER FOR LIVESTOCK WATERING</p>	
<p>9.1 Do you have adequate access to water from the solar-powered borehole for livestock watering?</p>	<input type="checkbox"/> 1. Yes <input type="checkbox"/> 2. No <input type="checkbox"/> 3. There is an allocated period to access water for drinking and other domestic uses <input type="checkbox"/> 4. I don't know
<p>9.2 What challenges do you face in accessing water from the solar-powered borehole?</p>	<input type="checkbox"/> 1. Limited power to run the borehole <input type="checkbox"/> 2. No troughs for livestock watering <input type="checkbox"/> 3. Inadequate time allocated for livestock watering <input type="checkbox"/> 4. Denied access to use water from the borehole <input type="checkbox"/> 5. Other (specify)_____
<p>END INTERVIEW AND THANK THE RESPONDENT</p>	

Annex 2. FGD Interview Guide for Community Members.

INTRODUCTION

Thank you for joining us for this interview. As you already know, the ClimBeR project implemented a solar-powered borehole in this community last year for various purposes. We want to evaluate how the borehole has impacted your lives since its installation.

We have developed an interview guide with specific questions that will cover the situation before the implementation of the borehole in terms of access to water for various needs, including drinking, domestic, irrigation, and livestock watering. The interview guide will also cover questions on the current water supply situation since the implementation of the solar-powered borehole. We would also like to know how the borehole maintenance is managed.

Please note that your participation in this process is voluntary, and we totally understand if you feel unable to.

We value your participation and appreciate you sharing with us your experiences in using this solar-powered borehole.

IMPLEMENTATION PHASE

Community Engagement Prior to Borehole Implementation

- To begin with, I would like to hear how the planning for the borehole was initiated before it was implemented. Kindly walk me through this process.
 - How was your community initially contacted and communicated to about the implementation of the borehole?
- Did you and other community members have input in the planning process for the borehole?
- How did you and/or other community members participate in the planning process for the implementation of the borehole?
 - Community meetings
 - What agreements did you make within the community and with the people that were implementing the project?
 - Did the community obtain authorization to use the land from local leaders or the government where the borehole and its reticulation system are implemented?

Borehole Implementation Phase

- I would now like to hear how the planning for the borehole installation and putting up of pipes was done.
 - How did you agree on sites where the borehole is implemented?
- Did you or the contractor conduct surveys to understand whether the sites selected for the implementation of the borehole were suitable or not?
- Did plans change at any point from what was proposed in terms of developing the water infrastructure? If so, what changes did you observe and how were they addressed?
- Were there any challenges faced at the time of drilling the borehole? How were encountered challenges addressed during drilling?
 - Theft of some parts, etc.
 - Resistance from some stakeholders?
 - Failure to comply with government regulations, e.g., ...?
- Was the borehole drilled at a depth that was agreed upon?
- How was the water yield?
 - Was the water yield from the borehole as initially desired during the planning for the borehole?
- How was the quality of the water after drilling?
- Did you have any concerns regarding the borehole implementation?
 - What were the concerns from the community, and how were they addressed?

Cost and Funding

- Would you know the total cost for the installation of the borehole?
 - What was the total cost of the borehole installation?
- How was the project funded?
 - Has the financial support continued after the borehole was implemented?
- Was there an agreement where the community agreed to make some contributions for sustaining the borehole in the future, during the planning phase?

- If so, how much was committed?
- How much do you pay now?

POST IMPLEMENTATION: BOREHOLE USE

Impact Assessment

- Does the borehole yield still provide enough water for community uses?
- Comparing the situation before the borehole was implemented and now, what major changes have you observed in access to water for the community?
 - For livestock watering
 - Gardening – field irrigation (if any)
 - Drinking
 - Other domestic uses
 - Other productive uses
- How many households are benefiting from the borehole? Could you approximate the number of people accessing water from the borehole for various uses?
 - For livestock watering
 - Gardening – field irrigation (if any)
 - Drinking
 - Other domestic uses
 - Other productive uses
- Have you made any modifications to the borehole pipes and taps, as well as the general installation of the borehole, to meet the required demand?
- Have there been any improvements in your life and the life of other community members since the implementation of the borehole?
 - Access to clean water, food, nutrition, and income in the rainy and dry seasons?
- How would you rate the overall performance of the borehole in terms of yield?
 - Is the water yield enough to meet all water needs in the community?

Levels of Satisfaction

- Have you received any feedback from people using the borehole about how it is performing?
 - If yes, what kind of feedback did you receive? Both positive and negative.
- Are all community members happy with everything surrounding the borehole?
 - If there are some that are not happy, what are some of the issues that have caused them not to be happy?
 - As a community, how do you plan to ensure that all people within the community are happy with the borehole?

Lessons Learned

- What are some of the lessons that you have learned from this borehole project?
- Is there anything you feel should be done differently if a similar project were implemented in the future?

Annex 3. FGD Interview Guide for the Water Committee Members.

INTRODUCTION

Thank you for joining us for this interview. As you already know, the ClimBeR project implemented a solar-powered borehole in this community last year for various purposes. We want to evaluate how the borehole has impacted your lives since its installation.

We have developed an interview guide with specific questions that will cover the situation before the implementation of the borehole in terms of access to water for various needs, including drinking, domestic, irrigation, and livestock watering. The interview guide will also cover questions on the current water supply situation since the implementation of the solar-powered borehole.

From you as the water committee, we would also like to know how the borehole maintenance is managed. We also want to know the plans you have, to sustain the water infrastructure so that it stands the test of time.

Please note that your participation in this process is voluntary, and we totally understand if you feel unable to.

We value your participation and appreciate you sharing with us your experiences using this solar-powered borehole.

Roles of the Water Committee

- What is the role of the water committee in relation to this borehole?
 - What are some of your specific tasks?
- How many people are part of the committee?
- How did you end up being a member of the committee?
- How have you ensured that all water needs are met, including drinking and domestic water, gardening and livestock watering?
- How do you ensure that people follow the set rules for using the borehole infrastructure?
- Are there any forms of sanctions for people or households that do not follow the rules for using the borehole?

Sustainability

- What measures have you put in place to ensure that the borehole is sustained for many years to come?
- Are there any requirements for maintaining the borehole since its implementation?
 - What are some of those requirements?
- Based on your assessment, how long do you think this borehole will last?
- Do you currently have a plan in place to ensure that the borehole is maintained regularly? Does this include regular repairs?
- Has there been any training on the maintenance and operation of the borehole?
 - If not, are there plans for the community to be trained on how to maintain and sustain the borehole?

Challenges of the Water Committee

- Do you face any challenges as a member of the borehole committee?
 - What are some of the challenges you face, particularly in the day-to-day running of the borehole?

Annex 4. Key Interview Guide for the Local Authority in the Monze District.

INTRODUCTION

Thank you for taking the time to conduct this interview with us. The ClimBeR project implemented a solar-powered borehole in the Hanzila community last year which is used for various purposes. We are now in the process of evaluating what has happened since the implementation of the borehole.

However, we are also aware that you have a responsibility to support the development of rural water supply in communities. We have visited you, therefore, to see what your role is as a local authority in supporting rural water supply projects, both those implemented by external donors and those implemented by the government.

We have developed an interview guide with specific questions that we would like to use to understand these details and learn from you if there are any opportunities for scaling up such water projects that support the livelihoods of rural communities.

We value your participation and appreciate you sharing with us your experiences using this solar-powered borehole.

Responsibilities of the Local Authority

- What are the main responsibilities of the local authority in managing rural water supply?
- Are there specific water supply infrastructures that you oversee as a local authority (e.g., wells, pipelines, treatment facilities)?
- How do you prioritise and select areas for infrastructure development or upgrades?
- What key policies or regulations guide the local authority's approach to rural water supply?
 - How do such policies guide your mandate?
 - How do you develop and implement long-term plans for rural water infrastructure?
- Do you have an adequate budget allocated for developing infrastructure for rural water supply?
 - How are budgets determined?
 - Are there any specific funding sources or grants available for rural water projects?

Community Participatory Planning for Water Supply Projects

- How do you ensure that you engage with rural communities in planning and decision-making for water supply?
 - Are there any programs or initiatives to raise awareness and educate community members about water infrastructure management?
 - Do you also do this for projects not directly initiated through the local authority?

Collaboration with NGOs in Developing Rural Water Supply

- Do you coordinate with other governments, NGOs, or agencies to provide water services?
 - How does the local authority coordinate with other government agencies or organisations to provide water services?
- Was the local authority involved in the implementation of the solar-powered borehole supported through the ClimBeR initiative? What was the role of the local authority?
- How do you ensure that projects such as the ClimBeR project borehole are implemented according to the guidelines of the local authority and that such projects meet government-set standards?
- Do you have plans to support the maintenance of the boreholes outside what was directly initiated by your office?
 - What are the processes for maintaining such water supply systems, e.g., the ClimBeR borehole?
 - Do you handle repairs related to the water supply?

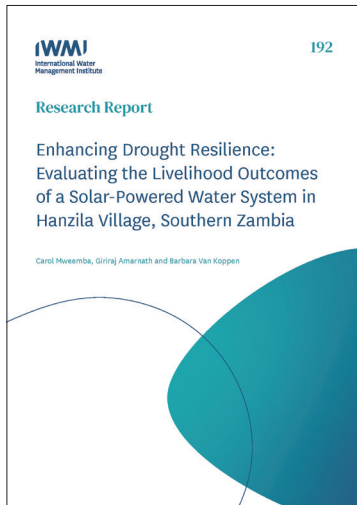
Scaling Up

- The ClimBeR project borehole used what we are calling a stepwise participatory planning process to develop the solar-powered borehole. This involved engaging communities to understand the challenges they faced in relation to water access and allowing communities to come up with their own suggested solutions that they felt would improve their water access. They were also involved in siting the location until the construction of the borehole. Do you see this as something that the local authority can use as a scale-up? What benefits or challenges do you perceive from such a process?
- How can the local authority enhance people's resilience to the impacts of climate change by replicating or developing a solar-powered borehole as achieved through the ClimBeR borehole initiative?

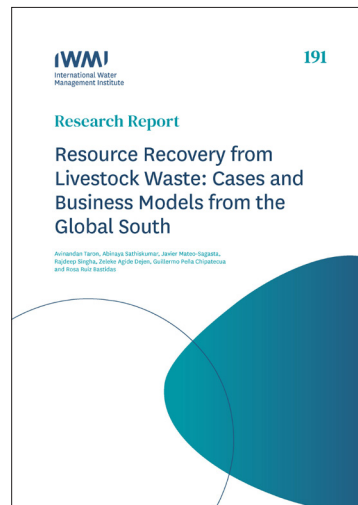
Challenges

- What are some of the significant challenges you face as a local authority in providing rural water supply?

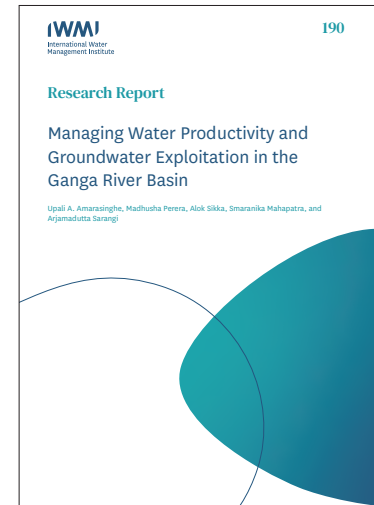
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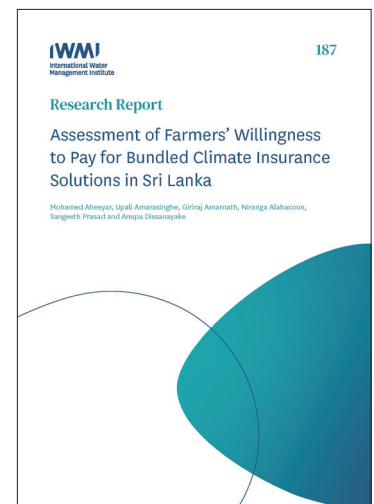
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