Assessment of the Simple, Market-based, Affordable and Repairable Technologies (SMART) approach for Water and Sanitation

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Name & Title: John Butterworth, for IRC Consult

Company: IRC

Postal Address: International Water House, Bezuidenhoutseweg 2, 2594 AV, The Hague
The Netherlands

Tel. No: +31 70 304 4000

Fax No: NA

E-mail: butterworth@ircwash.org

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Authors and acknowledgements

The report structure was developed by Kerstin Danert (Ask for Water GmbH). who also led the report writing, working with Sally Sutton (SWL Consultants).

The initial methodology for data collection for this assessment was developed by Richard Ward and Sally Sutton in conjunction with Reinier Veldman, Rik Haanen, Eugenia Kimaro and Leire Diez Larrea of the Zambian and Tanzanian SMART centres helped to develop the questionnaires. The two in-country surveys were undertaken by the SMART Centres in Tanzania and Zambia, under the supervision of Reinier Veldman. of the SMART Centre Group.

Key informant interviews and data analysis were undertaken by Kerstin Danert and Sally Sutton under the supervision of John Butterworth (IRC Consult).

Kevin Kruiter (DGIS), all of the eight SMART Centres covered by this report, and the SMART Centre Group (Reinier Veldman and Henk Holtslag) provided comments on the report before it was finalised.

Abbreviations and Acronyms

BZ	Ministry of Foreign Affairs
CCAP	Church of Central African Presbyterian (Malawi)
DFID	Department for International Development (UK) now Foreign and Commonwealth Office for Development (FCDO)
DHS	Demographic Health Survey
DGIS	Directorate-General for International Cooperation (the Netherlands))
EERN	Église Évangélique de la République du Niger
EMAS	*Spanish acronym for Mobile School for Water and Sanitation*
EMD	Eastern Manual Drilling
EUR	Euro
EWTI	Ethiopia Water Technology Institute
FIETS	Financial, institutional, environmental, technical and social
GHS	Ghana New Cedi
HDI	Human Development Index
KII	Key Informant Interview
PAH	Polish Humanitarian Aid *(Polska Akcja Humanitarna*)
PRDA	Presbyterian Relief and Development Agency (South Sudan)
LCS	Living Conditions Survey
MICS	Multiple Indicator Cluster Surveys
MoU	Memorandum of Understanding
NAWASCO	National Water Supply and Sanitation Council
NEET	Youth Not in Education, Employment or Training
NGO	Non-government organisation
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
SHIPO	Southern Highlands Participatory Organisation (Tanzania)
SMART	Simple, Market-based, Affordable and Repairable Technologies (used to refer to SMART Centres and the SMART Approach)
SMARTech	Simple, Market-based, Affordable and Repairable Technologies (term used to refer specifically to the technologies)
TNTC	Too numerous to count
ToR	Terms of Reference
TZS	Tanzania Shilling
WASH	Water, Sanitation and Hygiene
WARMA	Water Resources Management Authority (Zambia)
ZMW	Zambia Kwacha

Summary

Background and objectives

Appropriate technologies for water, sanitation and hygiene (WASH) are not new, and neither is promoting the private sector or household investments (Self-supply). However, from relatively humble beginnings in Nicaragua in the 1980's and a couple of decades later in Tanzania and Malawi, a small group of committed individuals and organisations have continued to work on this topic, growing into a larger network of organisations and individuals that are learning and adapting: SMART Centres, which follow a SMART approach to provide access to SMARTechs.

In the prevailing context driven by the Sustainable Development Goals (SDGs), and specifically SDG6, this report provides an assessment of the SMART approach. SDG6 'ensure availability and sustainable management of water and sanitation for all' demands that WASH interventions both 1) provide safely-managed services, and 2) enable universal access. To cover large areas, districts and countries, the implication of universal access is that multiple service delivery models need to be combined to cover everyone with services in a given area. In sanitation, on-site sanitation as well as sewers or adapted sewerage. In water, individual service models such as utility-managed or community-managed services are unlikely, except in a few locations, to serve everyone.

Household investments in safe, reliable water supplies at the home – also known as Self-supply – is a potential service delivery model that can complement other service delivery models such as community or utility-managed supplies.

The Directorate-General for International Cooperation (DGIS), Ministry of Foreign Affairs (BZ) Netherlands commissioned IRC to determine the potential of the SMART approach in reaching SDG6, and other related SDGs. Thus, an assessment was realised in eight African countries (Ethiopia, Kenya, Ghana, Malawi, Niger, South Sudan, Tanzania and Zambia).

The report is written with special reference to policy priorities of the BZ. The BZ seeks to contribute to the achievement of SDG6, by providing access to water supply for 30 million people, and to sanitation for 50 million people. That policy also emphasises sustainability of services, social inclusion, financial leverage and environmental sustainability.

The SMART approach comprises three pillars: 1) The use of innovative technologies, the SMARTechs; 2) Training of the private sector and 3) Promoting Self-supply. The use of SMARTechs (including manually drilled boreholes, various lifting devices including rope pumps and solar pumps, rain water harvesting systems and household water treatment) is considered as a way of reducing costs and scaling up the options for community and household investments at family level

The report is based upon review of documents, primary data collection (in late 2021) in Tanzania and Zambia including water point surveys and focus group discussions, key informant interviews and water quality testing. The planned methodology was adapted due to COVID-19 pandemic restrictions as set out in the inception report, and further adjusted due to changes in staff availability and the assessment team.

Overall findings

The main conclusions of the assessment are:

1. The SMART approach is contributing to SDG6, and such a market-based approach can provide safe water, located at, or close to people's homes.
2. Household water supplies can boost rural incomes and contribute to the rural economy and so are highly relevant beyond SDG 6.
3. The SMART approach is highly relevant to the BZ policy priorities to contribute to the achievement of SDG6, with their emphasis on sustainability of services, social inclusion and financial leverage and it can contribute to climate resilience.
4. The impact of the SMART Centres is significant, but localised.

5. Official recognition of Self-supply and targeted subsidies will both likely be vital to scale impacts and reach households that will be served last through other service delivery models.
6. The SMART approach has potential for much wider impact but is constrained by low levels of funding and staffing, and insufficient working partnerships.
7. Negative attitudes towards Self-supply, as well as misconceptions in the international water supply community, undermine the efforts of the SMART approach and limit the impact of other market-based approaches or efforts to support Self-supply,

Specific key recommendations to the BZ are to:

1. Given the relevance and effectiveness of the SMART approach, rooted in innovations and entrepreneurship within the Dutch water sector, but also recognising its limited impact and current lack of investment, this assessment recommends that BZ considers direct or indirect financing to scale up market-based approaches in rural WASH.
2. Reflect and challenge negative attitudes and misconceptions about Self-supply within the water supply sector and invest in development of evidence and policy dialogue.

The assessment also identified specific areas where the SMART approach, SMART Centres and the SMART Centre Group, could be strengthened. Specific recommendations are:

1. Invest in proof-of-concept, awareness-raising, programme development and working partnerships.
2. Consider broadening the SMART approach from three, to five pillars to including policy engagement and monitoring.
3. The SMART Centre management should increase its emphasis on documenting their efforts and sharing this information.
4. Strengthen monitoring to track outcomes and the use of data (e.g. for advocacy)
5. Strengthen sharing of experiences across the SMART Centre Group.
6. Continue to diversify interest in a broad range of technologies.
7. Continue to review country approach with attention to life cycle and focus of a SMART Centre.
8. Invest in professional fundraising and market research.

Introduction

In the first half of 2022, with less than eight years remaining to the 2030 deadline for the Sustainable Development Goals (SDGs), the world is not on track to achieve the Water, Sanitation and Hygiene (WASH) targets. Sub-Saharan Africa (SSA) is one of the regions that is lagging, particularly in rural areas. The Joint Monitoring Programme (JMP) of UNICEF and the World Health Organisation (WHO) estimates that 11% and 17% of rural dwellers of SSA still rely on surface water and unprotected sources respectively. An estimated 36% of the population use a basic supply, and only 13% are estimated to have a safely managed supply. These figures, and the trends that underly them point to the need for urgent, but sustained action to enable millions of rural dwellers in SSA to have improved water supplies. Household investments in safe, reliable water supplies at the home – also known as Self-supply – is a potential service delivery model that can complement other service delivery models such as community management, private sector, public utility or direct local government provision (World Bank, 2017).

The Directorate-General for International Cooperation (DGIS), the Netherlands commissioned IRC to determine the potential of the SMART approach in reaching SDG6, and other related SDGs in a number of African countries. The SMART approach, as defined in the Terms of Reference for this assessment comprises three pillars.

1. The use of innovative technologies, the SMARTechs (defined in Box 1)
2. Training of the private sector
3. Promoting Self-supply

The SMART approach combines SMARTechs with a focus on local production, use of local materials, family based management and supporting Self-supply to stimulate families to invest in their own well, or own household water treatment. The use of SMARTechs is considered as a way of reducing costs and scaling up the options for household investments at family level. Self-supply may happen without external intervention, or efforts can be made to support it. The latter – referred to as supported Self-supply - is what the SMART approach strives to do, by developing a critical mass of skills to, for example protect wells and produce pumps and install them, and encouraging consumers to invest. The SMART Centres try to stimulate a virtuous cycle of supply and demand, ultimately trying to stimulate a commercial supply chain.

Box 1 What are SMARTechs?

SMARTechs refers to WASH technologies which are Simple, Market-based, Affordable and Repairable. In general, these technologies can be produced with local skills and materials. Examples of SMARTechs for Water, Sanitation and Hygiene (WASH) and water resources management are:

- manually drilled boreholes (using techniques including rota-sludge, SHIPO and EMAS) and improved hand dug wells
- rope pumps, EMAS pumps, treadle pumps and submersible solar pumps
- rainwater harvesting systems including wire-brick cement and calabash tanks
- siphon and table top filters
- groundwater tube recharge
- SaTo pans (plastic ‘flappers’ that can be installed in latrine slabs or on traditional latrines) and corbelled zero cement latrines
- tippy tap hand wash option.

Figure: Eastern Manual Drillers drilling in Chipata peri-urban area, Tanzania (photo: Sally Sutton).

The SMART approach aims to tackle the following challenges

- Ensure access to water (both for domestic and productive use and sanitation for all, including "the last mile", i.e., people in remote rural areas and small communities. (SDG 6)
- Reduce the cost and increase the long-term functionality of rural water supply systems. (SDG 6)
- Reduce rural poverty (SDG 1), increase food security (SDG 2 – zero hunger) and increase resilience to climate change of rural families.
- Create (youth) employment opportunities (SDG 8).

This report presents an assessment of the potential of the SMART approach to contribute to SDG 6 – 'ensure availability and sustainable management of water and sanitation for all', and related SDGs in eight African countries (Ethiopia, Kenya, Ghana, Malawi, Niger, South Sudan, Tanzania and Zambia). The core structure of the report is in accordance with the sub-objectives of the assessment as set out in the Terms of Reference (ToR), i.e., the SMARTechs, SMART Centres, and the SMART approach[1].. Although the SMART approach includes sanitation, the assessment largely focuses on water supplies, which have been the emphasis of the eight centres.

This report is also written with special reference to policy priorities of the Dutch Ministry of Foreign Affairs (BZ), as funder of this study, The BZ seeks to contribute to the achievement of SDG6, by providing access to water supply for 30 million people, and to sanitation for 50 million people (BZ, 2017). Moreover, that policy puts emphasis on a number of key aspects, including:

- Sustainability of services. Where access is provided through Netherlands-funded programmes, these programmes are required to include measures to ensure sustainability of services. Moreover, they need to monitor whether services are used in a sustainable manner and report on that.
- Social inclusion. Dutch-funded programmes are expected to take specific measures to ensure inclusive access to services and particularly reach vulnerable groups.
- Financial leverage. Dutch-funded programmes are expected to mobilize and leverage additional investments from others, including the private sector.
- Environmental sustainability. A particular area of emphasis is the environmental sustainability of services. This implies that WASH services need to be developed in a framework of Integrated Water Resources Management (IWRM), ensuring sustainable access to water resources; and that any waste from sanitation is managed sustainably.

The report is structured to present an overview of the SMART Centres, and the SMART Centre Group, followed by an overview of the development and water supply context in the eight focus countries. [2] The assessment findings are presented in some detail, followed by the conclusions, which pull together insights, including on cost-effectiveness, long term functionality (sustainability) and (local) uptake of SMARTechs as well as the acceptance[3] of the training, development and guidance of the local private sector undertaken by SMART Centres. The conclusions provide insights into the potential of this approach to reach 'the last mile' – i.e., the yet unserved of whom a large part live in small and/or remote rural areas, the potential to create (youth) employment and to integrate SMARTechs into the curriculum of national vocational training structures. Additional material that supports the assessment is presented in Annexes.

1 All terms underlined are referred to explicitly in the Terms of Reference.

2 In preparing the report, an initial report structure was developed in line with the sub-objectives and insights sought in the ToR (see underlined above). Noting that the data collected went beyond the ToR, the structure has been adapted. Where relevant, the five principles of sustainability of FIETS (see bold text in Annex 1) have been used to strengthen the analysis.

3 Acceptance by whom is not defined in the ToR.

In light of the COVID-19 pandemic and changes to the evaluation team, several changes had to be made to the envisaged approach (Annex 1). The final approach used a mix of primary and secondary data[4], generated as summarised in Box 2.

The report writing was undertaken through an iterative process of analysing the data (Annex 2) and drawing out key issues. Analysis was largely qualitative, with quantitative data, as could be collected through the survey or from SMART Centre reports and other sources, used to enhance the analysis. Details of the survey methodology, focus group discussions and water quality testing are presented in Annex 3, 4 and 5 respectively. An overview of the methodology for the Key Informant Interviews (KIIs) is in Annex 6.

Box 2 Evaluation methodology

- Development of a written questionnaire for the SMART Centre management, a methodology and questionnaires for surveys of water points and water users, and a methodology for focus group discussions in Tanzania and Zambia.
- Collection of data from six SMART Centres (Ghana, Malawi, Niger, South Sudan, Tanzania and Zambia) through the aforementioned written questionnaires (referred to as Desktop Information Requests) [5] and from the other two Centres (Ethiopia & Kenya) through interviews and from presentations. Preparation of short reports on the SMART Centre Context in collaboration with the SMART Centre management in Niger, South Sudan and Zambia.
- Review of documentation and data shared by the SMART Centres and follow-up for more information where necessary.
- Collection of data by SMART Centre teams, and analysis of surveys[6] of water points, water users (owners and sharers) and water quality testing and reports of focus group discussions in Tanzania and Zambia.
- Design of semi-structured interview guide, collation of long list of potential key informants, selection of interviewees and interviews of key informants by telephone/online platform.
- Review of report draft by IRC and finalisation in light of comments received

4 Evaluation data sources are summarised in Annex 2.

5 Ghana (Abdul-Rahaman, 2021), Malawi (CCAP SMART Centre, 2021), Niger (McGill, 2021b), South Sudan (McGill, 2021a), Tanzania (SHIPO SMART Centre, 2021) and Zambia (Haanen, 2021).

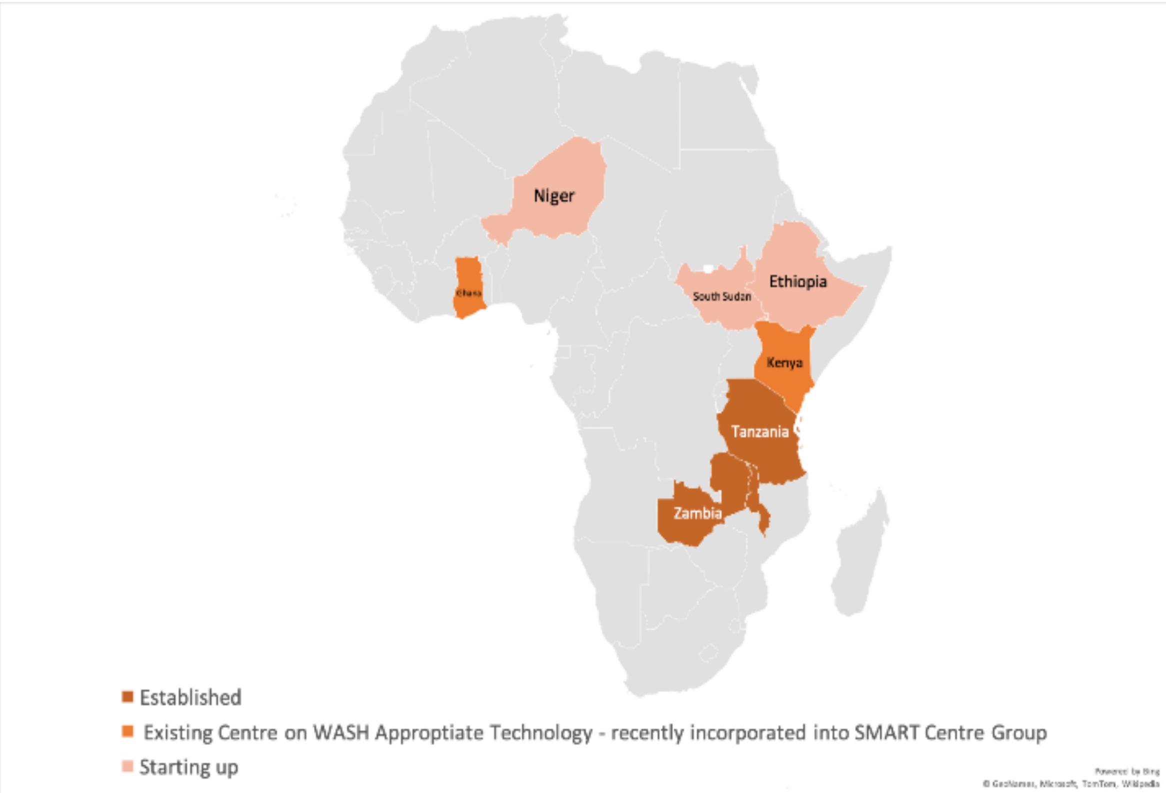
6 Survey data including water quality data was captured on the online platform mWater.

1. SMART Centres & SMART Centre Group

Appropriate technologies for WASH are not new, and neither is promoting the private sector or household investments (Self-supply). However, from relatively humble beginnings in Nicaragua in the 1980's and a couple of decades later in Tanzania, Malawi and Zambia, a small group of committed individuals[7] has continued to work on this topic, growing into a larger network of organisations and individuals that are learning and adapting. For a summary of the history of the SMART Centres, see Holtslag and Veldman (2022).

Today, SMART Centres exist in the eight African countries shown in Figure 1 as well as in Nicaragua[8], and in Mozambique[9]. Centres in Tanzania (Southern Highlands Participatory Organisation - SHIPO) Malawi (Church of Central African Presbyterian - CCAP), Zambia (Jacana), are well-established, having been started in 2007, 2012 and 2015 respectively (Holtslag, 2022a; MetaMeta, nd.). With the first training courses in South Sudan held in 2017 (Anon, 2017b), and interruptions through COVID and staff changes, this Centre is considered to be still starting up. Centres in Niger and Ethiopia are also still at an early stage of their development, with activities commencing in 2019. In the case of Kenya (Aqua Clara) and Ghana (Pumping is Life), the organisations were already promoting appropriate technologies for WASH, but have recently been incorporated into the SMART Centre Group.

Figure 1 African Countries with SMART Centres covered by this report and typology



[7] Henk Holtslag, Reinier Veldman, Jim McGill and Rik Haanen, Connect International and Aqua for All

[8] The SMART Centre in Nicaragua, which was established in 2017, was not included in this assessment. A SMARTech (the rope pump) started here 38 years ago. According to Briemberg (2022), to date 50.000 pumps are installed (3000 communal, rest on Self-supply farm and family wells which have generated an economic impact of over 80 million USD.).

9 The SMART Centre building in Northern Mozambique was destroyed in 2020, and staff, as well as activities have been severely affected in the ongoing insurgency in Cabo Delgado. The centre may be relocated, but given the circumstances., Mozambique was unfortunately not included in this assessment.

Each Centre has its unique history, institutional set up and staffing, ways of working and fundraising. Annex 7 provides an overview of each Centre. All Centres broadly follow the SMART approach as outlined in the Introduction, although they may focus on some technologies more than others.

The scope of the activities undertaken by each SMART Centre depends on the context, as well as funding opportunities and staff skills. For example, in Niger, the Église Évangelique de la République du Niger (EERN) is not only involved in manual drilling (considered a SMARTech), but also contracts drillers operating mechanised rigs. In Tanzania, among other activities, the SHIPO SMART Centre is also managing a plastics' recycling project and supporting fish farmers to add value to their products. These activities are beyond WASH, but relate to appropriate technologies and business development.

The SMART Centre Group, is an initiative that brings the various SMART Centres together, with a goal of scaling up by joining forces, ensuring quality and exchanging experience. The Group is not a legal entity, but is rather coordinated by the Dutch social enterprise MetaMeta. The Group was initially supported financially by Aqua for All.

The SMART Centres are each responsible for their own fund raising. There is also a SMART Centre Foundation, which is a registered charity in the Netherlands and which is supporting SMART Centres with small projects [10]. The SMART Centre group has signed Memorandums of Understanding (MoUs) with most of the SMART Centres (Veldman, 2022). The SMART Centre Group has two members of staff, one contributing 1 to 1.5 days per week and the other is working on a 0,8 Full Time Equivalent (FTE).

[10] https://stichtingsmartcentre.nl/en/home-2/

2. Context in the Eight Focus Countries

The concept of the SMART approach is that the use of SMARTechs (Box 1), the training of the private sector in these technologies and the promotion of Self-supply can contribute to addressing a number of pressing challenges, as described in the Introduction. These are improving access to water for domestic and productive use, improving access to sanitation, reducing the cost and improving the functionality of rural water supply systems, tackling rural poverty and food (in)security, while improving climate change resilience and reducing youth unemployment.

In order to provide the context for the eight African countries in which the SMART Centres are operating, this chapter provides a brief overview of the status and trends with respect to the aforementioned challenges, and reflecting on how the SMART approach could bring about changes.

2.1 Human development and poverty

Since the start of this millennium, all eight countries have witnessed an upward trajectory of their Human Development Index (HDI), with 2017 values ranging from 0.35 in Niger and 0.59 in Ghana (Figure 2). In terms of ranking, in 2017, Niger was ranked with the lowest HDI and South Sudan in the third lowest position in the world. Ghana, which has the highest HDI of the eight countries, is ranked in place 141 (UNDP, 2018). WASH has a direct bearing on poverty, and as one Key Informant stated so clearly – your future looks bright if you have access to your own water system, as water is so basic, "that if you do not have it, it takes away all your thinking".

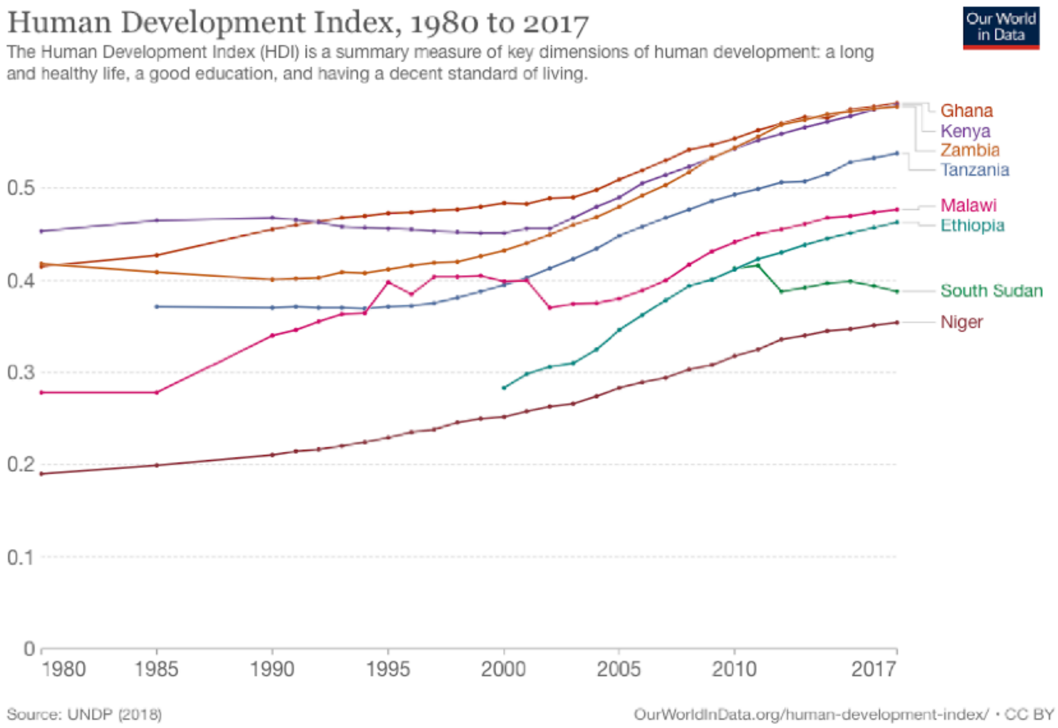


Figure 2 Trends in the Human Development Index in the eight African countries with SMART Centres

Figure 3 shows trends in the share of the population living in extreme poverty since 1981, which has clearly declined in Ghana, Ethiopia, Niger and Tanzania, but has actually risen in Zambia, South Sudan and Malawi. The rates of extreme poverty[11] in South Sudan, Malawi and Zambia are very high at over 80%, 68% and 59% of the population respectively. In contrast, extreme poverty rates in Ethiopia and Ghana are less than 20%. Based on the most recent data available, at least 30% of the rural population all eight countries in question live below the national poverty line, with more half of rural people living below the national poverty line in South Sudan, Niger and Malawi. (Table 1).

[11] Defined as the share of the population living in international $ 1.90 per day.

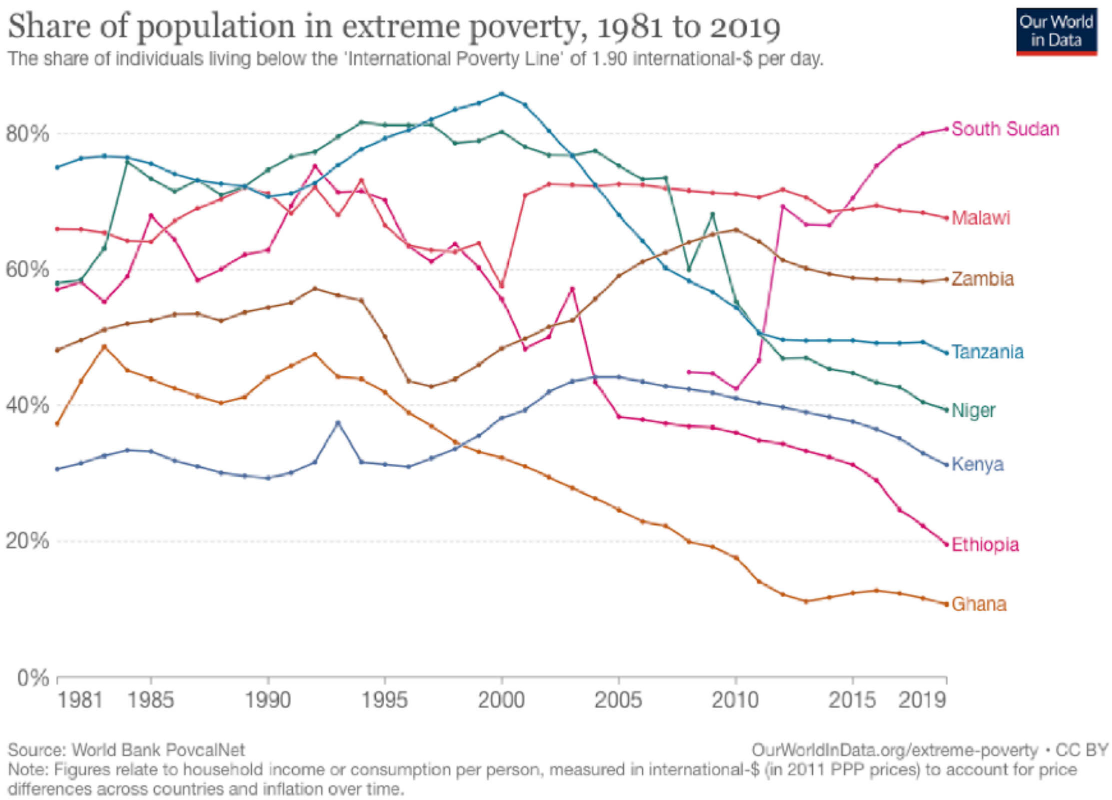


Figure 3 Trends in Extreme Poverty in the eight African countries with SMART Centres

The eight SMART Centres operate in countries with a range of poverty conditions at national level. Of the eight countries Ghana, Kenya and Zambia are classified as lower middle income countries, while the other five are all low income countries (World Bank, 2022a). While extreme poverty is lowest in Ghana, there are geographic inequities within the country: extreme poverty is outstandingly high in the rural Savannah at 46,1% and accounts for more than a quarter of those living in extreme poverty in rural Ghana (World Bank, 2022b). The SMART Centres have tended to focus on rural areas and to some extent, such as in Tanzania, on the populations of small rural towns.

Table 1 Proportion of the rural population living in poverty at national poverty lines and per capita GDP (Source: Our World in Data, 2022 and World Bank, 2018)

Country	Proportion of the rural population living in poverty at national poverty lines		Per Capita Gross Domestic Product (GDP) in $ (2011 prices)	
	Year	Proportion	Year	Per capita GDP
Ethiopia	2010	30.4%	2020	2,297
Ghana	2012	37.9%	2020	5,305
Kenya	2005	49.1%	2020	4,220
Malawi	2010	56.6%	2020	1,487
Niger	2011	55.2%	2020	1,199
Tanzania	2011	33.0%	2020	2,635
South Sudan	2009	55.4%	2020	-[12]
Zambia	2018	54.5%.	2020	2,370

By stimulating markets so that the private sector can produce, and households can buy water supply technologies and use water productively, the SMART approach tries to increase rural development and self-reliance.

[12] Data for South Sudan not available.

2.2 Population and population density

A common feature for all eight countries is their current high rate of population growth (Niger - 3.8%, Tanzania – 2.9%, Zambia 2.9%, Malawi, 2.7%, Ethiopia – 2.5%, Kenya – 2.2%, Ghana – 2.1%). South Sudan has the lowest of the eight, at 1.4%. When populations grow at such high rates, it remains a major challenge for governments to ensure that the expansion of social services (including water supply and sanitation) keeps up. As clearly demonstrated in these countries (but also in nearly all high-income countries too), Self-supply (defined as households investing in their own services) plays a significant role in supplementing efforts by the state to improve the access and quality of water supply services (Sutton and Butterworth, 2020).

The eight SMART Centres operate in countries with a range of average population densities from as low as 18 persons per km² in South Sudan to 203 in Malawi. Population distribution also varies within the countries themselves, with the concentration people in towns meaning that rural population densities are considerably lower (Figure 4).

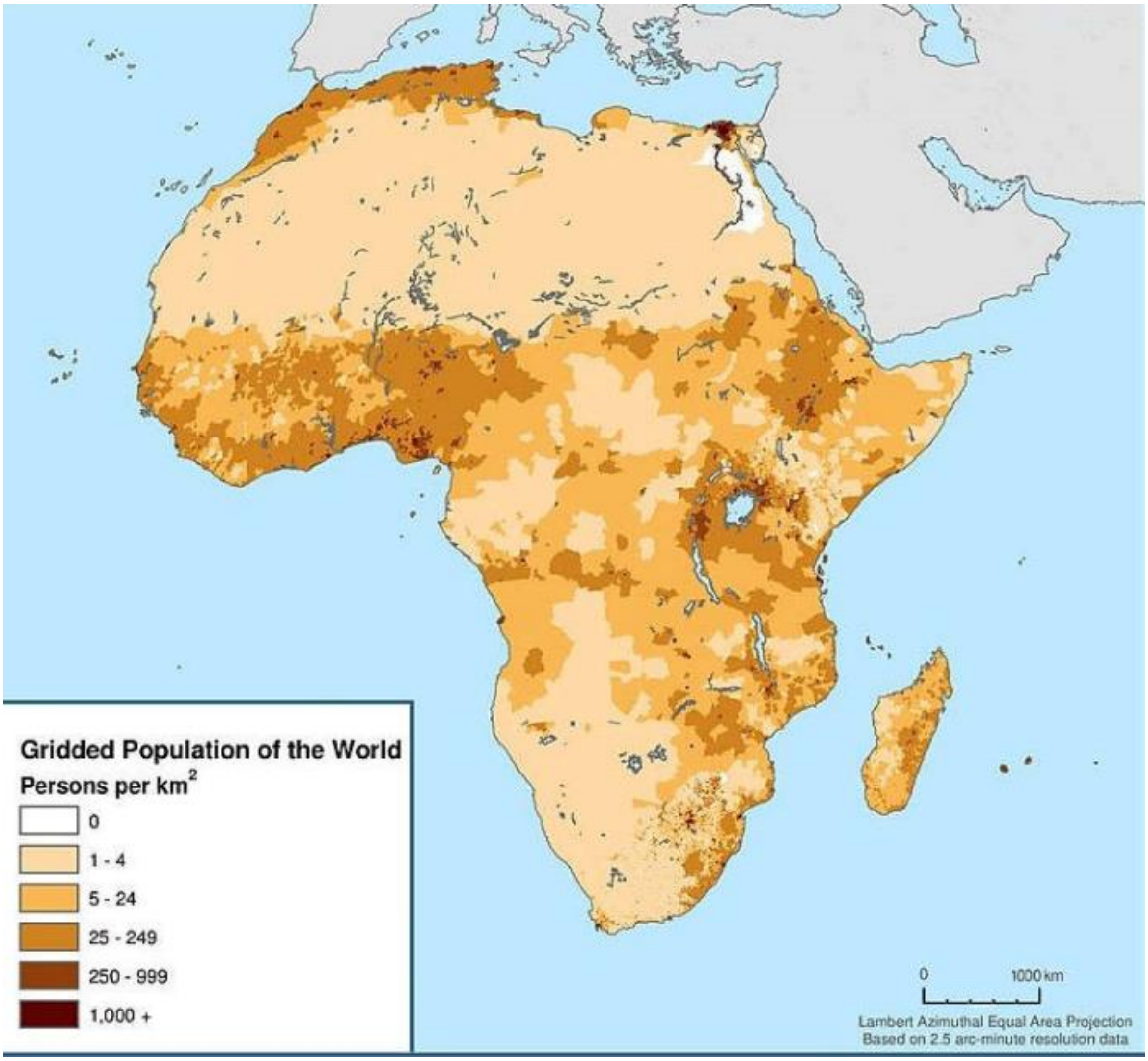


Figure 4 Gridded Population Density (people/km²) in Africa (Source: CIESN, 2011)

Low population densities and widely dispersed households present a challenge for the provision of infrastructure and services because per capita, and maintenance costs are high, and maintaining supply chains of spare parts is extremely difficult. On the other hand, where population densities are high, there can be high demand for limited services. In turn, this can lead to rapid wear, and high rates of breakdown[13]. SMARTechs (Box 1) can play an important role in both low, and high population density contexts. In low density areas, Self-supply may provide an alternative, financially viable option for some households, while in high density areas, supplementary sources can relieve the pressure on limited public or community supplies.

The different challenges faced in raising water coverage for these population density ranges highlights the importance of a range of technologies, strategies and service delivery models.

2.3 Food security and hunger

It is estimated that in 2018 across SSA (including Sudan), 23.9% of the population was food insecure, an increase from 19.9% in 2014., The situation is overall has worsened over these five years. The global hunger index scores for 2018 indicate that the situation in Zambia is alarming, with the situation in Ethiopia, Kenya, Malawi, Niger and Tanzania defined as serious. Hunger in Ghana is defined as moderate, and at the time of writing, data for South Sudan was not available. Water supply sources situated at the home and garden can contribute to improved food security by enabling crops and livestock to be easily watered, and yields raised by earlier propagation of seedlings and reduced dependence on early, and increasingly unreliable rains (see below).

2.4 Climate vulnerability and resilience

Climate change is already affecting populations in Africa, and this phenomenon is forecast to grow in the future, leading to increased flood and drought hazards, as well as more heatwaves. Particular concerns and adaptation measures for the eight countries covered by this assessment are summarised in Box 3. With its emphasis on water supply sources at the home, improving access to groundwater and promotion of groundwater recharge, in particular, the SMART approach tries to build resilience.

Box 3 Select climate challenges for the eight countries

- Ethiopia has a diverse climate and landscape, including equatorial rainforest with high rainfall and humidity in the south and southwest, the Afro-Alpine on the summits of the Simien and Bale Mountains, and desert-like conditions in the north-east, east and south-east lowlands (World Bank, 2022b). While the country is considered largely arid, it exhibits a high variability of precipitation.
- Climate change in Ghana is expected to bring disruptions to the electricity system, cash crop production, urban migration, livelihoods of smallholder farmers, and the coastline (World Bank, 2022b).
- Kenya's climate resilience efforts include investments afforestation and reforestation, geothermal energy production and other clean energy development, as well as climate smart agriculture, and drought management (World Bank, 2022b).
- Over the last decade, Malawi has experienced climate change and climate variability which has contributed to various devastating climate shocks that have increased in frequency. Most notable shocks are erratic rainfall, droughts, prolonged dry spells and strong winds. The changing climate has affected various sectors of the economy including agriculture, health, water, energy, transport, education, gender, forestry, wildlife and infrastructure (World Bank, 2022b).
- Niger is prone to natural disasters such as droughts, floods, and locust infestations, all of which contribute to chronic food insecurity (World Bank, 2022b).
- South Sudan faces natural hazard risks, including floods and drought and climate variability is anticipated to negatively impact agriculture, while projected increases in rainfall intensity may increase the risk of floods and the spread of waterborne diseases. (World Bank, 2022b).
- Tanzania is vulnerable to the impacts of climate change on coastal zones, public health, energy, infrastructure, water resources, agricultural production and availability of ecosystem goods and services. Tanzania is prone to risks from extreme weather events such as increased seasonal variation in rainfall and temperature, and frequent and prolonged droughts and floods. (World Bank, 2022b).
- Zambia's climate is highly variable and has recently experienced a series of climatic extremes, e.g. droughts, seasonal floods and flash floods, extreme temperatures and dry spells. Rainfall variability is a considered to be a key structural risk to sustainable growth, affecting agriculture and electricity supplies in particular (World Bank, 2022b).

[13] Using a combination of JMP data and comparisons with official data on handpump numbers, Danert (2022) estimates that the average number of users per handpump in both Niger and Malawi are high at 400. While population densities differ considerable, the pressure on limited infrastructure is actually similar.

2.5 Fragility

The Fund for Peace provides an annual fragile state index and ranking which considers cohesion, the economic, political and social situation and external intervention[14]. In 2021, of the eight countries, South Sudan ranked 4th, Ethiopia 11th, Niger 21st, Kenya 32nd, Zambia 42nd, Malawi 46th, Tanzania 61st, and Ghana 113th out of 179 countries.

Looking more closely at the three most fragile countries, Niger "has been prone to political instability and security crisis in recent years in the areas bordering Nigeria, Burkina Faso and Mali, where armed groups carry out attacks against the security forces and civilians (World Bank, 2022b). Ethiopia is currently beset by major civil unrest, and also facing potential famine in some parts of the country. Although South Sudan has been independent since 2011, over the last decade, the country has been tipping in and out of civil war ever since. Tanzania ranks in 61st place and World Bank (2022b) notes that as a large share of the country's population is close to the poverty line, even a mild economic shock can push numerous households into poverty, including the impacts of climate change.

Household solutions can be relevant in fragile contexts in which the state is weak, enhancing resilience at household level, particularly when centralised systems fail or investments are insufficient, although not all dwellers will be able to afford to invest.

2.6 Unemployment and Youth

Official unemployment figures for the eight countries are presented in Table 1Table 2 **Error! Reference source not found.**. However, these figures need to be treated with some caution, especially in countries where agricultural employment is high. [15] Further, there may be persons who are not officially considered as unemployed because they do not actively "seek" work, as they consider job opportunities limited, because they have restricted labour mobility, or face discrimination, structural, social or cultural barriers. The share of youth Not in Education, Employment or Training (NEET) capture untapped potential youth, including such individuals who want to work but are not seeking work (often called the "hidden unemployed" or "discouraged workers"). Data from the International Labour Organisation (ILO) indicate that NEET ranges from 11% in Ethiopia to 69% in Niger (data from Ethiopia and Tanzania is dated).

Table 2 Data on unemployment and share of youth NEET for select countries

Country	Unemployment – share of the labour force without work and seeking employment (Source: ILO, presented in Our World in Data, 2022)		Share of youth Not in Education, Employment or Training (NEET) (Source: ILO, presented in Our World in Data, 2022 Kenya figures from KNBS, 2019)	
	Year	Proportion	Year	Proportion
Ethiopia	2020	2.8%	2013	11%
Ghana	2020	4.5%	2017	30%
Kenya	2020	3.0%	2019	16%
Malawi	2020	6.0%	2017	33%
Niger	2020	0.7%	2017	69%
Tanzania	2020	2.2%	2014	15%
South Sudan	2020	12.7%		No data
Zambia	2020	12.2%	2018	43%

[14] https://fragilestatesindex.org

[15] It is especially difficult to measure employment and unemployment in agriculture. The timing of a survey can maximize the effects of seasonal unemployment in agriculture. And informal sector employment is difficult to quantify where informal activities are not tracked (Our World in Data, 2022).

By focusing on the development of small, local enterprises, either as service providers, or through enhanced water supply access for farming or other water-dependent enterprises, the SMART approach tries to contribute towards reducing unemployment.

3. Water Supply Context in the Eight Focus Countries

3.1 Water supply access

For the purposes of SDG 6 monitoring, drinking water access is defined according to five levels of a ladder as shown in Figure 5. An 'improved water source' has the ability to deliver safe water by nature of its design and is subdivided into the categories of 'limited', 'basic' and 'safely managed'. In order to qualify as a 'basic', rather than a 'limited' source, water needs to be collected in less than 30 minutes (round trip). To qualify as 'safely managed', the source needs to be located on premises, available when needed and free from contamination.

Community point sources, networked supplies and an improved Self-supply sources can all fall at different steps within the three upper (leftmost) steps on this ladder. As an example, a household that obtains a private pump can shift from using surface water or an unimproved dug well, to a safely managed service in one step, while their neighbours, who share the source may achieve a step up to a basic service.

Figure 5 Definitions across the drinking water ladder (Source: Our World in Data, 2022)

Figure 6 shows the proportion of the rural population that access different levels on the drinking water ladder for 2000 and 2020[16] in the eight countries. There has been a decline in the use of surface water in all countries except in Niger. However, in Kenya and Tanzania, 24% and 19% of the population respectively still rely on surface water.

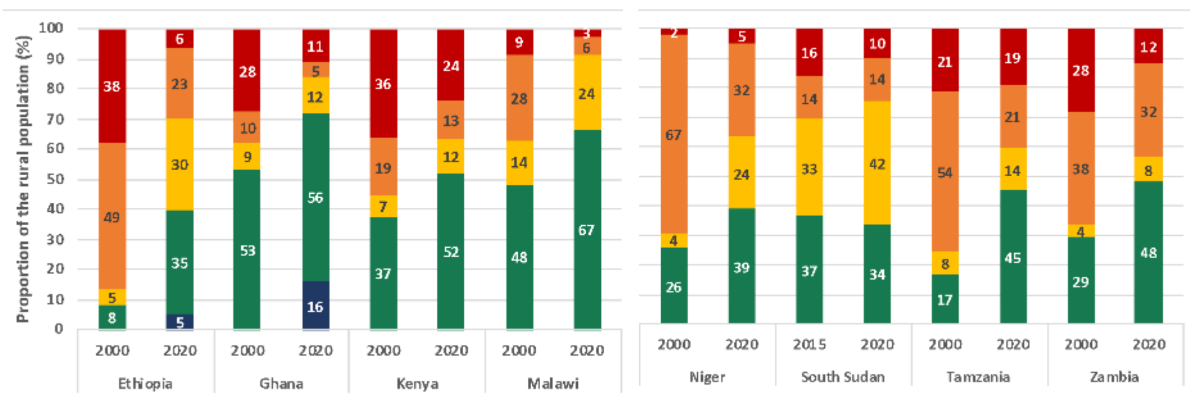


Figure 6 Trends in the proportion of the rural population (%) that access different levels of drinking water (Source: WHO/UNICEF, 2020)

While there has been a positive change, across all countries, a sizable proportion of the rural population still rely on unimproved sources in Zambia (32%), Niger (32%) and Tanzania (21%). Rates of use of a basic supply are highest in Malawi (67%), followed by Ghana (56%) and Kenya (53%). Across

[16] Annex 8 provides the full dataset for Figure 6.

the eight countries, it is estimated that 73.3 million people still rely on either surface water, or an unimproved source. And notably, use of a limited supply has increased from 9.8 million to 52.0 million between 2000 and 2020. These people rely on sources that are situated more than 30 minutes from the home.

Of the eight countries, data on the highest water supply service level, i.e., 'safely managed' for 2020 is only available for Ethiopia and Ghana and stands at 5% and 16% respectively.

Despite the advances illustrated in Figure 6, it is also worth noting some of the major challenges, for which household investments (Self-supply) may have a role to play (Box 4).

Box 4 Examples of how household investments can contribute to improving drinking water service levels

Niger: it was estimated that in 2020, 12.74 million people (63% of the population) had access to an improved drinking water supply. However, an estimated 6.38 million people (32%) still rely on unimproved sources and the population using surface water was estimated to grow 230,000 to almost 1 million between 2000 and 2020. With a population growth rate of 3.76% keeping up with population growth in terms of service delivery is a challenge for the country. [17] While great progress has been made much still remains to be done to improve drinking water access, especially amongst more dispersed communities. Many families are paying for others to lift water up and out of the well, relying also on animal power or by diesel-driven pumps, and when people are not able to use such a service, it may take as much as an hour to draw 20 litres of water (Sutton, 2022). However, given the fact that parts of Niger rely on deep groundwater, and that salinity is also an issue in some parts of the country, shallow-household wells can provide part, but not the whole solution for the country.

Figure (above) Rural Niger: Drawing water by hand (left), and with animal power (right) (Photos: Sally Sutton)

In South Sudan, it is estimated that the number of people with access to an improved water supply has increased from 5.08 (63% of the population) to 6.77 million (76%) between 2000 and 2020. [18]. However, in 2020, 3 million people (33%) had access to a basic service, and so more than half of those with an improved water supply (3.77 million people) still have a limited service and still have to walk for more than 30 minutes to fetch water. This illustrates the importance of bringing water services closer to consumers.

In the urban context, the World Bank High Frequency Survey 2017 indicates that almost 8% of urban dwellers in South Sudan have their own supply (Utz, 2017). A case in point is Juba, South Sudan's capital city which suffers unreliable water service delivery, and is dominated by private sector provision. (Matoso, 2018).

[17] See Annex 8 for data.

[18] See Annex 8 for data.

3.2 Water supply service functionality

It is not sufficient to provide a water supply facility, but rather the facility has to function, and perform well, whatever the type of service delivery model. Foster et al (2019) provides the most recent peer-reviewed collection of handpump functionality data and is presented in Table 3 alongside data for the eight SMART Centre Countries on borehole functionality from the databases from multiple organisations that are stored on the mWater platform. [19] Notwithstanding the limitations of this data, [20] they do indicate that non-functionality remains a significant problem in all eight countries.

Table 3 Functionality data for select countries

	Handpumps Technology (Foster et al, 2019)			Boreholes (mWater, nd (D))*		
Country	Year(s)	Scope	Non-functional	Years	Number of sources in the dataset.	Non-functional
Ethiopia	2010-14	2 of 9 regions	33%	2022	718	13%
Ghana	2014	6 of 10 regions	26%	2022	2000	14%
Kenya	2013	9 of 47 counties	24%	2022	767	9%
Malawi	2007	National	22%	2022	53260	9%
Niger	2015	National	15%	2022	318	13%
South Sudan	2009-11	5 of 10 states	20%	2022	2643	18%
Tanzania	2011-13	27 of 31 regions	33%	2022	140	9%
Zambia	2007	National	27%	2022	4155	18%
2019 data from the Government of the Republic of Tanzania estimates that 30% of all water points across the country are not functioning (MoW, 2020)				* Abandoned supplies have been excluded from the analysis		

Further analysis of data available from multiple organisations stored on the mWater platform in 2022 [19] across all eight countries, reveals that the functionality of public taps was the lowest compared to other sources (Figure 7). Further, public taps were more than twice as likely to be out of operation, compared with taps serving individual households, either within the house or in the yard/ compound. Protected dug wells were more than twice as likely to be out of action compared with unprotected wells,

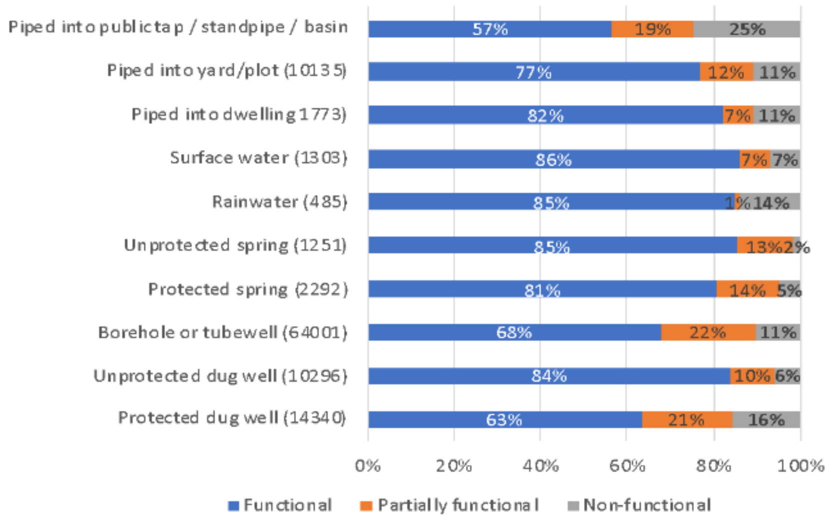


Figure 7 Aggregated data on source type and functionality for all eight countries with SMART Centres

(Source: mWater (nd-d)

[19] The data in the functionality dashboard come from the public updates provided by over 155,000 users in over 188 countries who use the free and open access mWater mobile data platform. Most of these users work for government, NGOs, and academic institutions (mWater, nd(d)..

[20] It is important to recognise that different methods are used to estimate national non-functionality rates and are thus not ideal for cross-country benchmarking. Further such estimates do not provide information on how handpumps are actually performing (e.g., ease of operation, taste/appearance of water), or why sources are failing (Danert, 2022).

3.3 Reliance on boreholes and wells for drinking water supplies

While there is considerable interest in upgrading to piped supplies, it is important to note that crystalline basement rocks underlie about 34% of Africa's land surface, where approximately half of Africa's rural population lives (MacDonald and Calow, 2009). These circumstances generally limit the amount of water that can be abstracted, emphasising the importance of handpumps and other low abstraction technologies.

Based on an analysis of 2020 JMP data, Danert (2022) estimates that about one in five people in SSA (plus Sudan) rely on a borehole or protected well for their main drinking water supply. [21] There is a high reliance of the total population in South Sudan (63%), Malawi (65%) and, Zambia (39%). Reliance on boreholes and wells is estimated to be higher in rural, than in urban areas, with figures for rural reliance as follows: Malawi (75%). South Sudan (66%), Zambia (51%), Ghana (43%), Niger (31%), Tanzania (20%), Kenya (13%). These figures do not include piped supplies that rely on groundwater.

In terms of potential improvements to existing water supply sources, it is worth looking at the overall reliance on groundwater point sources, which includes unprotected sources. Analysis shows that in South Sudan, Malawi and Niger, 68% or more of the population rely on such supplies, whereas figures are 58% in Zambia and 52% in Ethiopia. Kenya and Ghana show the lowest reliance, at 32% and 28% respectively (Danert, 2022).

3.4 Policies, strategies, programmes, practices and other key issues

Drawing primarily on the KIIs, and other information shared with the evaluation team, this section reflects on select policies, strategies, programmes, practices and other key issues that are particularly relevant for the SMART approach in five of the eight countries.

Ethiopia

Ethiopia is the only one of the eight countries which has a specific policy for small-scattered communities, with 'group Self-supply' for five to ten households and household-levels forming specific service levels (Sutton, 2022). In about 2010, to scale up rural water supply, the Ethiopian government developed a policy to stimulate Self-supply and then in 2020 a Self-supply group started with members from the Millennium Water Alliance, including World Vision and Catholic Relief Services, the Ministry of Water and Energy, IRC and MetaMeta (Gochem, 2022). Although Self-supply has been recognised in the policies of the Ethiopian government for over a decade, in practice, strategies on the ground and monitoring requirements, do not adequately support it. Further, despite the approach being included in the One WASH National Programme, few donors have supported investments for Self-supply. [22]

Major issues currently affecting Ethiopia include the urgent need for improved watershed management, given the large scale land degradation in the country, with the catchment often overlooked in the development of water supply sources (KII, 2022b). Given the challenges of obtaining foreign currency, there is also a need to focus more on technologies and services which rely on locally available resources (KII, 2022b; 2022c). The country has significant shortages of skilled human resources, and so there is need for training and capacity strengthening (KII, 2022b; 2022c).

Key Informants interviewed pointed out that there have been, and are other promoters of SMART Technologies, including IDE (primarily for irrigation), and that there are lessons to be learned from previous JICA-funded support of the rope pump[23]. Key Informants also noted that changes in the composition and structure of the Ministry that is responsible for water have may weakened the water

[21] Groundwater is also be the source for some piped water supplies, but its extent cannot be ascertained from the JMP data, which is based on national survey and census data.

[22] Some members of the Millennium Water Alliance are now supporting Self- supply (Holtslag, 2022b).

[23] Rope pumps were introduced by IDE and Practica foundation around 2005 and it has been estimated that over 25.000 pumps have been produced since then (Gochem, 2022). Around 2012 some 10.000 rope pumps were produced by 5 larger metal companies and mostly given away. (Gochem, 2022). Pump components and/or installation was of poor quality and in 2013 it was decided to improve the Rope pump, which was undertaken with support from JICA (Gochem, 2022).

sector, with a negative impact in staff retention, and institutional memory. Finally, there are also fragility concerns, with conflict situations in Tigray, Amhara, Afar and Benishangul, where water infrastructure has been destroyed, and will need to be rebuilt, or alternatives found. Self-supply is a widespread form of supply in parts of these regions.

Niger

Starting in the 1990's with the introduction of low-cost drilling and handpumps by the Lutheran World Federation and Enterprise Works Vita, the subsequent success of many of their trained entrepreneurs indicates both the development of a healthy market in Self-supply, and the degree to which SMART technologies can contribute to the local economy (Danert, 2006). The SMART Centre has identified about 14 drilling enterprises working in the country alongside ten active pump manufacturers (Sutton, 2022). The wells provide both irrigation and domestic water needs for small groups and individual households), but for at least a decade, there has been a lack of training of these enterprises, and there are concerned that there may be cartel practices (Sutton, 2022). This may be one of the reasons for the fact manually-drilled domestic wells are actually quite expensive, costing as much as USD 2,000 (KII, 2022d). The SMART Centre in Niger aims to try and introduce innovations with respect to borehole drilling and further open up the market.

South Sudan

The Director for Rural Water Supply in the Ministry for Water Resources and Irrigation of South Sudan is keen to promote affordable technologies and build the capacity of the private sector to speed up access to basic water supplies and provide employment opportunities. He has been very supportive of the SMART centre approach and was involved in its establishment as well as training sessions. Appropriate solutions for remote areas are considered as essential in the recovery from civil war, However, due to high rates of extreme poverty (see chapter 2), the potential for Self-supply investments by individuals in the country is fairly limited. Further, with such a strong emphasis on humanitarian response, which continues to respond to recurring crisis including floods and droughts, as well as many humanitarian organisations operating in the country, it is difficult to make the shift to more self-reliant development.

Documentation of the use of SMARTechs in South Sudan is patchy, but examples include manual drilling (hand augering) in Northern Bahr el Ghazal, which was initially introduced in the mid to late 1990's and then again in 2006, with rigs hired out by the government (Danert, 2015). In 2018, Practica Foundation provided training for staff of MedAir and Polish Humanitarian Aid (PAH) in Upper Nile State (McGill, 2021a). NGOs became aware of lower cost drilling options and a local entrepreneur now sells rigs to NGOs based on a modified design of rota-sludge drilling. Medair have set up their own drilling capacity to construct supplies especially for areas designated to accommodate Internally Displaced Persons (IDPs). Meanwhile, in Warrup State, there is also a small business which owns seven Vonder rigs (hand auger technology (McGill, 2021a). A Manual Drilling Technical Working Group has been established (McGill, 2018). In Juba, a public-private Institute for technical and vocational education and training (JUBA-TVET) was established in 2018 [24].

Tanzania

The National Water Policy 2002 emphasises technology choice, with communities empowered and facilitated to make choices that suit them, and an emphasis on low investment costs as well as least costly in operation and maintenance (MWLD, 2002). Pre-requisites for sustainability include "reconciling the choice of technology and the level of service with the economic capacity of the user groups" (MWLD, 2002). The use of environmentally friendly technologies including gravity, solar and wind were to be promoted, and the 2002 policy emphasises rainwater harvesting promotion. However, MoW (2020) notes that the pace with respect to the latter has been slow.

The Rural Water and Sanitation Agency (RUWASA) is mandated to ensure rural communities in Tanzania mainland have access to clean and safe water supply services, as well as specific urban

[24] See: https://www.juba-tvet.org/about-us/

areas (RUWASA, nd). RUWASA reports are not available on their website so it is very difficult to ascertain the technologies that are being constructed and maintained. However, the 2015-2020 Water Status Report (MoW, 2020) states that water coverage in rural areas improved from 48% in June 2015 to 70% by December 2019. The most recent water supply survey collated by the JMP is the 2008 Disability Survey, by the National Bureau of Statistics. It estimates that 43% of the urban and 20% of the rural population use tap water as their main source of drinking water and shows the important role of groundwater point sources, providing an estimated 40% of the rural population with their main drinking water supply.

The Government of Tanzania has an online water point mapping database, which is publicly available. [25] A search indicates the prevalence of communal standpipes across the country, of which there were 55,064, compared to 23,068 handpumps. [26] This database has been used to provide background data for the survey undertaken in Njombe region.

Stakeholders have estimated that over the years several hundred rope pumps with zero subsidy have been installed in Tanzania as a result of the training and awareness raising efforts (KII, 2022a). Kanyeto (nd) claimed that there were 4,000 rope pumps in Tanzania. Haanen and Holtslag (2016) stated that by 2016, 10.000 rope pumps had been installed in the country, over 50% of which were used for Self-supply and paid for by families. Laban (2022), one of the manual drillers in Tanzania since 2005, estimates that his company has installed over 4,000 rope pumps in the country.

In contrast, the national water point mapping database only includes data for 668 rope pumps. [27]. The lack of meta data available for the national database, makes it difficult to draw conclusions about the reasons for the difference in estimates but it is highly likely that not all household sources are counted in the national database.

Zambia

The National Water Supply and Sanitation Council (NWASCO) 2018 publication provides an overview of the current status, and plans for a regulatory framework for rural water supply and sanitation service provision (NWASCO, 2018). It recognised piped water supply schemes and water point sources, as well as offsite and onsite sanitation and notes a trend in which "more piped water supply schemes are being planned and constructed as growth centres[28] emerge". It is foreseen that new service provision and licensing arrangements for water supply and sanitation will cover piped schemes, water point supply (mainly boreholes and protected shallow wells fitted with handpumps), as well as sewer systems and onsite sanitation (mainly pit latrines, septic tanks and decentralised wastewater treatment systems).

Self-supply is common in both rural and urban areas throughout Zambia, especially in Northern, Luapula and Western Provinces. Previous initiatives support Self-supply have been funded by DFID and UNICEF, involving government and NGOs (documented case study 6 in Sutton and Butterworth 2021). Experience suggests a high suppressed demand for household water supply in the country, with more challenges to develop local markets in some provinces (e.g. Southern and Eastern) because of the greater difficulty to find adequate water within affordable hand-drilling/digging depths.

Government at national, as well as provincial and district levels, has shown interest in developing support to Self-supply as a service-delivery option, but although it was initially introduced in 2002/3, it is not mentioned in the current government policy, which is shifting towards piped supplies in rural areas. Ministry of Health trains environmental and primary health care personnel in household water supply siting, progressive improvement and household water treatment and, until recently, provided small subsidies to upgrade water supply sources. It also has responsibility for monitoring water quality, and so is a significant player in rural water supply.

[25] http://wpm.maji.go.tz (accessed on 10 March 2022)

[26] There is no metadata available on the website, but it provided data for construction periods in ten-year blocks from 1951-1960 to 2011-2020.

[27] Of which 209 are in Njombe, 208 in Mara and 127 in Morogoro, 37 in Kagera and 31 in Shinyanga

[28] Growth centres are characterised by a relatively concentrated population.

4. Assessment Findings: Technology, Water Services and Users

4.1 Technologies and centre outputs

Conventional water supply programmes that fund construction or hardware, generally involve Government (or NGOs) paying for the construction of facilities or distribution of technology, and (in some cases) longer term support to service provision. With such programmes, it is relatively easy to report on the number of facilities constructed. Further, an assumed number of users per facility (e.g., 250 people per handpump) is often used to estimate the population that have been served by a particular project.

In contrast, the SMART approach, which involves training, developing and guiding private enterprises as set out in the Introduction, comprises mainly 'software', rather than hardware investments. The enterprises trained are subsequently contracted by others (including private households, institutions and NGOs) to construct water supply facilities. Annex 7[29] provides detail of the SMART approach in Zambia. The SMART approach is thus an indirect method of raising access to water supply services and, as a result, it is more difficult to estimate the number of people served.

Whereas conventional water supply programmes are incentivised to report their consolidated outputs to donors, or taxpayers as an accountability mechanism, the enterprises that have been trained through the SMART approach do not all have such incentives to monitor or report. Likewise, the SMART Centres do not all have resources available to follow-up. This presents a challenge for monitoring the indirect outputs of promotion and training efforts. Nevertheless, considerable efforts have been made by SHIPO (Tanzania) and Jacana (Zambia) to encourage private enterprises to keep records (Box 5).

From 2016, when Jacana (Zambia) started training up to the end of December 2021, the organisation has tracked the installation of 425 pumps by the trained enterprises (Box 5), of which six were installed in early 2022. These pumps have been installed on hand-drilled and machine-drilled boreholes, hand dug wells and hand dug wells which have been deepened by hand-drilling. Only five of the installations were on boreholes that had been drilled prior to 2016. From 2016 to February 2022, of the pumps installed, a total of 66% were on hand drilled wells, with another 21% on hand dug wells, and 8% on deepened wells (see Annex 3 for details).

Starting from the first three rope pumps installed in 2016, Figure 8a shows a reasonably steady annual growth over the subsequent four years, reaching 126 pumps in 2020. The decline in rope pump installation in 2021 has been attributed to the effects of the Covid-19 pandemic coupled with investments in sponsored pumps growing more than usual - all drilling teams were deployed at clinics, hospitals and schools on available finances. Emergency funding targeted hospitals and clinics in Eastern province without access to water, installing rope pumps, due to difficulties in the supply chain of India Mark II and Afridev pumps. Solar pumps were also tested and by the end of 2021, 25 had been installed.

One of the three pillars of the SMART approach is Self-supply. Figure 8b shows trends with respect to owner-purchased and partially sponsored (also known as supported Self-supply) pumps between 2016 and 2021. Installations that were fully-funded by the owners have remained between 19 and 29 per year between 2018 and 2021. The Covid-19 pandemic, which commenced in 2020 had a negative effect on household finance in 2020 and 2021, a reality that may continue into 2022. Between 2016 and 2021, Jacana-trained enterprises have constructed 399 water supply facilities, that use the rope pump, 25 that use solar pumps, and one that uses the EMAS pump. Of these 109 (27.3%) have been funded entirely by the owners.

[29] See section - Zambia – Jacana SMART Centre

Box 5 Tracking the outputs of private enterprises in Zambia and Tanzania

Jacana (Zambia) has ensured that most of the boreholes drilled by the enterprises that it has trained are logged in the mWater platform. One of the incentives for this is the fact that the drillers all generally operate under EMD, which has a drilling licence, as required under Zambian law. Another incentive to log the boreholes is that Jacana provides drillers with unique tags, which are fitted onto the pump. The tags include the telephone number of the driller who constructed the well, and thus also serve as a marketing tool.

Summary data from mWater is presented to the public through the Jacana website (http://jacana.help/mwater/).

While Zambian law requires permits for manually drilled wells, this is not the case for hand dug wells, which are also upgraded by the drillers trained by Jacana. Haanen (2022a) estimated that 70% to 90% of pumps installed on hand dug wells by the enterprises that Jacana has trained are tracked on mWater and tagged. In case untagged wells are found by Jacana staff, they try to find out who installed the pumps so that they can be logged and also tagged.

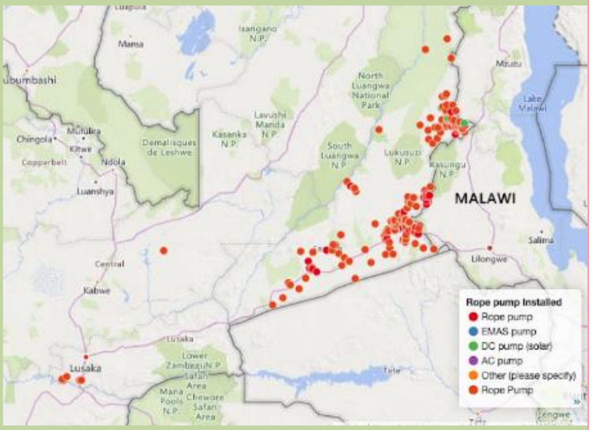


Figure (right) Map of waterpoints constructed by Jacana-trained enterprises (generated by mWater) [30]

A similar approach is followed in Tanzania, whereby the entrepreneurs report the water points, along with GPS data, a picture and data including depth and number of users. SHIPO then checks on these data (about 2/3 of what has been reported). At the same time, they check for the quality of the installations. This information is subsequently used to decide if a trainee obtains a certificate or not. Since 2020, the certificates are issues jointly by SHIPO and the Water Institute[31]. The certificate also means the person is licensed for drilling, with the Water Institute the only entity in Tanzania who can issue such licenses (Saladin, 2022).

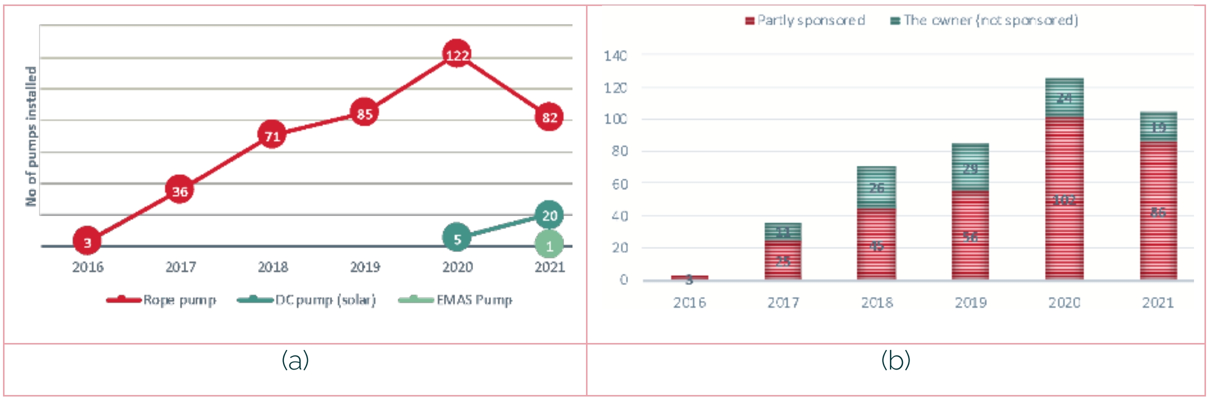


Figure 8 Trends in (a) number of pumps installed and (b) breakdown of private ownership and sponsorship by Jacana annually
(Source: Jacana dataset in mWater platform)

The publicly accessible mWater portals for the SMART Centre in Tanzania provide data on rope pump and well numbers, as summarised in Table 5. However, it is noted that "these are only water points that was captured by SHIPO SMART Centre Tanzania. there are more than these but it is impossible to reach all water points that have been brought direct from trained entrepreneurs due to different factor like distance [and] lack of fund" (mWater, nd(b)). It is important to note that in Tanzania, several hundred rope pumps have been installed without any hardware subsidies (Saladin, 2022).

[30] Accessed 8 February 2022

[31] https://www.waterinstitute.ac.tz

The relatively low capital costs of locally produced manual drilling equipment compared to imported conventional (mechanised) drilling rigs, means that the entry barrier for enterprises to buy equipment is considerably lower. Local production also means that the manufacturing and repair skills are locally available. The SMARTechs themselves are low cost, and intended to be affordable for household themselves. Table 4 provides an overview of the cost of facilities, as reported by the Centres in Ethiopia, Ghana, Malawi, Kenya and Zambia. Rope pumps are common to all centres, and manual drilling to some, with most of the Centres recently branching out into the promotion of solar pumping technologies.

Table 4 Data on installations collected by SHIPO Tanzania

Period	Installations	Further Details	Location	Source
2005 — end 2011	590 rope pumps		Iringa region[32]	mWater (nd(a))
Dec 2011 — Mar 2018	228 water points	• 183 fully paid for by owner • 23 partially sponsored by project • 21 community	Southern Tanzania	mWater (nd(b))
From 2018	130 water points	• 128 fully paid for by owner • 2 partially sponsored • 108 sources were private owned, of which 16 were used by the community	Southern Tanzania	mWater (nd(b))

Table 5 Reported costs of select SMARTechs in Ethiopia, Malawi, Kenya Ghana and Zambia

	Technology	Cost (USD)	Cost (EUR)
Ethiopia[33]	Solar pump 18v model (100 – 120 watts (12m lift plus 12 m head)	180	170
	Rope pump (pumping can extent to 30/35 meters)	19 - 57	18 – 54
Malawi[34]	Manually drilled wells using Mzuzu, SHIPO and EMAS technology (25 to 50m depth)	250 – 1,000	230 – 920
	Pumps – EMAS, rope and solar (to 40m depth)	40 - 300	37 – 276
	Table top water filter	12	11
	SaTopan latrine (including cement slab)	10 - 30	9 – 27
Kenya[35]	Aqua Clara Kenya hollow fibre water filter	34	31
	Rainwater harvesting tank and installation	200	180
Ghana[36]	Solar water system for the urban market	1,600	1,470
	Solar pump water system for the urban market	1,600	1,470
	Tulip household water filters	37	35
	Rain water harvesting tanks (40m3 Capacity	2,870	2,728
	Rain water harvesting tanks (15m3 Capacity	1,076	1,023
	Bulk water Supply (1000 liters)	1.56	1.48
	Geophysics Survey (EM343) Water Point survey (0.5Km)	386	367
	Mzuzu drilled Tube Well /Rope pump	492	467
	Rope pump	63	60
	Conventional drilled tube well/rope pump	1,194	1,134
	Pump repair services/year rate	45	43
	Other pumps repairs service /year rate	204	194
Zambia	Borehole siting	28	25
	Drilling and pump installation	868	775
	Rope pump@ 10m	91	81
	Small solar/submersible	88	79
	Large solar/ submersible	148	132

32 Njombe region was part of Iringa region until 2012.
33 Gochem (2022)
34 CCAP SMART Centre Malawi (2022)
35 Wakenya Pamoja SACCO and Aqua Clara Kenya (2018)
36 Abdul-Rahaman (2022) and Anon (2022)

Pumping is Life in Ghana reports to have enabled the construction of 430 rope pumps/tube wells, the rehabilitation of 56 hand dug wells and construction of 146 rainwater harvesting systems since they started operations, serving a total of 155,598 people (Abdul-Rahaman, 2022).[37]. However, the number of users per rope pump, at 219 is considerably higher than for the assessment surveys in Zambia or Tanzania (described below), suggesting that these are community supplies. Hand dug wells average at 188 users and rainwater harvesting systems at 350, which may mean that they are used in institutions such as schools.

At the time of preparing this assessment, there were no comprehensive databases, or consolidated reports available in the public domain that consolidate the services that have been brought about as a result of the demonstration, training and ongoing support by the Centres in Ethiopia, Malawi, Niger or South Sudan. It was thus not possible to estimate, or reflect on the impact of the Centres in these countries. Going forward, the evaluation team recommends that the SMART Centre Group continues with its efforts of consolidating referenced data.

One of the activities of the Aqua Clara SMART Centre in Kenya, in collaboration with the Participatory Microfinance Group for Africa (PAMIGA) has been to improve water access and solar energy through loans within a local microfinance programme (Wakenya Pamoja Sacco Society and Aqua Clara Kenya, 2018). From its launch in 2015 up to December 2017, Wakenya Pamoja Sacco Society, a savings and credit cooperative active in Kisii region, had offered (so-called Safi top-up) loans to over 475 clients (401 for water filters and 74 for rainwater catchment systems). The findings of a study on the effectiveness, outcomes and impact of these loans are summarised in Box 6.

Box 6 Summary of findings of study on the Safi loan scheme in Kenya (Source: Wakenya Pamoja Sacco Society and Aqua Clara Kenya, 2018)

A study, conducted in 2018 found that the majority of the water filter or rainwater harvesting loan clients were not the poorest of the poor, but that 35% of water filter and 49% of rainwater harvesting clients were poor, living on less than USD 2.50 per day. Both sets of clients primarily live in rural areas, with the majority having a low to medium education (secondary 3 or less), and a family size of 4 to 8 people). The study hypothesised that there is a self-selection bias among Safi loan clients with clients with better revenues more likely to invest.

Of the 118 Safi loan clients with water filters surveyed, 70% had their water filters installed for at least six months. A total of 93% of respondents stated that they had been using their water filter on the day, or previous day of the survey, and 97% of the filters showed signs of being used according to observation by the surveyors while 70% use it on a regular basis. The decision to invest in a water filter was found to be directly linked to high levels of dissatisfaction with current water sources, causing health problems. Seeing and testing the filters during demonstration sessions, coupled with access to a loan were the reasons for purchasing a filter through the scheme. Notably the Safi Loans borrowed on average EUR 400, whereas the filter cost only EUR 28 [38]. The study concluded that "the use of the water filter has clearly substituted to the lack of water purification or to the boiling method". While there was no reduction of time spent on fetching water, the clients liked the fact that they had more clean water, no more turbidity and did not have to boil the water. Dislikes included the limited storage capacity and price (which was considered a bit expensive) and the fact that spare parts were not available for free.

The survey of 30 rainwater harvesting loan clients found that 80% of the clients were women, with an age profile slightly older than that of the water filter clients. As above, the decision to invest in rainwater harvesting facilities was directly linked to a high level of dissatisfaction with current sources of water, with distant sources, long queues and limited quantity of water specifically mentioned. The initial agreement had been that clients were required to have the installation undertaken by a *fundi* who had been certified by Aqua Clara Kenya, which was intended as a quality assurance measure. However, only one of the 18 households. (5.6%) did this. Upon inspection only 56% of the systems were found to have been properly installed and fully operational. Weaknesses were found in the construction of systems by both certified and non-certified *fundis,* with one system (5.6%), not properly installed and not functional. Of those surveyed, 77% stated that they are facing some difficulties in repaying the loans, and while the exact

[37] see Table A7.1 for details

[38] i.e. KES 3,500 – exchange rate: Oanda.com on 31 December 2017

reasons are not known, the focus group discussions undertaken alongside the survey indicated that the instalment schedule was not adapted to cash flows.

The 1 m^3 and 3m^3 were the most popular tank sizes serving 60% of the survey sample. The study found no linkages between tank size, household size or poverty levels. Only 60% of respondents that had taken out a loan had installed their rainwater systems. The survey found that 30% had taken out a loan to sufficiently cover the cost of the system, but had not installed, while 36% of those who did install, had taken out a loan that did not cover the full cost of the system. As with the water filters, most people (70%) borrowed more than the cost of the polyethylene tank and its installation. While before the installation no clients had been using rainwater systems in the dry season, 20% were afterwards, with 53% of clients using rainwater systems in the rainy season, compared to only 3% beforehand. In the rainy season, the rainwater systems have substituted for other sources (i.e., rivers lakes, ponds as well as protected and unprotected springs) for all households who had installed a system. Given that many of the tanks were relatively small storage volumes, it is not surprising that their dry season use is constrained, and it would be worthwhile to look in the future at whether households are willing to invest in larger tanks. Further outcomes are that in the rainy season, the average time fetching water in the rainy season reduced from over 2 hours to 21 minutes, while expenditure on the purchase of water reduced from an average of EUR 9.4 to EUR 2.2.

4.2 SMART Water Supply in Zambia and Tanzania

The assessment survey provides valuable insights into experiences of rope pumps in Zambia: [39].

- Of the 143 rope pumps surveyed, in Zambia, 120 (83.9%) are functioning well, with 8 (5.6%) functioning badly, 11 (7.7%) not functioning and 3 (2.1%) abandoned[40]. This functionality rate is considerably higher than national estimates of 73% (Table 3), but in line with data collated in the mWater platform for boreholes more generally at 82% (Table 2). Comparisons of the detailed assessment data with other data sources are presented in Box 7, and indicate that the functionality of the rope pumps and solar pumps is higher than for boreholes or shallow wells in general.
- All of the ten solar-driven pumps surveyed were found to be functioning well.
- Notably, out of 119 rope pump owners surveyed, 43 (36.1%) stated that their source had never broken down since it was installed. Of the ten broken down rope pumps with data available, seven (70%) had been broken down for 30 days or more. All rope pump owners responded that spare parts are readily available.

Perhaps even more important than the snapshot of functionality, is to understand who undertakes maintenance, and the cost of repairs:

- Of the 23 rope pump owners who responded to the question on who undertakes maintenance 21 (91.3%) undertake it themselves, or a member of the family does, while two (8.7%) call in the installer.
- The average cost of repair for the rope pump was EUR 3 (ZMW 56), with the maximum EUR 32 (ZMW 600). While this is very encouraging from the perspective of the users, the low costs may not be sufficient for local enterprises to sustain a business in providing maintenance services if it is the only service they were to provide.

[39] See Annex 3 for survey methodology, and sampling and an explanation of what findings can be inferred

[40] Of the abandoned sources, one is on a mechanically drilled well, whereas of the ten sources that are not functioning, one is mounted on a mechanical-drilled borehole and the other nine are on manually-drilled boreholes.

Box 7 Comparison of functionality data sets for Zambia

The data below compares the SMART Centre assessment water point survey data with data in mWater on Zambia (mWater, ND(d)). a government waterpoint inventory of three districts of Eastern Province[41]. It suggests that the functionality of the boreholes and the handpumps that have been installed with rope pumps or solar pumps is higher than for boreholes, or shallow wells in general. However, it should be noted that the assessment survey sources are all five years old, or less, which may positively affect functionality rates.

Data source	Number	Are sources FUNCTIONAL (%)?		
		Yes - well	Yes - badly	No
Smart assessment survey (boreholes with rope pumps or solar pumps)	133	88%	3%	9%
Smart assessment survey (hand-dug wells with rope pumps or solar pumps)	30	87%	7%	7%
mWater boreholes (2022)	4155	74%	7%	18%
mWater shallow wells (2022)	381	60%	10%	28%
Government of Zambia for three districts (borehole and handpump) 2020[42]	1667	76%	n/a	12%
Government of Zambia for three districts (hand dug well and handpump) 2020	89	47%	n/a	30%

In the case of Tanzania: [43].

- Of the 63 rope pumps surveyed, 31 (49.2%) are functioning well, with 2 (3.1%) functioning badly. This is lower than the estimated functionality of 70% for all water points in the country (Table 3). Of the 30 rope pumps that were not functioning, 12 were reported to be abandoned. The main cause for non-functionality reported was mechanical breakdown (18 out of 21) with 3 reported as having dried up. Of the 16 non-functional rope pumps with data on how long they have not been functioning 13 (81%) had been out of service for more than 30 days.
- Out of the 23 motorised systems, 21 (87,5%) were functioning.

The lower functionality rate for the rope pumps surveyed in Tanzania compared to Zambia may be partly due to the fact that many are older systems, but the sampling frames do not enable attribution. In addition, 21.2% of owners responded that spare parts are not available. This problem was also reflected in the focus group discussions (Box 8).

Box 8 Reflections on poor rope pump functionality in Tanzania (Source: assessment focus group discussions)

Focus group discussions in ten communities in Njombe region Tanzania (details in Annex 4) found that, in most communities, most of the rope pumps were not working, although one community did note that if they are functional, they are a great help to residents. Poor functionality was often attributed to poor management, although some communities explained that they had struggled to get spare parts (including ropes and guide blocks). This echoes survey funding described above that 21.2% of owners responded that spare parts are not available. One community stated that they had failed to find solutions to the dried wells. In more than one community, there was mention of a scarcity of mechanics.

[41] The survey was conducted using Akvoflow, and the project was under the National Rural Water Supply and Sanitation Programme (NRWSSP), Ministry of Water Development, Sanitation and Environmental Protection, funded by KfW. The consultants organising the survey were the Icon Institute from Germany and COWI A/S from Denmark. Data provided to Sally Sutton by Francis Kalenda in Feb 2022.

[42] See footnote above.

[43] See Annex 3 for survey methodology, and sampling and an explanation of what findings can be inferred

In terms of rope pump maintenance, in Tanzania, of the 31 who responded to the question, in 24 cases (77.4%) it is undertaken by the owner themselves or family members. None call in the installer, but 6 (19.4%) rely on the local mechanic or area pump mender. The average cost for the rope pump repair was EUR 7 (TZS 18,000), with the maximum EUR 59 (TZS 150,000).

4.3 Water use, including sharing and user satisfaction in Zambia

A significant change for the owners of rope pumps is the reduced distance to the water supply service (Figure 9), with 106 out of 114 (93.0%) respondents now having supplies within 100m, compared to 50 (43.9%) beforehand. In 25 cases (21.9%), the distance was reduced from over 1km to less than 10 meters, while 67 households (59.8%) now have their main drinking water source within less than 10m[44]. The new rope pump site situated at a distance of over 1 km has its own particular story. [45]. The Focal Group Discussions emphasised the time savings that can be made when water is in reach, in the form of private wells, with an example of one woman no longer having to fetch water from the river as a result of being able to share her neighbours private rope pump.

The owners of rope pumps were asked about the advantages and disadvantages of sharing these sources. Advantages included reducing the distance to fetch water; creating unity, strengthening relationships, showing love and helping one another; ensuring that neighbours drink clean water and that maintenance becomes easy when all users contribute when necessary. The main disadvantage given was that some people don't care, or use the source carelessly and that maintenance can be a problem. Almost half of the owners mentioned that elderly and vulnerable people share the pump.

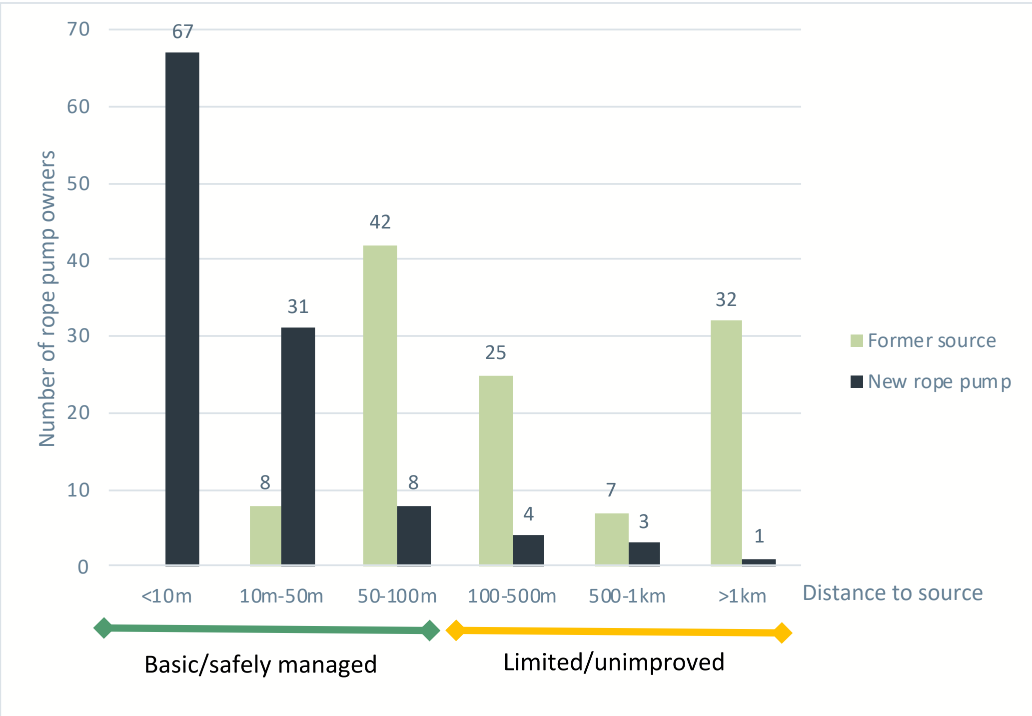


Figure 9 Accessibility: Distance to source before and after new rope pump in Zambia (Source: Assessment Survey Data) [46]

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[44] For full details, see Annex 3.

[45] The owner (in Lundasi) was one of the first to pull together funds (600 ZMW) for a (sponsored) new borehole. However, the siting in 2019 did not find any potential near the house because of hard rock. This confirmed the owner's experience of hitting rock within a few metres when constructing a hand dug well and giving up. The nearest spot with potential for hand-drilling was some distance away, still on the owner's fields but far from the house. This makes it difficult to oversee its use and prevent vandalism. Having installed the distant source, the owner returned to the shallow well, getting different well diggers to chip away at the rock until they broke through to water below. So thus, this particular owner now has a supply by the house (traditional well) too which he uses for drinking (source: Sally Sutton interview Bester in Lundazi).

[46] Note that five respondents did not give the distance to the source used previously, hence 114 rather than 117 respondents.

Although households invest in their own supplies, in most cases, these sources are actually shared with neighbours and relatives. The regular monitoring data collected by Jacana (Zambia) indicate that, on average, privately-owned pumps which are used by others in the community serve an average of 13 households, and even those that are considered to be used by only one family, are reported to serve an average of two households. The Focal Group Discussions found that there are some families that restrict use to only the owner or one or two neighbours. In some cases, shares contribute to the maintenance costs, as well as keeping the water point and its surroundings clean. Box 9 uses the survey data to estimate how many people have benefitted from the pumps installed and wells drilled or improved by Jacana-trained enterprises.

Findings with respect to user satisfaction in Zambia are also very positive:

- 107 out of 117 rope pump owners (91.5%) interviewed were satisfied with the work, with 7 neutral (6.0%) and 3 (2.6%) not satisfied[47]. In one of these three cases, where they were not satisfied, the rope pump was not the main source of drinking water supply, while in the other two it was.
- 62 out of 63 (98.4%) of the sharers of rope pumps were either very satisfied, or satisfied with the supply, with one person neutral. The reason for satisfaction included enough water, proximity, clean water, reliability, and ease of use[48].

Box 9 Estimating user numbers for the services that have been provided by Jacana-trained enterprises

The survey found that on average, privately-owned rope pumps are used by 7.46 households. The average size of rope pump owner households is 6.5 persons, whereas that of sharer households is 5.30. Assuming one owner household, and 6.46 sharer households means that each privately-owned rope pump serves an average of 40.7 people.

Multiplying this up for the 399 rope pump sources in the Jacana database, equates to 13,797 people. If this figure is adjusted for functionality, and to only include the rope pumps that are functioning well (87.9%), as calculated above, then an estimated 12,128 people use well-functioning rope pumps at household level due to the efforts of Jacana. If community sources were to also be included, the overall number of users will be higher than this [49].

Focus group discussions were held with water users in seven communities in Zambia (details in Annex 4). While these are not statistically representative, they do provide insights into perceived advantages and disadvantages of private sources at the home (or shared), vis-à-vis community supplies, alongside a range of water quality perceptions. While the rope pump was found easier to use, community pumps were considered to be more robust. Having a choice of pump for household supplies was also valued, and management of private pumps was easier. Conflicts can occur at both private and community sources, but for different reasons. For more details, see Box 10,

[47] Neutral, or no satisfaction was attributed to the water running dry, slots on the casing pipe that were too large, seasonality and difficulty in using the pipe.

[48] No reason was given for the neutral response.

[49] Notably, the survey shows that institutional and community-owned rope pumps serve more households than individual sources at 24.7 and 19.6 households respectively. As the current Jacana database does not distinguish between family, community and institutional wells, no estimates can be made for these.

Box 10 Comparisons between private and community sources in Zambia from the focus group discussions

The focal group discussions highlighted the following differences between private and community pumps,

- One community noted that the quality of the water from private pumps is better than that of the community India Mark II pumps (which contain rust), and the scoop holes, which are open, shared with animals. However, another stated that there is need to filter out sand for most private boreholes.
- Rope pumps are easy to use, and can easily be operated by little children, unlike the India Mark II pumps. While the rope breaks easily and the pumps are less durable, unlike in the case of community pumps, the installers usually train the family on how to fix the rope pump themselves, and so they can usually be fixed immediately. Community pumps need the community to come together and require a pump mender who needs to be paid. While overall, spares are easy to find for the rope pump compared to the India Mark II, in cases where there is need for welding, the rope pump has to be transported into town, which, at times, is expensive. In one community, it was noted that while there is a choice of pump menders, there are few trained technicians for the rope pump. It is worth noting that Jacana explicitly trains few producers because it wants to ensure that they are able to generate a small profit and this remain in business and maintain their tools.
- Community pumps are stronger and have the capacity to last longer than the private rope pumps, which can easily break down, especially with a large number of users.
- Community water points benefit a lot of people compared to private water points but have higher maintenance fees than the private supplies. In one community, it was stated that the capital cost for the community pumps is higher.
- It was stated on the one hand, that there is less conflict at private pumps because users are well guided on the rules and there are less users. In the case of community pumps conflicts can arise when financial contributions need to be made and some members are not willing to pay. There is less conflict at the private pumps – they are shared with close friends and neighbours with a common understanding. In one focus group, it was stated that private pumps can bring about conflict, especially if owners restrict usage. Private pumps were noted as bringing about jealousy, with vandalism a problem at times. With community pumps, there is a sense of uniformity in social status, and also brings people together as they meet when fetching water.
- Ownership of private sources is very clear. Private owners can decide on which pump to install, and, unlike in the case of community pumps, where the fees are decided by community leaders, in the case of private pumps, the owners set the regulations.

4.4 Water use, including sharing and user satisfaction in Tanzania

A significant change for the rope pump owners in Tanzania, is also the reduced distance to the water supply service (Figure 10).

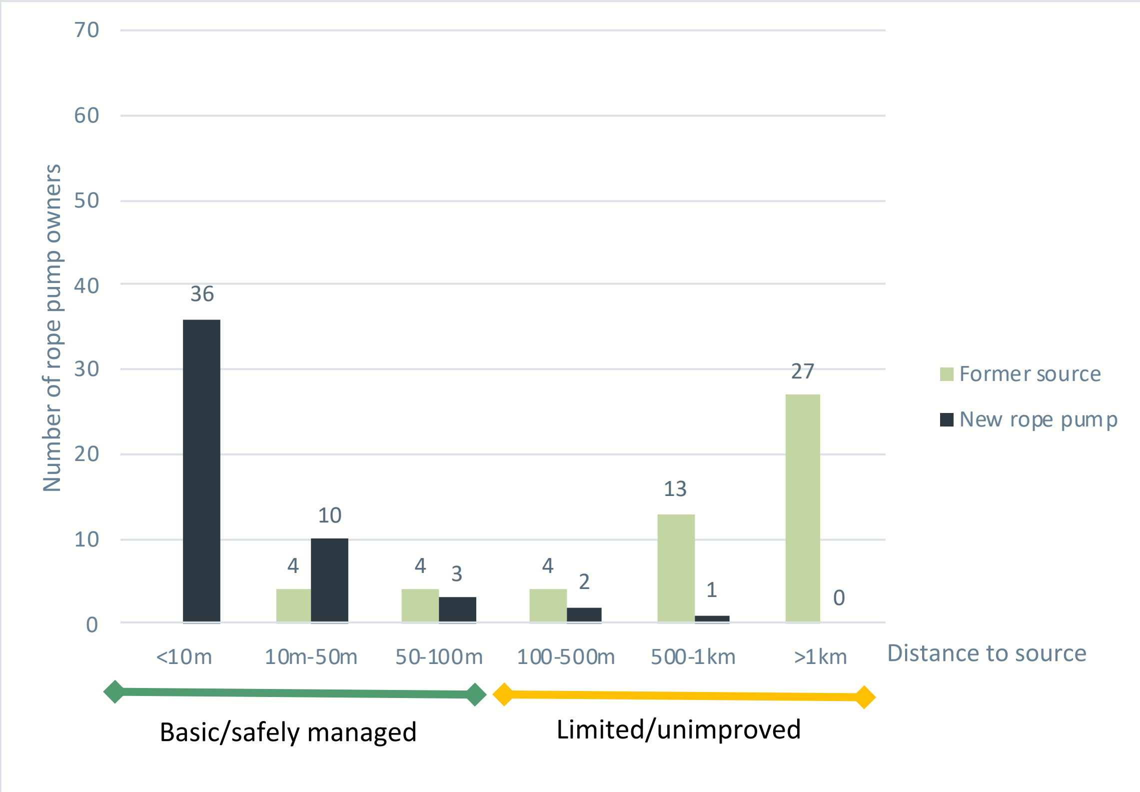

Figure 10 Accessibility: Distance to source before and after new rope pump in Tanzania (Source: Assessment Household Survey Data)[50]

A total of 49 out of 52 (94.2%) respondents now having supplies within 100m, compared to 8 (15.49%) beforehand. In 19 cases (36.6%), the distance was reduced from over 1km to less than 10 meters, while 36 households (69.2%) now have their main drinking water source within less than 10m[51].

In Tanzania (as in Zambia), most rope pumps, mechanised pumps and hand dug wells are shared with neighbours. The water point survey found that on average, privately-owned rope pumps are used by 20 households. The average size of a sharer households using handpumps was 5.71 persons, and, assuming all households comprise an average of 5.71 persons (using assessment survey data[52]), on average, 113.5 persons use each rope pump. [53] In the SHIPO data (December 2011 to March 2018), the average number of water users per well are 40. However, it is worth noting that the water point survey found that, in contrast only 3.76 households are reported to share privately-owned motorised pumps and 6.72 households shared private-owned traditional wells with a rope and bucket. This may indicate that those with higher service levels are less willing to share, and is an issue that deserves further attention, particularly with respect to equity concerns.

The Focus Group Discussions in Tanzania showed a common aspiration to replace/upgrade the rope pump technology with electrical pumps. Reflecting on different water systems, a range of views were expressed by the different focal groups, illustrating that there is actually no one -size-fits all solution, and that private sources do complement public taps (Box 11).

[50] Note that 26 respondents did not give the distance to the source used previously, hence only 52 respondents.

[51] For full details, see Annex 3.

[52] According to https://www.statista.com, national average rural household size is 4.9 persons.

[53] Unfortunately, the water point survey data on the size of owner household in is unreliable.

Box 11 Summary of issues raised in Tanzania focus group discussions

One community pointed out that they prefer the gravity water as it is cheap to maintain,

Another (5) stated that they prefer wells over gravity schemes, as, unlike the tap water, the water is available all of the time/is not reliable.

One prefers the Afridev pump to the rope pump because it is easier to pump; another two communities noted that wells with rope pumps are hard to operate.

One prefers private water points for the freedom to decide how and when to fetch water for any uses. Notably, this community feels that they are being overcharged for their piped supplies. Three communities noted that private wells are easier to manage than community-owned supplies.

In one community, while they have government-supplied piped water, many residents have opted to drill their own wells due to the distance between their houses and the water points.

In one community, it was stated that the rope pump cost is a bit higher than people can afford. In this village, it was also stated that most of the wells with rope pumps that were built by SHIPO were still functional due to good communication with Laban Kaduma, who was trained by SHIPO.

In terms of gender issues, it was pointed out that men generally take the decisions in the home, including whether to drill a well or not, and the women expressed that they are used to not participating in decision making. In one community it was stated that they believe that even if they air their views they will not be listened to. In another community it was stated in the report that "the inferiority complex was observed among women who participated in the group discussion".

Analysis of the household survey data highlights the following issues with respect to user satisfaction and changes due to the rope pump.

- 49 out of 51 (96.1%) of 117 rope pump owners were satisfied with the work.
- 24 out of 26 (92.3%) of the sharers of rope pumps were either very satisfied, or satisfied with the supply, with two people (7.7%) unsatisfied. One of these two stated that the reason for this was because it is now not working. Proximity and year round availability were among the reasons for satisfaction.

The owners of rope pumps interviewed were asked about the advantages and disadvantages of sharing these sources. Advantages included strengthening friendships and relationships with neighbours and the community, creating unity, bringing people together, upholding a culture of sharing, helping others and cost-sharing. Relatively few respondents provided disadvantages, but these were lack of payment by sharers, faster wear of rope (than if it was not shared) and careless use of the pump by sharers. The main vulnerable groups mentioned as sharing were the elderly, with a few siting persons with disabilities.

4.5 Outcomes and impacts in Zambia and Tanzania

Across both Tanzania and Zambia, many positive impacts by rope pump owners were cited, with different benefits for women, men, and the family as a whole. Time savings through no longer of having to fetch water from distant sources was particularly valued (Box 12).

The surveys indicate a range of benefits that these household supplies in both Tanzania and Zambia have has on the household, and business economy (Figure 11 and 12b). These gains are fully in line with the aims of the SMART approach to impact on human development and employment, as outlined in chapter 3.

Reductions in the cost of water was reported, alongside gains in income and the use of water for productive activities. In Zambia, additional income enabled respondents to pay school fees, purchase of additional animals (pig, goats, chickens, cattle), cover farming costs, fertilizer, new set of welding machine, motor bike increased labour force, and has contributed to constructing a house. In Tanzania, this additional income enabled respondents to pay school fees, cover farming costs, increase farm size, house building as well as contributing to basic needs. Follow-up after the survey by the Centre in Tanzania one of the businesses with a reported increase in income of over USD 400 per year (Figure 11b) found that a man has a nursery for avocado seedlings; and that he can earn more EUR 400 per year selling the small trees – a business that he would not be able to undertake without a well – an example of substantial income attributed to a rope pump.

Focus group discussions revealed that making compost manure, which needs a lot of water is more convenient with a private water supply, with watering gardens also mentioned frequently. The location of a reliable water source close to, or directly at the home is likely to be the main factor driving these impacts. Findings from both countries are summarised in Table 6.

**Box 12 Different Impacts of rope pump sources on men, women and children and the vulnerable in Tanzania and Zambia, and gender issues
(Source: assessment surveys)**

For women - time savings, and no longer having to walk long distances to fetch water, In Zambia, one Focus Group Discussion found that women have more decision-making power with respect to private sources, as they are sometimes the owners, unlike in the case of community sources women have little, or no influence.

Impacts on the family - the fact that men themselves can draw water near the house, ability to concentrate on other works rather than water scarcity, feeding livestock, saving money, time savings/more time for other activities, easier for building construction, reduced/no costs for water, irrigation, hygiene and sanitation improvements,

In the case of children, the impact mentioned were safety (at home and not an open well), time savings including more time to study, read, for school, other chores and other things, ease of washing clothes, general cleanliness at home and at school, washing hands before eating, no more long distances for children to fetch (and carry) water, reduced risks of waterborne diseases, not having to skip school (to fetch water).

In terms of vulnerable groups 39% of supplies in Tanzania were used by elderly community members and over half (58%) counted elderly and disabled members amongst their users.

Table 6 Reported impacts of rope pump sources in Tanzania and Zambia, and gender issues

Impact and reason	Zambia	Tanzania
Reported that costs of water had reduced after the improvement.	117 out of 118 rope pump owners, (97.3%)	50 out of 52 rope pump owners (96.2%). In the case of electrical pumps, the corresponding figure was 20 out of 22 (90.9%),All five stand pipe users also reported a cost reduction
Increase in income	45 out of 117 rope pump owners (38.5%) Reason: Evenly attributed to (i) more time available for work, (ii) water used productively and (iii) both[54].	32 out of 52 rope pump owners (61.5%) Reason: 59.3% of those attributing this to both (i) more time available for work and (ii) water used productively.
Use of water (by sharers)	All but one of the 65 rope pump sharers use the water for drinking and cooking, and all but two use it for washing clothes and bathing, 46 (70.7%) use it for livestock, 18 (27.7%) for a house vegetable garden, and two respondents for small scale irrigation. One sharer uses the water to wash cars and motorbikes (which is presumably a business activity).	All of the 25 rope pump sharers interviewed use the water for drinking and cooking, washing clothes, 24 use it for bathing, four for livestock, two for a house vegetable garden and three for small scale irrigation.
Increased value of annual business	42 out of 119 (35.3%) rope pump owners	31 out of 52 rope pump owners (59.6%)

[54] This was also echoed in the focus group discussions, i.e. a private water point provides an opportunity to generate income through doing various business activities at the home.

Figure 11 Distribution of approximate value of increase in annual business in Zambia as a result of rope pump by owners where they reported an increase

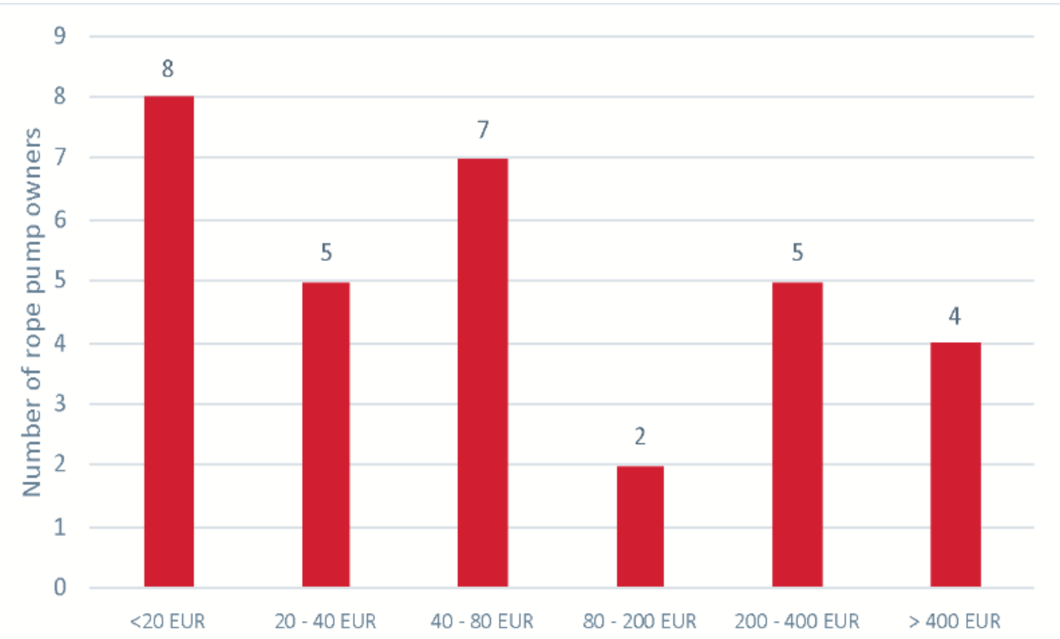

Figure 12 Distribution of approximate value of increase in annual business in Tanzania as a result of rope pump by owners where they reported an increase

5. Assessment Findings: Water Quality, Household Water Treatment and Safe Storage

This chapter presents and analyses the water quality and sanitary inspection data from the surveys as well as information on household water treatment and safe storage – a practice that many of the Centres have been trying to promote in order to improve the quality of drinking water at household level. The chapter draws upon limited data from the SMART Centres, as well as information from other sources.

The household surveys undertaken for this assessment in Tanzania and Zambia included sanitary inspections and were complemented the testing of water quality for a sample of sources. Annex 5 sets out the methodology for the water quality testing, including limitations. It is important to note that bacteriological water quality varies, particularly with source type and protection, as well as season of the year and the weather in the days immediately preceding sampling. As a result, the comparison of samples taken at different times of year was difficult. While the selection was not undertaken using a sampling framework that enables statistically significant conclusions to be drawn, the testing does provide pertinent insights.

5.1 Water quality of the sources surveyed in Zambia and Tanzania

In Zambia in 2021, the boreholes sampled were two years' old or less, and the survey found that faecal coliform were absent from almost three-quarters of samples taken, with 93% having with less than 10 (Figure 13).

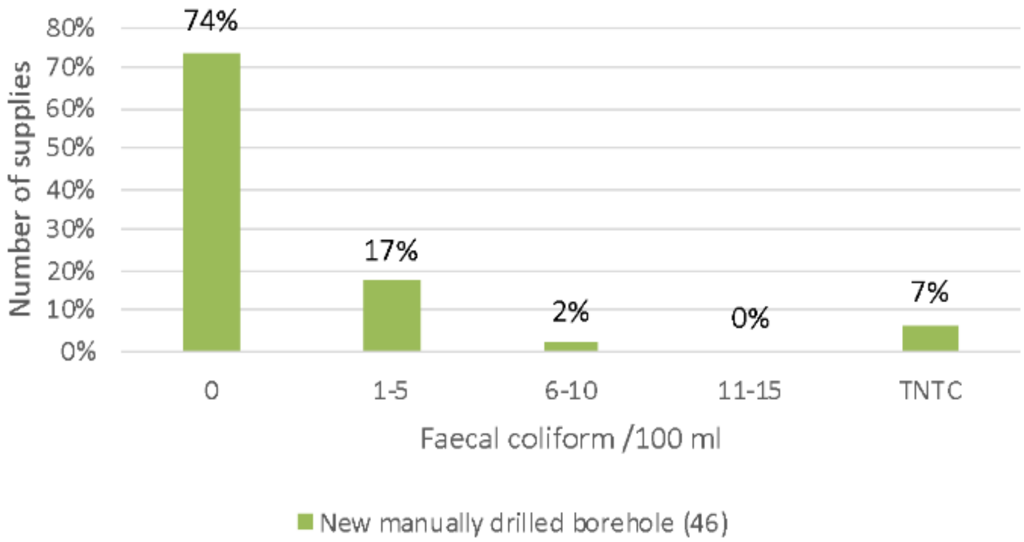

Figure 13 Water quality in Zambian boreholes at the end of the rainy season 2020/21

In Zambia, at an early stage in the rainy season, faecal coliforms were absent in 66% of all boreholes at the time of sampling (Figure 14). This is not as high as the samples taken earlier in the year (Figure 13). It is not clear whether this is because rains were particularly heavy that year, or whether boreholes had been in use for that much longer, and so contamination pathways had developed further. Either way, it suggests a need to check procedures for gravel packing and sanitary sealing of the borehole annulus, and a need for greater hygiene around the facility. Surprisingly, shallow wells appear to be performing slightly better than boreholes, indicating that wellhead protection design and installation practices are generally good. However, the sample size was small.

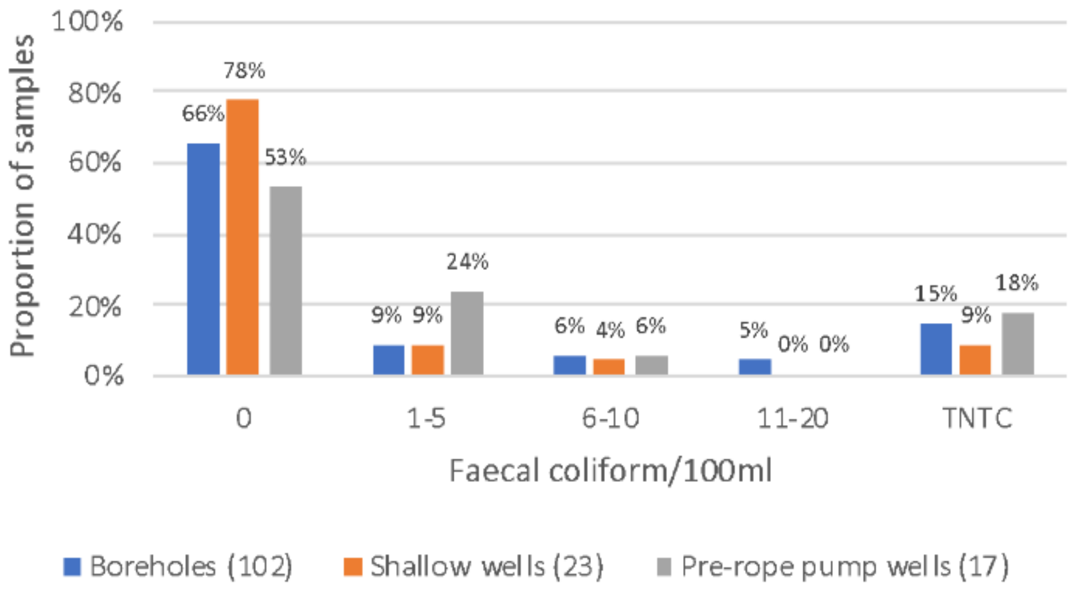

Figure 14 Water quality in Zambian rural water supplies at the beginning of the rainy season 2021/22

The survey also suggests that supplies which are privately owned are twice as likely not to be contaminated (69% vs 32%) compared with institutional and communally owned supplies. However, supplies used by only one family were almost twice as likely to be badly contaminated, ie. with faecal coliforms that are too numerous to count (TNTC) as those which are shared with several (15% vs 8%) which raises a number of questions that could not be examined in this assessment.

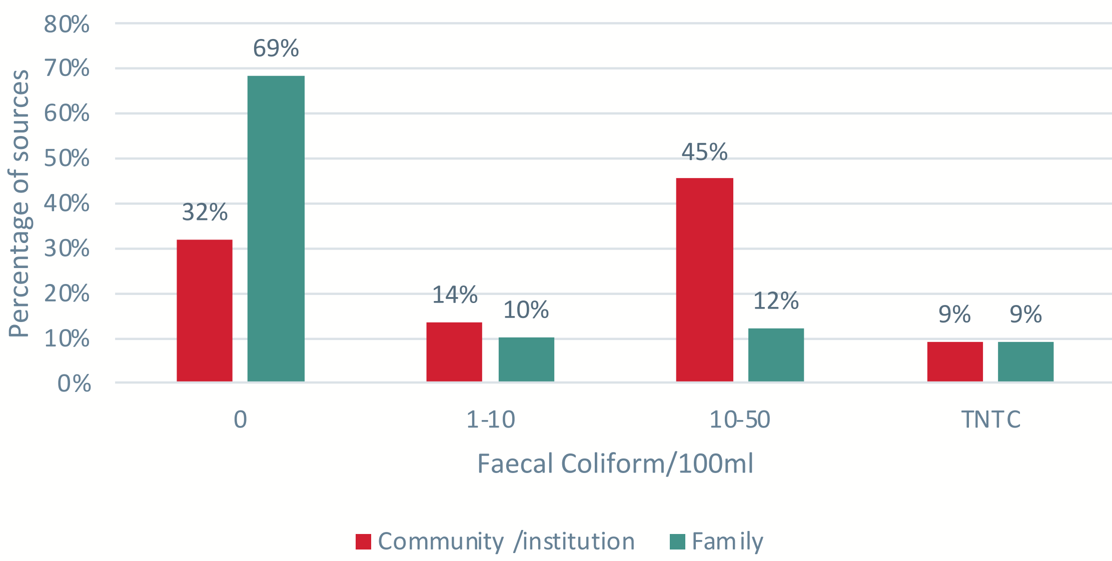

Figure 15 Comparisons of water quality between community-owned and family owned sources in Zambia

Due to the limited samples and some questionable results (i.e. very different value for duplicates at the same sites), there is a limit as to how much information can be ascertained from the Tanzania survey. However, cleaned data suggests that motorised pumps perform poorly in terms of water quality (Table 7), pointing to the need for a stronger emphasis on hygiene at the wellhead. As to be expected, rope and bucket sources performed the poorest, but a third still provided 'safe water'. The authors hypothesise that this may be due to well head hygiene by owning households and imposition of rules that sharers dare not break for fear of exclusion.

Table 7 Lifting device and water quality, Tanzania (Source: Assessment water quality survey)

Lifting device	Proportion with Faecal Coliforms Absent	Number of samples
Motorized pump	60%	10
Rope pump	83%	12
Rope/bucket	39%	23

Comparing performance of the SMARTechs with wider sampling in neighbouring Malawi for MICS 2020 (Table 8) suggests that the SMARTechs can perform as well or better than conventional supplies and are a marked improvement on wells which are unimproved.

Table 8 Comparison of water quality in water supplies in Malawi, Tanzania and Zambia

	Malawi MICS 2019*	Assessment Tanzania 2021	Assessment Zambia Mar 2021	Assessment Zambia Nov/Dec 2021
Sample numbers	10,623	43	76	142
	PROPORTION WITH FAECAL COLIFORM ABSENT			
Borehole	43%	71%	74%	66%**
Shallow well	14.5%	39%	37%	78%**
Unimproved well	4.90%	n/a	n/a	53%**

***Malawi conventional water supplies, not SMART From Malawi MICS survey. UNICEF 2020.** https://mics-surveys-prod.s3.amazonaws.com/mics6/eastern%20and%20southern%20africa/malawi/2019-2020/survey%20findings/malawi%202019-20%20mics%20survey%20findings%20report_english.pdf

** There is an anomaly in that in the last quarter 2021 set, shallow wells appear a slightly lesser risk than boreholes, which is not the expected pattern or the one found in the first quarter. It does suggest, however, that the sanitary seal created at the surface for shallow wells is quite effective but brings into doubt whether the same is true for all boreholes.

5.2 Sanitary inspection

No significant correlation between water quality and sanitary inspection was found across assessment data for Tanzania and Zambia, which is as to be expected (Kelly et al, 2020). The score does, however, reflect risks, and so provides a measure of the overall state of the installation. The sanitary inspections in Tanzania reflect the greater age of installations and perhaps less quality control over their construction, and/or follow-up over the years (Figure 16) The average score overall 6.2/10. with the average scores for Zambia 9.8/10.

In Zambia, the rope pump sources surveyed show a very high level of compliance with source protection measures, which reflects highly on the skills and knowledge, as well as motivation of the private enterprises that site and construct the sources. The main area of non-compliance was lack of fencing. Compliance was not as high in the Tanzania sample, where more than half of the rope pumps sampled had other sources of pollution within 10m. and there was evidence of faulty drainage allowing ponding within 2m of the borehole in one third of the rope pumps samples where this question was asked.

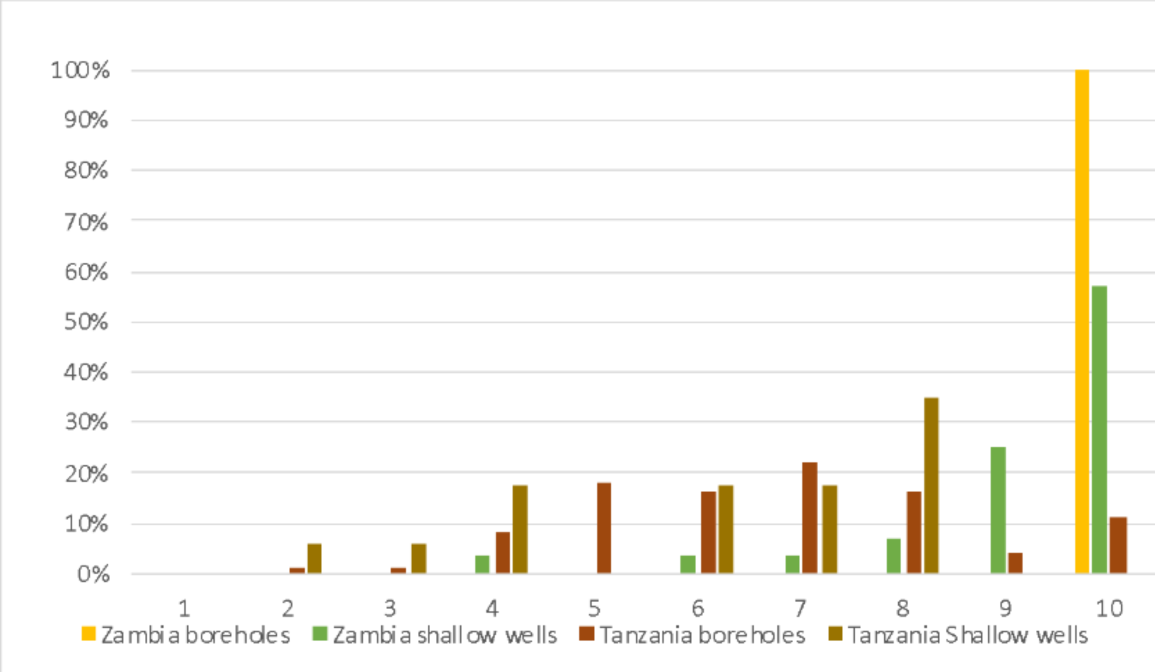

Figure 16 Distribution of sanitary inspection scores for sources surveyed in Tanzania and Zambia
Key - 10 = excellent, 1 = very poor

5.3 Household water treatment and safe storage

Household water treatment offers the 'belt and braces' to ensure safe water, and water filters are one of the SMARTechs, especially household water filters, which are promoted. The Centres in Kenya, Malawi and Niger also sell water filters (Holtslag, 2022b).

Household water treatment technologies are promoted to a varying degree by the SMART Centres, but the emphasis of the ToRs was on wells and pumps, and so this assessment did not examine household water technology, uptake or effectiveness in depth. Nevertheless, as filter technologies are within the suite of SMARTechs, household water treatment was examined to some extent in national household surveys.

According to national household surveys, in the eight SMART Centre countries, the degree of up-take of household water treatment is variable (Table 9); highest in Tanzania, Kenya, Zambia and Malawi, lowest in Niger and Ghana. There has been a significant increase in use of water filters in Ethiopia. This number represents a small proportion of the population, considering the high proportion of the population that rely on point sources (98.2% in 2016 Demographic Health Survey report). Open, or inadequately protected point sources sources are prone to contamination or contamination takes place in transport or storage at home. Across the eight countries, there seem to be considerable obstacles to the successful promotion of any type of treatment, and Table 9 indicates that an increase in one method, such as filtration, seems to be offset by a decrease in another (e.g. boiling).

Table 9 Percentage of the population using different water treatment methods among rural populations in SMART centre countries
(Sources: Demographic Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS) and Living Conditions Surveys (LCS))

Rural						
Country	**Survey Date**	**Boil**	**Filter**	**Chlorine**	Total	Trend
Ethiopia	DHS 2011	2.4%	0.2%	4.9%	7.5%	↓
	DHS 2016	2.0%	1.1%	2.6%	5.7%	
Ghana	DHS 2008	1.9%	0.8%	1.4%	4.1%	↓
	DHS 2014	1.5%	0.1%	0.6%	2.2%	
	MICS 2018	1.3%	0.4%	0.4%	2.1%	
Kenya	DHS 2009	25.4%	3.5%	16.3%	45.2%	↑
	DHS 2014	22.4%	3.2%	22.5%	48.1%	
Malawi	DHS 2010	11.3%	0.1%	24.4%	35.8%	↓
	DHS 2016	8.6%	0.5%	20.4%	29.5%	
	MICS 2020	6.3%	0.2%	17.1%	23.6%	
Niger	DHS 2012	0.1%	0.5%	0.2%	0.8%	
Tanzania	DHS 2010	24.2%	0.4%	1.5%	26.1%	↓
	DHS 2016	22.8%	0.6%	1.3%	24.7%	
Zambia	LCS 2004				24.0%	→
	DHS 2014	7.6%	0.1%	16.7%	24.4%	
	DHS 2018	8.7%	0.1%	15.2%	24.0%	

SMART centres have carried out limited exploration to sell filters directly (e.g., Kenya, Malawi and Niger), or support others to do so (e.g., Kenya and Niger), with an emphasis on local assembly Notably, filter uptake requires market research in order to identify who to target, but can tap into carbon credit funding.

With respect to water treatment, the assessment survey estimates of 28% of sharers treating their water (Table 10). This reflects the estimate for rural populations Zambia of 24% (Table 9). However, the water supply-owning families are almost twice as likely to treat water. The reasons for this are not known, but are worth investigating further, as they may provide insights into the drivers of water treatment uptake.

Table 10 Proportion of owners and sharers using household water treatment in Zambia
(Source: assessment survey)

Water treatment method	Owners	Sharers
Nothing	48%	72%
Some form of treatment	52%	28%
Add chlorine/bleach	41%	20%
Boil	2%	7%
Boil, Add chlorine/bleach	4%	1%
Use modern filter	5%	0%

In Zambia adding chlorine is the preferred option, which is also the option that is most promoted by the Ministry of Health, especially during cholera outbreaks. The assessment also found that wealthier families (i.e. those owning a television) are more likely to treat their water while the higher use of household water treatment by supply-owning families, may help to compensate for their greater neglect in ensuring that sanitary measures at the source are adhered to.

In Tanzania, the assessment found that water treatment is more common amongst supply owners and sharers than indicated by national figures, with boiling being the preferred option (used by 70% of survey respondents).

In both countries, awareness of water treatment and its importance are high (Table 11). In Zambia almost all households were aware of the need to treat water. This has been achieved by multi-channel communications (health centres, radio, TV, schools and some NGOs. Notably, the gap between knowledge and practice is so large that there is need to develop a much better understanding of the barriers, if the practice is to become a more important element of SMART Centre promotion and advocacy. Perhaps in association with organisations such as CAWST and their in-country partners, expansion into this field could be a valuable step in achieving more safely managed supplies.

Table 11 Knowledge of household water treatment and safe storage in Tanzania and Zambia (Source: assessment survey)

Knowledge of Household Water and Safe Storage	Tanzania	Zambia
Owners	84%	99%
Sharers	79%	96%

5.4 Contribution of SMART approach to SDGs in Zambia

Given the importance of the service ladder (Figure 5) and safely managed water supplies in particular to reach SDG 6.1, this assessment has tried to analyse the survey data from Zambia. The definitions used are detailed in Box 13.

Box 13 Basis for estimating contribution of SMARTechs in Zambia to the SDG service ladders

A **safely managed supply** is assumed to be:

- Supply on premises - supply into the house, or on the plot of the owner's house, with a threshold of 100m distance.
- Available when needed – assuming that water was supplied without a break of more than 2 days at a time in the past 12 months. This assumes more than a days' storage at the house.
- Water that is water free of faecal coliform (count 0 faecal coliform colony/ 100 ml)

A basic supply is taken to be one with an improved supply within 30 minutes water collection time of the house. In the case of the survey, these are water sources within 500m of the home. By definition, conventional community water supplies (borehole/well with handpump) cannot provide a higher level of service than this.

Using the above definitions in mind, SMART technologies in Zambia provided 53/120 (44%) of households with supplies which fulfilled safely managed criteria, Further, through the creation of new or improved supplies with SMART technologies a basic supply (at least) was provided to 99% of the sampled households that share, rather than own the source.

**Table 12 Summary of values for elements of safely-managed and basic supply in Zambia for water supply owners
(Source: assessment survey data)**

	Sample size	Number Conforming	Percentage Conforming
Used for drinking water	153	145	95%
Availability: On-premises (<100m)	143	139	97%
Reliability: Out of service for 2 days or less out of 12 months	135	102	76%
Water quality: Zero faecal coliform	120	80	67%
Safely managed: Available on premises, reliable and good water quality	120	53	44%
Basic supply: Available within 500m	84	83	99%

6. Assessment Findings: SMART Centres

6.1 Finance, management and human resources

Table 13 provides a summary of the SMART Centre expenditure for the centres for which data was available[55]. With the exception of Zambia, it illustrates the low levels of funding that they are relying upon – arguably actually working with 'shoestring' budgets. The Centre in Malawi has stated that their activities have been recently affected by funding challenges, with the result that not all of their projects have been able to continue (CCAP SMART Centre Malawi, 2022). In the case of the SMART Centre in Ghana, most of their revenue actually comes from the sale of goods and services, such as complete water facilities (e.g., solar water supply system) and sale of water to households, with donor-funded projects not always available.

Table 13 SMART Centre Expenditure[56]

Country data source	Currency	2016	2017	2018	2019	2020	2021
Ghana[57]	EUR	N.A.	N.A.	N.A.	46,700	80,500	134,000
Niger[58]	USD	—	—	8,200	22,500	30,300	28,000
Malawi[59]	EUR	N.A.	110,000	139,000	109,000	47,000	48.600
South Sudan[60]	USD	30,500	28,900	25,400	18,750	29,300	15,700
Tanzania[61]	EUR	13,639	47,898	N.A.	N.A.	45,445[62]	N.A.
Zambia[63 and 64]	EUR	12,248	64,583	72,135	124,096	134,635	82,238

Key: — not applicable (as Centre had not been established.
N.A. data not readily available, or not in the public domain or SMART Centre expenditure could not be disaggregated within the time-frame of the assessment.

The gaps in publicly available financial data among the Centres is considerable, with Zambia being the only country that has consistently produced annual reports and placed them in the public domain. Zambia has also managed to successfully attract increased levels of funding. Going forward, the SMART Centre Group could provide support to the Centres with respect to transparent financial reporting.

From existing data, it has not been possible to identify the proportion of costs spent on running the Centres as opposed to direct capital and labour costs for projects. However, discussions with some

55 Financial data for the SMART Centre in Ethiopia, which is within EWTI is available quarterly in reports that are presented to parliament but these are not available in the public domain. In the case of Aqua Clara Kenya and Pumping is Life Ghana, there are no annual or financial reports available on their websites.

56 With the exception of Zambia, note that expenditure may include other areas than water.

57 Pumping is Life (2020), 2019 - converted from GHS at rate on 31 Dec 2019 https://www.oanda.com/currency-converter/en/?from=GHS&to=EUR&amount=299227.29 , 2020 converted from GHS at rate on 31 Dec 2020 https://www.oanda.com/currency-converter/en/?from=GHS&to=EUR&amount=582015.69 and Pumping is Life (2021(converted from GHS at rate on 30 Dec 2021 https://www.oanda.com/currency-converter/en/?from=GHS&to=EUR&amount=940281.03

58 McGill (2022)

59 2017 & 2018 data: CCAP (2018); converted from MWK at rate on 31st Dec on 2017 & 2018 https://www.oanda.com/currency-converter/en/?from=MWK&to=EUR&amount=96751701; 2019 % 2020 data: CCAP (2020), converted from MWK as above; 2021 data CCAP SMART Centre (2021). – converted from USD at rate on 31st Dec 2021 https://www.oanda.com/currency-converter/en/?from=USD&to=EUR&amount=55000

60 McGill (2022)

61 SHIPO (2020) and SHIPO (2017)

62 Converted from TZS at Exchange Rate on 31 December of the respective year on oanda.com (accessed 23 March 2022)

63 Data abstracted from Jacana Annual reports 2016 to 2021 - Jacana Business Empowerment (2016, 2017, 2018, 2019, 2020, 2021a),

64 Only Includes reported expenditure on Water entrepreneurs

Centre Managers highlight that there are considerable demands on the limited human resources, which is likely to negatively affect reporting.

The number of staff per centre range between two and six, not all of whom are full time. Most Centres pull in additional contract staff/consultants when needed, such as for a training course. The Centres are all small, and, so far, have relied on relatively low levels of funding, which is usually tied to specific projects. Where they do exist, multi-year projects, particularly those that run for five years and more, have been observed to provide opportunities for continuous learning and improvement (KII, 2022a).

Only one of the Centres (Zambia) is currently managed by expatriate staff while the others are managed and primarily staffed by nationals from the respective countries. In the case of Tanzania, the expatriate staff do not manage one of the main self-supply projects. In the case of Niger and South Sudan, the expatriate WASH Advisor still plays an instrumental role. The management of some of the Centres have remarked on their being uncompetitive in employment for competent management level, compared to international NGOs, so losing valuable trained staff and facing a fast turnover. Such losses, where they occur, reduce institutional memory and weakens management capacity. By devolving sales of products and services from most centres to trained SMEs which mean the centres depend totally on donors for funds. Donor agencies generally seem concerned about their money going into outputs on the ground, rather than management, yet competent management is vital for sustainability.

While the external expertise to provide technical training is considerable, there does not seem to be such a strong focus on other aspects such as enterprise development, financial management, monitoring, reporting and fundraising. This is a gap that could be addressed by the SMART Centre Group in the future.

6.2 Activities – training and certification

Training is a key activity of the SMART Centres. Table 14 provides examples of training courses that have taken place at the Centres in the eight countries between 2016 and 2021, including information on numbers and types of people trained where this information was readily available.

The Centres draw on professional trainers that are based in-country as well as those that operate internationally[65], several of whom are based in the Netherlands as well as trainers/entrepreneurs from other countries with SMART Centres. [66] The SMART Centre Group is in the process of developing an overview of the numbers of people that have been trained in the centres over the years (Holtslag, 2022a). More details on the trainees and entrepreneurs are provided in chapter 7.

Jacana's approach is to guide the entrepreneurs but not take over responsibilities and thus guarantee their independence (Haanen, 2021b). Further, the logic applied is that each district should only have a number of trained drillers and pump manufacturers which the market can support at the start. This is to try and prevent competition from undermining embryonic businesses which are entering and responding to an emerging market (Haanen, 2021b).

[65] Including Henk Holtslag, Dolf Heubers, Gerrit van Roekel, Arnold van De Kamp, Wolfgang Buchner and others.

[66] An example of the latter is Mr. Laban Kaduma, a master driller from Tanzania, who, for example provided training in South Sudan (Anon, 2020) and Malawi and Zambia (Holtslag, 2022b).

Table 14 Examples of SMART Centre Training Courses

Country (organisation) and source	Year	Course(s)	Participants	
			No	Type
Ethiopia (EWTI) Mekonta (2022) Gochem (2022)	2019	Held in Addis Ababa	12	Woreda/District Staff
	2019	Manual well drilling, rope pump manufacturing and installation. Held in Dilla, SNNPR, Dilla	31	
	2021	Solar water pumping, solar electrification, solar mini-grip planning,		EWTI Technicians
Kenya Aqua Clara (Holtslag, 2022b)	2022	3 week training course in technologies for Self-supply and households. Course was a cooperation of SMART Centre Kenya, Smart Centre Group and the EMAS group	12	Technicians, entrepreneurs program officers including from Ethiopia and Cameroun
Malawi (CCAP) CCAP SMART Centre (2021b) (Holtslag, 2022b)	2012 - 2021	Various trainings on low -cost drilling technologies, rope, EMAS and solar pumps, latrines, rainwater storage tank (wire mesh and calabash), tube recharge and household water filters, as well as business training	>60	
	2021	WASH Technologies for Self-supply, including EMAS, especially the construction of the drill set and EMAS pump models and introduction to a suite of SMARTechs (two weeks)	15	Technicians, entrepreneurs and program officers including from Kenya, Tanzania and Zambia
South Sudan (PRDA) Anon (2019b)	2017, 2018	Hands on training on the fabrication of rope pump and Mzuzu manual drilling tool set.	2+2	Fabricators
	2019	SMART technology introductory short course (two weeks)[67]	19	PRDA and government staff, local entrepreneurs & NGOs
Tanzania (SHIPO). SHIPO SMART Centre (2022; 2017)	2019	Three-week training for drillers, producers and farmers		Drillers, pump manufacture
	2014	Four-week training in rope pump construction		Local entrepreneurs
Zambia (Jacana) Jacana Annual reports	2016-2021	Technical training in (i) Manual drilling; (ii) Manufacture of low cost handpumps., VES borehole siting, solar electrical systems/pumping. Business development including writing business, financial and marketing plans, as well as training in marketing and sale of household water treatment filters.		Entrepreneurs who become manual drillers and pump manufacturers. Water users (businesses[68]), other rural entrepreneurs honey production, mushrooms farming, organic farming

6.3 Activities – technology demonstration, development and testing

The Centres are introducing new, or modified technologies into the countries in which they operate. Alongside the training and support local businesses to introduce the technologies, establishing demonstration facilities for people to see and use at the Centres forms a cornerstone of promotion (for photographs, see Annex 7).

However, it is recognised that such demonstration is likely to primarily have relatively local outreach. In the case of Niger, for example, security issues with respect to travel, limit the demonstration effect of the Centre facilities in Niamey. In contrast, the Jacana SMART Centre in Chipata, which started operating in 2015, initially provided training on manual drilled wells and rope pump fabrication and

[67] Course objectives: Raising awareness to SMARTechs; Demonstrating low-cost but high-quality WASH technologies; Increasing local capacity in manual drilling; Improving local capacity to produce drill sets and hand pumps (EMAS and Rope Pump); Creating supply chains of low-cost water technologies fit for families, small scale irrigation and communal supply for small / remote rural communities. Topics covered: Introduction to Metalworks and PVC Fabrication of WASH SMARTechs; Mzuzu Drilling; SHIPO Drilling; PAH Drilling; Well casing, developing and finishing the well; Handpump installation and training of Rope Pumps and EMAS Pumps, low-cost solar pumps, Wire cements storage tanks and tube recharge systems, household water treatment and storage.

[68] Businesses include poultry and pig farmers, beekeepers, vegetable producers, dairy farmers, organic farmers, hairdressers, car washers, brickmakers and mushroom growers.

installation, but has subsequently moved on to providing support to businesses. It has established two more Centres (in Lundazi and Petauke), and continues to develop, test and promote other new technologies.

Some Centres also develop and test technologies continuing to evolve, and take on new challenges including low cost solar pumping, sanitation pit emptying and low cost siting technologies (Box 14).

In Ghana, the Centre is expanding to explore ways to support household food production alongside the empowerment of women through raising their incomes (Abdul-Rahaman, 2022). It supports household level food production using technologies such as drip irrigation and rope pumps. Solar pump irrigation is promoted, and women are supported with these technologies through clustering and establishing agribusiness value chains - notably, the main catalyst is water (Anon, 2022).

Box 14 Examples of SMART Centre Technology Development and Testing

Niger: The EERN SMART Centre linked up with the West and Central Africa Solar Hub[69], which provides training in solar water pump installation and maintenance. The Centre has been purchasing locally available solar pumps and importing new technologies and undertaking testing to determine the pumping capacities from an array of pumps and panels at the lowest costs (Anon, 2021a).

The Centre is also working with people who manually empty sanitation facilities, and are introducing protective gear, as well as new tools such as the 'Sludge Digger' to enable them to improve their working methods (Anon, 2021a).

Further, centre was constructing a low cost incinerator that can withstand the temperatures to properly dispose of biohazardous waste70 and was exploring whether paving tiles, produced by the City of Niamey from waste plastic bags and sand as an alternative to cement, could be marketed for less costly sanitation slabs and pedestals (Anon, 2021a).

South Sudan: demonstration rope pumps and well recharge systems were installed in 2017 at the workshop of the first two fabricators trained (Anon, 2017b). Introduction of water filters also commenced in 2017,

Zambia: Over the past couple of years, the centre has also been involved in the development and testing of low cost solar pumps, as well as low-cost VES (vertical electrical sounding)71 and Horizontal Electric Profiling for drilling siting. Interest in the low-cost geophysical siting technology was a response to low drilling success rates in Eastern Region, coupled with the relatively high cost of siting equipment for small manual drilling businesses (Haanen, 2022a). A manual on how to make the VES equipment has been developed (SMART Centre Group, nd).

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[69] The Solar Hub is implemented by Water Mission and UNICEF

[70] Most incinerators in Niger have been constructed with Portland Cement, which cannot withstand high temperature and are thus not functioning (Anon, 2021a)..

[71] As initially developed by Prof J Clark of Wheaton College, see Clark and Page (2011), with an Android APP subsequently developed by Practica

6.4 Activities – supply chains support

In South Sudan, the Centre has worked to establish supply chains for filter elements and taps from China (manufactured by the Dutch Company, 'Basic Water Needs'). Importation was handed over to a local enterprise (Water4Life), which has also modified and produced manual drilling rigs that were introduced by Practica Foundation). Staff of this business (Figure 17) have been trained to assemble table top filters using locally available buckets combined with the imported components (Anon, 2019a).

Figure 17 (From left to right) Jim McGill with Mr. Joel Lay and Ms. Asunta Leila (Water4Life) holding Table Top Water Filter components in South Sudan

Some Centres have diversified beyond WASH - in the case of Tanzania, SHIPO have diversified into a project for plastics recycling (Annex 7) while in Zambia, Jacana is also supporting a beekeeper's cooperative and Pumping for Life (Ghana) is also considering self-sufficiency in terms of energy and. works with community health clubs in order to try and generate interest and stimulate demand in SMARTechs.

6.5 Reaching out, knowledge exchange and knowledge sharing

Demonstration facilities at each of the Centres provide a place that other organisations can visit and learn about SMARTechs, and staff from other organisations have been trained by the Centres in various technologies (Table 14). Specific examples of outreach by the SMART Centres in-country include:

- In Tanzania, in around 2005, the, a non-profit organisation MSABI, was one of the first organisations to be trained by the SHIPO SMART Centre to use technologies such as the rota sludge well drilling and rope pumps (Holtslag, 2022b). MSABI has gone on to drill manual boreholes and install locally manufactured rope pumps for over 400 water points in Tanzania[72] (MSABI, 2022). MSABI reports to have also created one drilling enterprise, as well as a rope pump workshop in Ifkara (MSABI, 2022).
- In Malawi, the SMART Centre provided training in rope pump manufacture to Pump Aid, which has subsequently established a private company called Beyond Water [73] to sell pumps and provide service contracts to water users (Marsh, 2022).
- In South Sudan, the WASH Advisor has sought and actively reached out to other players with overlapping interesting in the country, including government. For example, low cost WASH technology options were presented at the WASH Cluster meeting in 2017 (Anon, 2017b). In the subsequent visits in 2018 and 2019, links with a number of other potential partners with experience and interested in manual drilling technology, as well as organisations involved in business development, household water treatment and vocational training were established (Anon, 2018; McGill, 2018; Anon, 2019a). In 2020, the Centre begun partnering with Water for South Sudan, based in Wau, and the Rotary Club of Wau to

[72] Specifically, in Kilombero, Malinyi, Ulanga and Kilosa Districts.
[73] https://www.beyondwater.co.uk

undertake and assessment and ultimately apply for funding to introduce manually drilled family wells into the area, (Anon, 2021b).

- In Ghana, Pumping is Life is trying to reach out to government to support with private sector participation in household water treatment and safe storage (Pumping is Life, nd). The centre promotes renewable energy through solar pumps and use of solar panels for other applications like lighting in homes, schools and health centres in rural communities (Anon, 2022).
- In Ethiopia, the SMART Centre is actually a unit/department within EWTI, which is a government entity. Thus, the Centre should be very well placed to connect with the 46 technical and vocational education and training (TVET) centres in the country, for which the EWTI undertakes competency assessments, as well as training.

The SMART approach is market-based, where users, rather than NGOs or government are expected to pay for the capital cost of facilities. Several key informants interviewed indicated that while there may be interest in NGO headquarters in market-based approaches, that this may not be reflected in the decentralised national offices, and so in-country partnerships are not always forthcoming. A good fit could be between SMART Centres (supporting enterprises) and NGOs or CBOs that raise awareness of WASH needs at community level – which could help to stimulate demand among users. Unfortunately, the assessment was not able to establish why more of these types of partnerships are not in place already. This is something that should be explored in collaboration with the SMART Centre Group.

Outreach is also occurring beyond one country. Jacana (Zambia) and the SMART Centre Group have produced a range of training videos which are also used by the other Centres. The Jacana website contains a suite of free online tutorials and manuals, (Annex 9). These are regularly downloaded by practitioners from all over the world. As an example, instruction videos were viewed 23,300 times in 2017, and by March 2021, 4,339 people had downloaded one of more of the manuals (Haanen, 2021a).

It is worth noting that in some countries, the SMART Centre is not the only organisation in WASH following a market-based approach, and that there may even be some duplication of efforts, e.g.:

- iDE [74], ICEaddis [75] as well as Selam Technical and vocational training [76] are examples of organisations supporting innovation and start-ups in Ethiopia.
- In Western Zambia, Village Water has trained manual drilling enterprises for a number of years, as well as supporting artisans to register as local businesses.
- In Malawi, the Pump Aid spin-off Beyond Water, is selling rope pumps to users., including a service guarantee.

Notably, both Village Water and Pump Aid received training through the SMART Centres (see above).

The above are examples of slightly different approaches, and there is scope for learning between them, an area that could prove to be of interest for the SMART Centre Group, which could consider expanding beyond the current focus of its own Centres,

6.6 Cost-effectiveness

in Zambia, from 2005-2015 the proportion of the total population with access to an improved drinking water supplies rose from 37-44% at a cost of some USD 146 million (World Bank 2020). The achievement is well below the 2015 target of 75% of the population. Low population densities, including an average number of users per source of 69, rather than the planned 250 resulted in a

[74] https://www.ideglobal.org/country/ethiopia

[75] https://www.iceaddis.com

[76] http://www.selamchildrenvillage.org/TVET

per capita cost of over USD 120 (EUR 110), compared to the design cost of USD 28 (EUR 26) (World Bank 2020).

In Zambia, the SMART Centre's expenditure between 2016 and 2021 totalled EUR 489,935 (Table 13). This resulted in a total of 399 pumps being installed on new boreholes, or improved wells (Figure 8a). On a per well basis, Jacana's contribution is thus an average of EUR 1,228 per source. This compares with a unit cost for newly constructed/ rehabilitated boreholes in the National Rural water supply and sanitation programme (NRWSSP) of EUR 7,675. (World Bank 2020). [77]

In the Jacana case, the assessment survey data found that a total of 1,592 households have been supplied by 159 wells with pumps (solar pumps and rope pumps). This equates to 10.1 households per supply, and, based on assessment survey figures for the average number of people per household, this would equate to 54.2 people per supply. This is slightly lower than the average number of users for community systems in Zambia mentioned above in World Bank (2020), at, 69 persons.

Taking the average cost per source of EUR 1,228 per source, and dividing it by 54.2 persons per source indicates a per capita cost of EUR 23. However, this assumes that all sources are household sources, which is not the case – some sources serve communities, and others institution. More detailed analysis of annual outputs and expenditure would be required to develop a set of per capita costs, but it is estimated that these are likely to be in the range of EUR 10 to EUR 35. The upper estimate of per capita cost using the SMART approach in Zambia is thus is less than one third of the aforementioned estimate of EUR 110 by the World Bank (2020). As is the already case in Tanzania and Malawi, it would be expected that the private sector increasingly constructs more sources that are paid for fully by users, The per capita expenditure by Jacana in a particular geographic area would this be expected to decrease over time.

Despite the simplicity of the above cost-effectiveness analysis, it does suggest that the SMART approach as followed by Zambia in Jacana is considerably less costly than the conventional community approach whereby implementors pay fully for hardware (capital) costs. And, as chapters 4 and 5 indicate, service levels for the household supplies provided through the SMART approach, are actually relatively high, including good levels of water quality.

The initial costs for establishing a SMART Centre, and building up private sector capacity to provide supply construction and maintenance is considerable, but once that capacity and infrastructure are established, the enterprises can continue to provide the service at little additional cost to the public purse. Additional funds are leveraged from households and can be augmented by subsidies depending on government policies and how the market develops. The unit and per capita costs linked to the initial investment of water supply services should reduce over time to a base level as more supplies are constructed through the businesses already established.

If 100% subsidies of the capital cost were to be provided, for instance by a voucher system to poor households and those in remote and scattered communities, the cost per user would increase. However, as user numbers per new supply decrease in sparsely populated areas, the gap in per capita costs between conventional supply provision and SMART approach options widens and the potential savings to the public purse using the latter becomes larger. Savings are also clear in recurrent costs, with 75% of the most recent repairs of SMARTechs in Zambia undertaken by the owner or his family. Most of the rest (16%) were mended by the installer who was known to and easily contactable by the owner, while only 5% required the intervention of a local pump mender or mechanic.

This seems to be how the system would be when it is working well and has sustained support through monitoring and advice. In Tanzania the picture is different, because the maintenance system has partly broken down with some of the initial investment therefore lost. The role of centres in keeping the support services active, well-trained and motivated is been vital. Notwithstanding the importance of not undermining the market, there may be a need to gradually shift some of this responsibility for ongoing support to monitoring and the provision of advice from the Centres onto

[77] In both cases the total programme cost is divided by the output in terms of improved supplies brought into production.

other agencies, including government and CBOs. but such a process takes time and resources over several years.

6.7 SMART Centre Group

The SMART Centre Group, currently hosted, and partly financed by MetaMeta provides a platform for exchange between the eight SMART Centres covered by this assessment plus the Centres in Nicaragua and Mozambique. The efforts of the Group in bringing together Centres to learn from each other through online meetings, regional exchange, and face to face training is highly appreciated by the management of the Centres. Of particular note is the visibility that being part of the group brings, alongside networking opportunities, and the exposure that the SMART Centre Group provides for the Centres, as well as opportunities for learning about new, or emerging technologies that may be applicable, such as low-cost solar systems.

However, despite its importance, and as with many other networking organisations, fundraising for the SMART Centre Group has remained a challenge beyond the inception phase from 2017 to 2019. Nevertheless, assuming that funding can be realised, the Group and the Centres would benefit from boosting the knowledge management function of the SMART Centre Group in the future, The SMART Centre Group, should consider clearly separating the roles of training support to the SMART Centres, from that of knowledge management, research and learning, with a staff member (or more) dedicated to the latter.

The SMART Centre Group should also see how it can better support the Centres in reporting, including strengthening systems to effectively monitor the outcomes and impact of their efforts. Monitoring would cover enterprises and water users and may even extend to market-based approaches in WASH that are implemented by others. Over time, the consolidation of information should help to build up a strong, evidence-based information of the impact of the Centres and key challenges faced. The SMART Centre Group should also actively engage in dialogue with organisations that are open to, or are supporting market-based approaches in WASH including, but not limited to CAWST, UNICEF, SNV, Simavi and Village Water.

One of the key informants suggested that the SMART Centre Group hosts an annual, or biennial event or conference to bring like-minded organisations together, and share their experiences with a wider audience. The idea of the SMART Centre Group certifying the Centres against a set of criteria was also put forward. Another key informant expressed the desire for the Centres to explicitly involve women much more in their activities, including supporting enterprises that are led by women.

One potential future role for the SMART Centre group would be to enhance and expand research and learning agenda. As a starting point, the surveys undertaken for this assessment in Tanzania and Zambia raise a whole series of interesting, and important research questions which could not be examined in detail, but could contribute to improving the effectiveness of future implementation (Box 15).

The assessment recommends that the SMART Centre Group takes the lead in partnering with local and international organisations to further explore these, and other important questions and to jointly raise awareness of market-based approaches in WASH.

Box 15 Examples of important research questions for the SMART Centres or others working on market-led approaches for WASH

- Performance and reliability: Do privately-owned sources perform better in terms of functionality and maintenance than community sources? Does the remoteness of self-supplied sources have an influence on their performance? Does whether the users fully invest in the sources themselves of the extent to which they are subsidised affect performance, and if so how, and why? What are the underlying causes for the lower functionality rates observed in Tanzania, and how could they be addressed? Are there significant differences between the functionality of family-owned and community-owned sources and if so, what are the reasons for this?
- Full coverage and leaving no one behind: To what extent does the SMART approach, when supported in a locality over a number of years, ensure that everybody, including the most vulnerable, access an acceptable service level? Are there particular groups that are still being left behind? If this is the case, why, and what are the implications for the SMART Centres and other stakeholders (e.g. government)? Going forward, would it be effective to provide subsidies to women's groups? To what extent are female-headed households represented as supply owners and sharers?
- User preferences: Are preferences of particular technologies changing over time? To what extent? Where and for whom are rope pumps a viable, long-term alternative in countries, or localities with a growing preference for motorised pumps, as seems to be the case in the areas surveyed in Tanzania.
- Water quality: Does private ownership bring stronger rules with respect to sanitation and cleanliness around the supply, and do those that share feel more compelled to keep them clean as they may be seen by other families? Examination of the complexity of the effects of owning and sharing, and the implications of sharing privately owned supplies with neighbours, especially if this should fill water supply gaps. Are those who pay in full for their supplies more at risk of bacteriological contamination, and if so, how can this be addressed?
- Household water treatment and safe storage: What specific activities have been undertaken, and what are the outputs, outcomes and impacts of the efforts by the SMART Centres to introduce, support private investment and promote household water treatment and safe storage in the centres? How effective have the Centres been with this technology, and how should future efforts effectively complement ongoing efforts by governments and others? What are the barriers to the uptake of household water treatment and safe storage? Explore the employment of marketing professionals and liaison with health sector professionals…
- Incentives: What are the drivers for household investment in their own water supplies? How do gender norms affect these incentives? What about needs for livestock or watering of gardens? What can be learned about the wealth, education and gender of those who are investing in private sources
- Investments vs changes in income and time savings: how can the costs and benefits of private water supplies be even more clearly demonstrated?
- Government and NGO engagement – How can SMART Centres most effectively engage with local and national Government? To what extent should they invest in liaising with government, and how could they combine forces with other NGOs operating in the country?
- Private sector artisans and quality– How many artisans have been trained and mentored at each centre, in what topics, and what was the level of training (e.g. introductory short course, intermediate or advanced) and type of mentoring provided by the centres? How many of those trained have continued to be active, and what are the reasons for this, or for drop-out. How independent are the enterprises from the Centres in terms of getting work? How do trained and active enterprises cooperate, support and compete with each other? What are the most effective incentives for assuring quality? What are the pros and cons of multiple small-scale providers working alone, an association model that tries to control quality, and a franchise model whereby there are tighter quality controls?
- Household water treatment and safe storage:
- Climate change and resilience - Increase knowledge of /evidence on sustainable gains from SMART technologies and their role as an insurance policy against more variable rainfall. Undertake research into the efficacy of borehole/ well recharge systems and their impact on local groundwater resource.
- Learning from the past – what lessons can be learned from previous efforts with respect to promoting appropriate technologies in WASH, e.g. past project supported by JICA in Ethiopia to promote the manufacture and uptake of rope pumps, the Appropriate Technology Centre in Uganda, or Community Health Club efforts around the world.
- Staff retention and staff turnover– what are the experiences of the SMART Centres, and enterprises of retaining staff, or loosing staff to other organisations? What could to be done to retain staff, or provide career opportunities within this area, or ensure that handover is such that institutional memory is not lost.
- SMART Centre finance and sustainability: What fundraising and income generating activities could the SMART Centres and SMART Centre group undertake to become more financially sustainable?

7. Assessment Findings: Technology Providers

Given that not everyone trained has the capability, financial resources or desire to keep on working as an entrepreneur, there will always be gap between the individuals trained and those running successful enterprises in the future, as the story of the manual drilling entrepreneur Laban in Tanzania illustrates (Box 16).

Box 16 From plumber to driller to entrepreneur – the story of Laban Kaduma in Tanzania (Source: Kaduma, 2022)

While living in Iringa, 230 km north from SHIPO in Njombe, Laban Kaduna, then working as a casual labourer and plumber, saw a poster advertising the opportunity to be trained as a driller by. He applied, travelling by bus to hand in the applications for himself and his two colleagues. Two weeks later they were called for interview, and upon passing, all three were called to start the training course in Njombe in May 2005.

The training commenced in the field, and after three weeks of practical training, they were in the classroom, for two weeks learning more about subjects including soil formation and safety. They were then sent to the field to drill wells for SHIPO. The community always played a role in construction, providing food and accommodation for the drillers, as well as labour. Laban was given more training by SHIPO, including on site selection, how to install the rope pump and about how to prevent drill pipes from getting stuck on the job.

Laban felt that he was by then experienced enough, but the SHIPO first grouped the drillers, and offered them jobs for a Netherlands-funded project, TAZAMO, mainly drilling around Njombe. This was where Laban clearly saw differences between those that had been trained, with some wanting to be employed and others wanting to work as entrepreneurs "everyone has his own idea". Laban estimates that they drilled about 600 wells between 2005 and 2006, with about ten or more drilling teams working.

Laban observed the different ways that his fellow drillers spent their earnings. He was among those that wanted to invest in tools, and then later use that profit. Of his then team of three, one person left for his home, having had enough of the work, to be followed the other team member leaving with other plans, and so Laban, who wished to continue as a driller, found others to work with. Laban and his team were challenged when trying to agree on an organisational constitution, paying for it to be legalised or having enough time for these steps. By 2007, by which time between half and three quarters of people now had mobile phones, Laban set up a small office "so that I could be found", and. in which drilling cuttings "which are useful for future work" could be stored. Again, people that he was working with left, including one person who preferred to continue with hand dug wells rather than manual drilling.

In 2010, Laban stopped drilling physically and was instead monitoring his three drilling teams, initially transporting himself by bicycle, and later using a motorbike. Eventually, Laban built his business up to six, and then seven teams, initially registering a Community Based Organisation. This certificate enabled him to get small jobs from the government and councillors, and before he eventually managed to register a company. Uvinjo. It was 2015 when the company managed to get a drillers licence. This opened new doors for Laban, who was, for example, invited to the Water Week Pavilion.

Figure (right) Laban Kaduma trains rope pump producers (photo: Henk Holtslag)

The climate for businesses and NGOs for the six years from 2015 under president John Magufuli was not easy, but Laban's business survived. Laban has subsequently become a trainer, and trainer of trainers in manual drilling and rope pump installation, and with this skill set has trained people in Malawi, Zambia, Zimbabwe, Mozambique, Uganda, Kenya, Ethiopia, South Sudan, Liberia and Sierra Leone. On the way to Malawi, he almost lost his demonstration rope pump from the roof of the bus as nobody knew what it was, and he was not able to understand the local language as the bus company looked for the owner of this strange bicycle. Looking back, after about 17 years working as a manual driller, Laban is very happy to have managed to be able to improve his English and is particularly grateful to Rik Haanen for having supported him to learn how to use a computer.

So, what is Laban's advice to the SMART Centres? Find people who to train who are serious – not just people in the street, but rather people in the field who are working in related areas, and improve them.

There is evidence of artisans who were trained in SMARTechs by the centres remaining active, and provide products and services in their local areas, for example:

- Malawi - over 60 artisans have been trained since 2012, either directly, or working in partnership with other organisations (CCAP SMART Centre Malawi, 2022). In 2022, there were still about 20 active enterprises (i.e. rope pump manufacturers and other builders) of those who have been trained over the years are still active and still provide updates to the Centre (Mhango, 2022). Box 17 provides an example of one transformation in Malawi thanks to the Centre.
- Tanzania – SHIPO Tanzania undertook a survey of contractors, in which it found that 70% of the 87 trainees trained by SHIPO by March 2022 were still active in the WASH business (Kimaro, 2022). Further, at least 30 welders have established pump production and 28 active manual well drilling enterprises. Based on self-reported data from contractors, SHIPO estimates that over 20.000 pumps have been produced and over 5,000 boreholes drilled (Kimaro, 2022). SHIPO Tanzania also has a partnership with the Water Institute, so that after training and monitoring of the outputs of the artisans to assure quality, they can be certified. As an example, 20 artisans were certified in 2020 (SHIPO, 2020).
- Box 18 provides an example of a SMART technology promotion by the centres to support a business in South Sudan.

Box 17 From well digger to owner of a drilling company in Malawi (Source: CCAP SMART Centre Malawi, 2022)

Mr. Mzumala used to work as a well digger, but following training by the SMART Centre subsequently formed a drilling company with three drilling teams. Whereas before he owned a bicycle, he now owns a car (Figure right), as well as a hostel where he rents accommodation to students.

Box 18 Pokwow Services in South Sudan (Source: Anon, 2018)

Within a year of the training on the Mzuzu drilling technology, water treatment and the production of table top filters in 2017, Mr. Othow Okoti, who had previously been in business, established Pokwow Services, a business with services that include manually drilling wells and retailing household water filters along with other WaSH products. He was assisted in setting up the business by PC(USA) Mission worker Kristi Rice who has a background in business and micro-finance. In 2018, he was planning to attend a workshop to support private sector to be businesses held by the Academy for Professional Development, who is an informal partner of PRDA.

However, there are challenges faced by the businesses, and for the SMARTechs, for example:

- In the case of Kenya, the Centre has observed that some of the trained artisans look for quicker returns than can be realised, and so discontinue to market their products (Nyamboki and Nyakundi, 2022). The Centre plans to address this by providing more support to the enterprises, including linking them with institutions who can pay for their services, also so that they are able to practice more.
- Encouraging Private business in WASH has also been found to create challenges in Malawi, where it has been observed by those working at the Centre, that others, who were not trained by the Centre copy the products and sell sub-standard versions to customers. This has affected the market, with the poor-quality products damaging the reputation of the

SMART Centre, which is associated with these technologies (CCAP SMART Centre Malawi, 2022).

- Poor quality manufacture has also been observed in Ghana, alongside poor response times to repair facilities when they breakdown (Abdul-Rahaman, 2022). In Ghana, with the introduction of i-Maintenance centres in 2014, the Centre has witnessed functionality rates increase from 45% to 95% (Abdul-Rahaman, 2022).
- Meanwhile, in Kenya, rainwater harvesting systems. While clients expressed that they like the fact that the water is easily and readily available, with time and money saved, and even money earned for some clients who are selling water to neighbours, there were also some problems. In terms of dislikes, the water tank storage capacity was found to be insufficient, there were no taps, gutters or pipes provided with the tank, making it difficult to use and there was a lack of orientation about which *fundis* to use, and how to contact them, as well as a lack of training on how to use the tank and no information regarding the warranty and after-sales service.
- In Tanzania, the popularity of rope pumps means that there has been a growing 'informal' business copying the rope pump production (referred to by some key informant interviewees as 'copycats'). The survey reported that approximately 1 in 4 pumps was not provided by a SHIPO trained mechanic. It would appear that 'copycat' installers are less likely to train the owner in pump maintenance and repair (27% trained compared with 62% for SHIPO trained installers). However, at first glance this does not seem to have affected performance. Almost 70% of them had not broken down, compared with 17% of pumps provided by SHIPO trained mechanics. The average number of breakdowns per unit was actually four times higher for those where the owners stated that they had been provided by SHIPO trained installers. This, apparently worse performance may in fact reflect the age of the pump (i.e. older pumps). However, the assessment surveys found no evidence that 'copycat' producers are damaging the reputation of the technology established by SHIPO.
- In order to separate the training role of the Centre in Zambia from the implementing role of the trainees, the Eastern Manual Drilling (EMD) Cooperative was established (Box 19). Any requests for water supplies that come to the SMART Centre are handed on to EMD. This is in contrast with Pumping is Life in Ghana, which also operates as a commercial water service provider, and drills wells alongside those that they have trained.

The small enterprises that have been trained by the SMART Centres do not work in a vacuum, nor in a free market. They face challenges including consolidation of materials for purchase, registering as a business and getting a licence to practice as well as dealing with currency fluctuations and disputes. One of the greatest competitors for businesses offering water supply services to users are the highly subsidised water supplies (and sometimes sanitation) offered by NGOs and governments. Breaking down barriers to household investments requires advocacy at high levels as well as marketing techniques. Given that both aspects are generally beyond the capacity and competence of small enterprises, the SMART Centres can support them and help their voices to be heard.

Box 19 Eastern Manual Drilling Cooperative in Zambia (Source: Haanen, 2021b)

In 2018 Eastern Manual Drillers was established, a Chipata-based cooperative which provides drilling services both within and outside Eastern province by SMART centre trained hand-drillers. Drillers in satellite districts can join this cooperative or form their own, but so far, all have opted to join EMD. The EMD board consists of local drillers elected by the team. As of 2021, EMD had a membership of 27 drillers, operating in teams of two, and assisted by casual labour or members of the owner's household. The Board allocates jobs to the drillers on a rotational basis and tries to maintain construction and pump installation quality, and is able to negotiate prices more easily than individual artisans would.

Figure (above) manually drilled borehole and rope pump, plus recharge well with well owner and Rik Haanen of Jacana Zambia (photo: Sally Sutton)

One of the main incentives for establishing the cooperative is Zambia's legal framework whereby all drillers need to be licenced (Danert et al, 2022). Rather than applying for individual licences, EMD has a licence that was issued by the Water Resources Management Authority (WARMA), and the manual drillers that are members of the cooperative all work under EMD. However, despite several attempts, EMD has struggled recently to renew the annual licence, without being clear on what the problem actually is.

Figure (below)) Manual drilling above Chipata town (photo: Sally Sutton)

Conclusions

The SMART approach is contributing to SDG 6, and a market-based approach can provide safe water, located at, or close to people's homes. The approach is able to provide safely managed services to pump owners, alongside basic services to their relatives and neighbours, with whom supplies are generally shared. The measured reduction in distance to collect water as a result of efforts of the SMART Centres in specific parts of Zambia and Tanzania is a testament to the value of the SMART approach. This has a tremendously positive impact on the lives of women and children, who have a reduced burden of water collection. This demonstrates that Self-supply, if adequately supported, is a service delivery model that can be included in a portfolio of solutions alongside community or utility managed supplies. In Kenya, it has been shown that households who are unsatisfied with the performance of existing supplies, are keen to invest in their own water supplies and these can be supported through credit schemes. Those who invest or use the supplies are generally highly satisfied with them and recommend them to others. However, market development is slow, and vulnerable to economic shocks, as COVID has shown.

Household water supplies can boost rural incomes and contribute to the rural economy and so are highly relevant beyond SDG 6. Some SMART Centres have made explicit links to productive use of water, but more importantly, many water users themselves have reported increased incomes as a result of supplies at their household, on their land and for their businesses. This highlights the importance of considering the intersectoral benefits of water, and presents opportunities to forge links with government and NGOs in other sectors than WASH. Those who have been trained in WASH technologies, and invested in related enterprises have witnessed real gains in their incomes and quality of life,

The SMART approach is highly relevant to the BZ policy priorities to contribute to the achievement of SDG6, with their emphasis on sustainability of services, social inclusion and financial leverage, and it can contribute to climate resilience. The assessment found that services can be sustainable, although the service life of some of the SMARTechs should be examined, and, as with community pumps, there may be need for some form of external support to ensure that spare parts remain available, and that maintenance can still be undertaken. While in some countries (e.g., Tanzania) aspirations seem to be changing toward submersible pump technology, there is still a vibrant market for rope pumps. The SMART approach is able to leverage investment by local private enterprises in developing businesses to upgrade wells, drill boreholes, manufacture rope pumps and sell household water filters and also to leverage investment by users in these technologies. The assessment found that social norms in Tanzania and Zambia mean that while not everyone can invest in their own water supply, families who own supplies generally share these with neighbours, including vulnerable groups. As an example, in Zambia, about 40 people on average will benefit from one household rope pump. These social norms of sharing are likely to apply widely within the other six SMART Centre countries covered by this assessment. While environmental sustainability was not a core question in the assessment, the quantities of water extracted for domestic use, livestock watering, gardens and small businesses are small compared to large scale industrial or agricultural use.

The impact of the SMART Centres is significant, but localised. With dozens of enterprises now active in Malawi, Tanzania and Zambia as a result of the efforts of the SMART Centres over a number of years, markets for rope pumps installed on manually drilled boreholes and upgraded wells have developed. In Malawi, the SMART approach has subsequently been adopted, modified and applied by another organisation that was initially trained by the SMART Centre. However, constrained by funding to expand further, and working on relatively low budgets, and often in relative isolation, the impacts of the SMART Centres are localised fairly close to the vicinity of the Centres themselves, or to other organisations that have adopted a similar approach.

Official recognition of Self-supply and targeted subsidies will both likely be vital to scale impacts and reach households that will be served last through other service delivery models. The rates of progress in market development recorded by the SMART Centres to date will not address the huge gap in covering scattered and remote communities. Pathways to scale are hard to envisage without national policy recognition for Self-supply, leadership driven by government departments (and ideally coordinated action by multiple ministries) that can reach to local levels, and substantial supporting investments in the systems that are needed to support Self-supply such as better monitoring, planning and information (in addition to technologies and a trained private sector). Further, the provision of subsidies (of some level), and/or credit to those for whom community supplies would be more expensive, and for vulnerable groups also has a role to play. Subsidies, or credit could support the market for local enterprises the SMEs and the opportunities for employment in rural areas. Subsidies for the most vulnerable should be a specific target.

The SMART approach has potential for a much wider impact, but is constrained by low levels of funding and staffing, and insufficient working partnerships. There is clearly need for low-cost, affordable technology options, in all eight countries covered by this assessment, to meet the needs of dispersed populations, and those in densely populated areas where state and NGO funding is not able to keep up with demand. Further, key informants from Ethiopia, Ghana and Niger emphasised the importance of bringing water much closer to the home for domestic use, alongside watering animals and gardens and for small businesses. The assessment has shown that these needs can be met by the SMART approach. There is also considerable untapped potential for manually drilled boreholes and improvements to hand dug wells, as well as domestic rain water harvesting in many parts of the eight countries in question. It was pointed out that there are people 'wasting their time' every year digging new wells that collapse when the rains come. They could benefit tremendously from permanent year-round sources in the form of protected manually drilled boreholes.

The SMART approach has the potential to impact on the lives of many more people than it has to date, but low levels of funding and staffing at the Centres, coupled with insufficient working partnerships with other actors, mean that fulfilling this potential is highly constrained, and limited to fairly small scale, localised efforts. Full financial sustainability of the SMART Centres would require that the Centres charge commercial fees for training and mentoring. to cover all of their costs. Given the high rates of extreme poverty in most of the eight countries in question, this is not realistic. There may be scope for more hybrid approaches, as is the case with the SMART Centre in Ghana. However, current donor funding focuses on immediate results on the ground, leaving little room for advocacy, policy change and building strategic partnerships. As a result, the sustainability of the Centres is precarious.

The assessment highlights that training artisans in technical aspects or providing credit to households on their own are not always enough to develop a market and ensure consistently high-quality products in the long term, noting also that others, who may not have been trained properly also start to make and sell the technologies. Likewise, while TVETs are important, it takes much more than technical and business training to develop entrepreneurs, and so even if there was more outreach through TVETs, this would not necessarily result in a growing cadre of WASH enterprises. Thus, to develop markets at scale, a range of partnerships will be needed coupled with government backing and policy support.

Negative attitudes towards Self-supply, as well as misconceptions in the international water supply community, undermine the efforts of the SMART approach and limit the impact of other market-based approaches or efforts to support Self-supply, Household investments in water supply are a reality, and are compensating for shortfalls in public spending, whether all governments, water supply sector stakeholders and financing organisations are completely comfortable with them or not. Household investment in sanitation is widely recognised of course. In all of the eight countries covered by this assessment, there is need to move people users up the water ladder in the immediate, and long-term (see Figure 6). Arguably users would benefit from a range of service delivery modes, including Self-supply and a market-based approach. Unfortunately, despite evidence of the importance of Self-supply, negative attitudes and misconceptions about it are widespread. There is a reluctance by governments, UN agencies and donor organisations to invest in supporting Self-supply at scale. There are exceptions: a financing agreement for USD 200 million between the World Bank and Bangladesh supports microcredits to both households and entrepreneurs to finance investments in water and sanitation facilities. (World Bank, 2021).

Recommendations

Key recommendation 1 - Given the relevance and effectiveness of the SMART approach, rooted in innovations and entrepreneurship within the Dutch water sector, but also recognising its limited impact and current lack of investment, this assessment recommends that BZ considers direct or indirect financing to scale up market-based approaches in rural water supply alongside similar investments and initiatives in sanitation and hygiene.

The Dutch BZ has invested in flagship initiatives – in areas like strengthening utilities, improving water resources management and market-based approaches - that focus on critical gaps and the delivery of innovative solutions through long-term partnerships. Market-based investments in WASH have focused on sanitation including FINISH Mondial and Aqua for All's initiatives. These programmes show that high levels of leverage in investments can be achieved through market-based models, with targeted public actions to build market systems triggering private investments.

Development of rural water supplies through market-based mechanisms and household level investments remains more controversial and neglected within the mainstream practice of the water supply sector than in sanitation or hygiene. Nevertheless, almost all high- and middle-income countries that have reached near universal access to water in rural areas, have done this with a substantial contribution of Self-supply especially for access by remote and scattered households. Such supplies are more often improved than was previously understood (Sutton and Butterworth, 2022) and state-of-the-art programmes are now investing in Self-supply for its ability to deliver safely-managed water, including recent World Bank investments in Bangladesh in market-driven approaches for water and sanitation (World Bank, 2021)..

The critical need and challenge is to combine water access through market-based Self-supply with other service delivery models such as utility- or community-managed supplies. No service delivery model is likely to be sufficient alone to realise universal supplies. It is realistic that public investments in Self-supply through SMART Centres, can contribute, providing they adapt their approach and partnerships to address scaling and give more emphasis on the enabling environment.

This approach is particularly pertinent for low density areas, as lower per-capita costs can be realised with low-cost, but effective household, family-owned supplies compared to community supplies. This assessment clearly shows that sharing of sources with neighbours, is the norm. In the case of high-density areas, household supplies can alleviate pressure on existing infrastructure, particularly as investments struggle to keep up with rapidly growing populations.

The Dutch development sector is well placed to provide leadership in this area due its strengths in food security, agriculture and multiple uses of water as well as experiences in market-based approaches in sanitation and hygiene.

The SMART approach, as practiced by the SMART Centres and coordinated by the SMART Centre Group is one market-based approach in WASH. The BZ may consider funding SMART Centres, or a number of organisations working as a coalition, or in the form of an alliance with a main focus on market-based approaches in rural water supply. This would build on the experiences of different stakeholders, while stimulating learning about the pros and cons of different approaches and technologies for Self-supply.

It will be essential that national government leads, and this will be an essential criterion in any country selection process. Scoping is required to identify government interest, which may be in different ministries. For example, the health or agriculture ministries have been the leaders of Self-supply in countries such as Mali and Zimbabwe. There may also be need for efforts to challenge development consensus in rural water supply and complement ongoing efforts to learn and build on the widely-perceived failure of the community management model, by not only improving it but with alternative service delivery models. Such a programme would need government agencies to invest in supporting Self-supply and monitoring outcomes and challenges. While critical for the enabling environment, Self-supply requires local as well as national government support and a conducive climate for local business development. Self-supply approaches can be attractive to local governments who have limited budgets, as it offers a low-cost, but effective way to provide practical support to improve the water supply services for households and communities.

Given the time that it takes for markets to develop, and show results, such a programme should be for a minimum of ten years, perhaps as distinct five-year phases. Such a programme should contain explicit monitoring, research and learning components with dedicated resources. Any programme needs to pay attention to the "leave no one behind" (LNOB) agenda. This is vital as many remote and scattered households may not be reached by other service delivery models. There is wide experience in the use of SMART subsidies to support market development through well designed programmes that reduce costs to targeted households, and wide potential to link to the micro-finance sector to support household investments.

Key recommendation 2 – To challenge and reflect upon negative attitudes and misconceptions about Self-supply within the water supply sector and invest in development of evidence and policy dialogue. BZ, or the SMART Centre Group and its partners should consider catalysing further investment in policy dialogue. For example, funding one or more ambassadors for Self-supply/the SMART approach who would engage with stakeholders at international and national level, particularly those who are sceptical or concerned about the approach. The role would not be to simply market the approach, but rather to determine opportunities and constraints, and engage in international policy dialogue to foster understanding of the key issues on all sides of the Self-supply debate.

The assessment has also found a number of specific areas where the SMART approach, SMART Centres and the SMART Centre Group, could be strengthened:

- Invest in proof-of-concept, awareness-raising, programme development and working partnerships – use the reports, information and research from the SMART Centres as well as information that has been collated by this assessment for targeted, evidence-based awareness-raising of the SMART approach, including its achievements and limitations. Consider learning from the experiences of other organisations that use market-based approaches in WASH, and try to collaborate with them, so that information from a broad range of organisations is collated and shared.

  This information should be used as a basis for discussion with potential in-country partners to further explore collaboration, and also to include in funding proposals. Given the difficulty for in-country organisations to change from conventional WASH approaches that fund hardware to Self-supply, the SMART Centre Group, together with other key organisations pursuing market-based approaches should engage in dialogue with potential partners and funders such as UNICEF, DGIS, USAID, Aqua for All and SDC. Government of Netherlands embassies are well placed to support such dialogue and the potential links with other issues and sectors e.g. climate action and food security and nutrition. This dialogue should explore the potential for development of multi-year, multi-country market-based programmes.

- Consider broadening the SMART approach from three, to five pillars to include policy engagement and monitoring. Alongside (i) the use of innovative technologies; (ii) training of the private sector and (ii) promoting Self-supply, add (iv) policy dialogue and (v) monitoring outcomes. The fourth element would ensure engagement with national and local government, while the fifth is critical to track sustainability and support learn about the approach.. Ideally, adequate monitoring should be government-led, so that there is a link between these two additional pillars. Currently Self-supply alongside assessments of markets supply chains typically absent in national monitoring systems.

- Improve reporting, documentation and transparency: SMART Centre management to increase its emphasis on documenting their efforts and sharing this information. Annual, or biennial reports from each Centre should be placed in the public domain on the respective Centre websites and SMART Centre Group websites and consider making information accessible nationally as well globally e.g. reporting to the International Aid Transparency Initiative portal. The reports should not only include numbers of new users, but be transparent on how these figures have been derived. The reports should also include information on existing users, as well as other outcomes that have been verified. Information on enterprises, should extend beyond the number of people trained, and include quality, the type of training/mentoring, and, there should be information about existing enterprises and their achievements, as well as challenges. Reports should also include expenditure and staffing. Where possible, these reports can be linked to summary data on the mWater platform, which is already the standard reporting tool for three centres (Malawi, Tanzania and Zambia). Jacana (Zambia) has already set an example with respect to reporting, which could provide a starting point for the other Centres. The SMART Centre Group should consider developing a set of numerical key performance indicators, alongside guidance on qualitative reporting for the Centres.

- Strengthen monitoring to track outcomes and the use of data (e.g. for advocacy): while it is not feasible for the SMART Centres to continue to track all of the water and sanitation systems that have been installed by private enterprises, they should consider monitoring a sample, and ensure that there are mechanisms that enable users to provide feedback when quality standards are not maintained. In terms of monitoring, ensure that sampling frameworks provide statistically significant results, with annual, or biennial survey results contributing towards the strategic direction and practical action of the centres, and should be reported (see reporting above). The Centres should also engage with government and other organisations who maintain local, or national inventories of water points to ensure that privately-owned, and other water points that originate in the SMART approach are captured.
- Strengthen sharing of experiences across the SMART Centre Group: the different SMART Centres would all benefit from more sharing of experiences between them. This should not be limited to relatively short video conferences, but should include cross-country exchange visits and placements, even of several months. This would enable staff to have a more in-depth understanding of the nuances of the different stages of technology introduction and private sector development, as well as the influence of different contextual factors. The SMART Centres should also engage more with other organisations who are undertaking similar approaches in-country, and government agencies, possibly setting up or supporting in-country exchange platforms so that different market-based approaches can be discussed (e.g. merits of franchise vs small-scale artisan approach, or subsidies). Given the delicate path that the centres have between being non-profit organisations and commercial enterprises, the Centres should share options on how to remain viable, reflecting on the advantages and disadvantages of different approaches in different contexts.
- Continue to diversify interest in a broad range of water, sanitation and hygiene technologies. given the differing aspirations of water users, as well as their differing economic circumstances, alongside the fact that not all technologies can be applied in the same geographical regions, it is very important that the SMART Centres promote a range of technologies, while not spreading themselves too thin so as to become ineffective. The rope pump is likely to continue to play a role in some contexts and has already made a tremendous impact on the lives of poor, rural households as well as those living in rural towns. However, it is important that the SMART Centres are not considered synonymous with rope pump technology and are clearly able to articulate in-country, and internationally which type of technologies are suitable for which contexts and how they complement other technologies (e.g. more emphasis on solar pumps where feasible). If household water treatment and safe storage is to become a stronger element of the SMART approach, Centres should invest more into research, advocacy, quality assurance and monitoring, and establish links to health ministries, so as to support health policies and campaigns.
- Continue to review country approach with attention to focus and life cycle the SMART Centres: in countries where other organisations have adopted the SMART approach, with positive outcomes, which are well-funded for several years, and able to cover the country, alongside a SMART Centre that is struggling to operate over years, the relevance of the SMART Centre should be called into question, and it may be prudent for the host institution to consider focusing on other activities, or other technologies. However, rather than considering this as a failure, the

adoption of the SMART approach by others should be celebrated as successful innovation diffusion.

- Invest in professional fundraising and market research – the SMART Centres and SMART Centre Group should consider employing or contracting professional fundraisers to support them to raise funds, rather than relying on largely technical staff to combine this demanding, and challenging role alongside their other activities. These may target foundations which may have more scope for innovation than some bilateral agencies, but also innovative financing programmes that seek to developed blended investments. Professional market research could focus on both the international market, barriers to communication and attitudes as well as the more local markets centres and entrepreneurs that could be targeted to expand their businesses. The opportunity is unlocking and getting performance from household Self-supply investments which are then main source of local and private finance in water in most of these countries.

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Annex 1 Changes to the evaluation approach

The original approach planned involved country visits to Malawi, Tanzania and Zambia by the evaluation team. Unfortunately, these could not be undertaken in light of the travel constraints due to the COVID-19 pandemic. The field visits were replaced by online data collection from the SMART Centres, through a detailed written questionnaire (desktop information request), followed by interviews to jointly reflect on the responses. Responses were received from five SMART Centres, and interviews held with the managing directors of three of them.

Further, towards the end of the assessment, there were changes to the evaluation team. The original lead dropped out, and the final analysis and report writing was undertaken by a new team member who had not been involved in the research design, online data collection and interviews, but did plan and undertake subsequent key informant interviews, and analyse data from household surveys in Tanzania and Zambia.

The original approach set out to collect data in relation to 73 indicators which combined the evaluation criteria of two methodologies: (1) FIETS, i.e., Financial, Institutional, Environmental, Technical and Social; and (2) Organisation for Economic Co-Operation and Development (OECD) Development Assistance Committee (DAC), i.e., Coherence, Effectiveness, Efficiency, Impact, Relevance and Sustainability. These indicators were re-grouped into seven thematic categories that specifically related to the SMART Centre approach, i.e., SMART Centres, services, monitoring, engagement, Theory of Change, governance and financial governance. This provided the framework to develop the questionnaires the online data collection and household surveys.

Due to the aforementioned staff changes, coupled with budgetary constraints, the envisaged approach, using the 73 indicators, which would have involved numerical scoring, could not be followed through. Instead, the final approach has been to analyse all the written and numerical data collected, and augment this by additional data collected through key informant interviews.

Annex 2 Assessment Data Sources

Type	Country	Response	Organisation	Date	Reference
Desktop Information Request	Ethiopia	No			
	Ghana	Yes	Pumping is Life	19 Mar 2021	Abdul-Rahaman (2021)
	Kenya	No			
	Malawi	Yes	CCAP SMART Centre	22 Mar 2021	CCAP SMART Centre (2021)
	Niger	Yes	Eglise Evangelique de la Republique du Niger (EERN)	23 Mar 2021	McGill (2021b)
	South Sudan	Yes	Presbyterian Relief and Development Agency (PRDA)	24 Mar 2021	McGill (2021a)
	Tanzania	Yes	Southern Highlands Participatory Organisation (SHIPO)	31 Mar 2021	SHIPO SMART Centre (2021)
	Zambia	Yes	Jacana SMART Centre	19 Mar 2021	Haanen (2021a)
Type	**Country**	**Comments**		**Period**	
Implementation data stored in mWater platform	Malawi	No data available in the public domain.		2019-2021	
	Tanzania	Publicly accessible on mWater platform. Does not contain information for all contractors		2005 to beyond 2018	mWater (nd(a)) mWater (nd(b))
	Zambia	Data stored on mWater platform was made available to the evaluation team.		From 2016	mWater (nd(c))
Type	**Country**	**Description**			
SMART Centre assessment survey data	Tanzania	Survey of waterpoints & water quality			
	Zambia	Survey of waterpoints & water quality			
	Tanzania	Survey of owners and sharers			
	Zambia	Survey of owners and sharers			
Type		**Description *(availability)***		**Years**	**References**
SMART Centre reporting	Ethiopia	*None – all information collected through telephone interviews*		-	-
	Ghana	Annual reports Over 35 project activity reports			Pumping is Life (2020) Pumping is Life (2021) *Too numerous to be listed*
	Kenya	Client satisfaction and impact study report		2015 – 2017	Wakenya Pamoja Sacci Society and Aqua Clara Kenya (2018)
	Malawi	SMART Centre Report Annual Report 2016 Technical Mission Report May 2016 Technical mission CCAP SMART Centre Malawi November 2018 Financial audit reports		Up to Dec 2014 2016	Mzuzu University (2014) CCAP (2016) Holtslag (2016) CCAP, EMAS and SMART Centre Group (2021) Holtslag (2018) CCAP (2018; 2020)

	Niger	Annual reports to Transform International *(internal report)*	2019/20 & 2020/21	Anon (2020a) Anon (2021a)
	South Sudan	Five Mission reports & one training report for 2019 Two Annual report *(all internal reports)*	In 2017, 2018, 2019 2019 2019/20 & 2020/21	Anon (2017a, 2017b,2018), McGill (2018), Anon (2019a), Anon (2019b) Anon (2020b), Anon (2021b)
	Tanzania	Biennial report (2017 – 2017) Annual Report (2020(	2017 & 2020	SHIPO (2020), SHIPO (2017)
	Zambia	Six annual reports (available on website)	2015 – 2021	Jacana Business Empowerment (2015. 2016, 2017 2018, 2019, 2020, 2021a)

	Country	Organisation	Websie address
Websites	Global	SMART Centre Group	https://smartcentregroup.com/
	Ghana	Pumping is life	https://www.pumpingislifewash.org/
	Kenya	Aqua Clara	https://www.aquaclarakenya.com
	Malawi	CCAP	https://www.smartcentremalawi.com/
	Niger	EERN	
	Tanzania	SHIPO	https://www.smartcentretanzania.or.tz/ https://shipo.or.tz/
	South Sudan	PRDA	
	Zambia	Jacana	https://smartcentrezambia.com https//jacana.help

Annex 3 Methodology for Waterpoint, Household and Water Quality Surveys

Objectives and design

The overall objective of the surveys was to evidence to support or negate SMART centre approaches as one way to increase coverage with basic/safely managed water supply services and contribute to development/poverty reduction

The surveys, which were undertaken in Tanzania and Zambia collected information on:

A. Water Supply Sources (including location, type, protection and water quality, as well as reliability, adequacy, users and users and ownership)

B. Characteristics and experiences of the households that use the supplies categorised into in two groups:

- B1 Owners of the supply
- B2 Sharers of the supply

The Survey design was by R. Ward, R. Veldman and S. Sutton. Analysis by Kerstin Danert and Sally Sutton.

Zambia

Jacana (Zambia) monitors most of the pumps that have been installed by the enterprises that it has trained, with data logged by the installers in the mWater platform (see Box 3). There is also ongoing monitoring of pump performance and functionality by Jacana. For the purpose of this assessment a total of 160 water points were surveyed, corresponding to 37% of the 431 pumps that were recorded in the Jacana mWater platform as of December 2021. According to Jacana, which also managed the assessment survey, sampling was purposive, with an emphasis on older installations, and consideration of logistics[79]. Comparing the sample from the survey and the database retrospectively, shows that:

- In the database, 19.1% of pumps have been installed on traditional wells, while in the survey, 18.1% of the samples were of traditional wells (Table A3.1). The survey includes a higher proportion of manually drilled wells compared to that of the database (76.9% compared to 70.7%). The survey is thus not fully representative in terms of the proportion of the different types of wells upon which the pumps are mounted.
- Only sources in the Districts of Chipata (No. 77) and Lundazi (No. 89) were selected for the survey whereas the drillers and pump installers have operated in a wider area in the Eastern Province and, to a very limited extent beyond. Thus, survey sample is not representative of the geographic area.

[79] The selection methodology was such that Jacana used a map of the data on sources, (www.jacana.help/mwater to draw some circles using GPS to make a selection that made sense in terms of logic and pump-age.

Table A3.1 Breakdown of what the pump is mounted on for Jacana Database and assessment survey

Data from Jacana database in mWater platform			Survey data		
Source Type	No	Proportion	Source Type	No	Proportion
Borehole (machine drilled)	36	8.8%	Borehole (mechanically drilled)	8	5.0%
Tube well (hand drilled, PVC casing)	289	70.7%	Borehole (manually drilled)	123	76.9%
Deepened well (hand dug and hand drilled with PVC casing)	18	4.4%	Lined hand-dug well	12	7.5%
Well (hand dug, no casing)	60	14.7%	Traditional well	6	3.8%
			Semi-improved traditional well	11	6.9%
			Unimproved traditional well	0	0.0%
Other (natural stream)	1	0.2%			
Other (tank)	1	0.2%			
Other (scoop hole in Dambo)	1	0.2%			
No data	3	0.7%			
Total	409		Total	160	

- Table A3.2 compares the types of pumps in the database with that of the survey and shows that, ten of the 25 solar pumps were surveyed (40%) and out of 411 rope pumps, 143 were covered by the surveys (34.8%). In the household survey, 119 out of 151 owners/owner family members (78.8%) stated that the rope pump provided their main source of drinking water, while rope pumps provided the main source of drinking water for 65 out of 82 of the sharers interviewed (79%).

Table A3.2 Breakdown of types of pumps installed Jacana Database and assessment survey

Data in Jacana database on mWater platform			Survey data		
Source Type	No	Proportion	Source Type	No	Proportion
			Rope/bucket	1	0.6%
Rope pump	411	94.1%	Rope pump	143	89.4%
			Afridev		0.0%
			India Mark (2-5)	2	1.3%
			Motorized pump	1	0.6%
DC pump (solar)	25	5.7%	Solar Pump	10	6.3%
EMAS Pump	1	0.2%			
			None	3	1.9%
Total	437		Total	160	

- In terms of age of installation, the proportion of the sources covered by the survey were slightly higher for 2017 (1 percentage point), 2018 (3.3 percentage points) and 2021 (six percentage points) as detailed in Table A3.3. The survey results thus do not represent the age of installations.

Table A3.3 Breakdown of year of installation of rope pumps

Jacana mWater database (rope pump)			Survey (main source is rope pump)		
Year of pump installation	**No**	**Proportion**	**Year of pump installation**	**No**	**Proportion**
2016	3	0.7%	2016		0.0%
2017	36	9.0%	2017	12	10.1%
2018	71	17.7%	2018	25	21.0%
2019	85	21.2%	2019	20	16.8%
2020	122	30.4%	2020	30	25.2%
2021	84	20.9%	2021	32	26.9%
Total	401		Total	119	

In conclusion, the Zambia surveys can provide valuable insights into rope pump and solar pump use, protection, functionality but cannot be used for comparisons with other supplies (i.e., India Mark, rope and bucket or motorised pumps). There is need for caution in drawing conclusions with respect to wider population in relation to the age of installation.

With 118 owners or owner family members, and 66 sharers, who own or use rope pumps interviewed, the household survey is able to provide insights on their experiences including acceptance, payments and impacts. However, with such small numbers for solar pump owners/owner family members (13) and sharers (7) the sample may be too small to make comparisons between the experiences of these technologies.

Tanzania

In Tanzania, most of the SMARTechs have been installed in Njombe and Iringa regions in the south west of the country (Figure A3.1). For the survey, sites were selected in Njombe region only, since it has both old and new pumps. In Iringa, specifically in Mafinga district, there have been a lot of water points constructed in the past years, but there are no very old wells.

Figure A3.1a Regions of Tanzania (Sémhur, 2022)

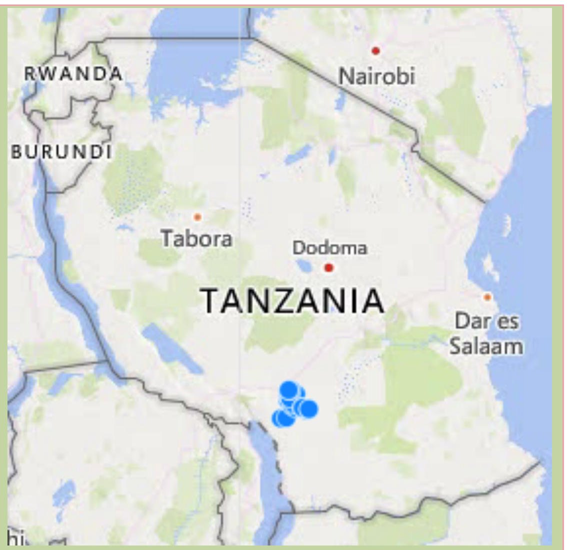

Figure A3.1b Locations of wells/households surveyed (source: mWater platform)

A list of the wards and villages in the three districts of Njombe region where the target: of around 120 wells was prepared. Finally, a total of 129 sources, and 218 users were included in the survey (Table A3.4).

In every village, a caretaker, technician, artisan or government staff in every village was contacted, who would direct the survey team to the water points around. When reaching there, this person guided the group around. These people mainly knew the water points constructed through SHIPO programs/drillers. Once at the site, the survey team was able to understand the situation in the village and look for other interesting information, such as other kinds of technologies popular in that place (e.g., traditional wells, electric pumps). The plan was to visit 2 or 3 villages (approx. 1 ward) per day (with some flexibility) but in most cases, the time was not enough to visit all of the suggested water points by the person in the village.

The survey team always interviewed the owner or someone who could "act" as the owner of the water point. In the case of the sharer, in most cases they interviewed whichever sharer was around since it was not easy to find them. Of those interviewed, 62.4% were owners and 37.6% sharers, aligned to the interviewee selection design, for which, half of the wells, one sharer was also interviewed. In terms of sex of the respondent, 51.8% were female and 48.2% male.

Table A3.4 Breakdown of sources and households surveyed in Tanzania

Sources surveyed			Households surveyed		
Location	No	Proportion		No	Proportion
Njombe District council (rural)–	74	57.4%	Njombe District council (rural)–	130	59.6%
Njombe Town council	34	26.4%	Njombe Town council	47	21.6%
Makambo Town council	21	16.3%	Makambako Town council	41	18.8%
Total	129		Total	218	

Table A3.5 Types of sources surveyed and pumps mounted for water point survey in Tanzania

Sources types			Water lifting devices		
Location	No	Proportion		No	Proportion
Borehole (mechanically drilled)	4	3.1%	Rope/bucket	43	33.3%
Traditional well	4	3.1%	Rope pump	63	48.8%
Unimproved traditional well	2	1.6%	Motorised pump	23	17.8%
Lined hand dug well	25	19.4%			
Semi-improved traditional well	34	26.4%			
Borehole (manually drilled)	60	46.5%			
Total	129		Total	129	

Details of the water point sources included in the Government database for these three local government authorities are shown in Box A3.1, A3.2 and A3.3..

Box A3.1 Njombe rural - extract from Government of Tanzania Water Point Database (accessed 10 March 2022)

Water point source type for Njombe Rural LGA

Name	Total Water point Num	shallow well	borehole	spring	rainwater harvesting	river/lake	dam	other
Idamba	34	0	0	34	0	0	0	0
Igongolo	108	4	5	99	0	0	0	0
Ikondo	65	0	0	34	0	30	0	1
Ikuna	36	2	19	12	0	3	0	0
Kichiwa	82	10	14	58	0	0	0	0
Kidegembye	87	0	40	29	0	18	0	0
Lupembe	59	1	0	58	0	0	0	0
Matembwe	110	0	3	50	0	57	0	0
Mfriga	0	0	0	0	0	0	0	0
Mtwango	89	2	5	82	0	0	0	0
Ninga	43	0	4	21	0	18	0	0
Total Njombe Rural LGA	**713**	**19**	**90**	**477**	**0**	**126**	**0**	**1**

Select details of water point extraction type:

- rope pumps –68; gravity – 482; swn 80 – 31; nira/tanira – 11; electricity-powered – 1; submersible -111

Box A3.2 Njombe Town Council - extract from Government of Tanzania Water Point Database (accessed 10 March 2022)

Water point source type for Njombe Urban LGA

Name	Total Water point Num	shallow well	borehole	spring	rainwater harvesting	river/lake	dam	other
Ihanga	34	0	0	34	0	0	0	0
Iwungilo	66	0	0	66	0	0	0	0
Kifanya	83	1	0	82	0	0	0	0
Lugenge	38	0	0	38	0	0	0	0
Luponde	65	5	0	60	0	0	0	0
Makowo	72	0	0	72	0	0	0	0
Matola	131	0	0	131	0	0	0	0
Mjimwema	0	0	0	0	0	0	0	0
Njombe Mjini	0	0	0	0	0	0	0	0
Ramadhani	60	6	0	9	0	45	0	0
Utalingolo	15	0	0	15	0	0	0	0
Uwemba	93	32	0	42	0	19	0	0
Yakobi	93	0	0	93	0	0	0	0
Total Njombe Urban LGA	**750**	**44**	**0**	**642**	**0**	**64**	**0**	**0**

Select details of water point extraction type:

- gravity – 650; rope pumps – 42; swn 80 – 2; electricity-powered – 0; submersible -55

Box A3.3 Makambo Township Authority - extract from Government of Tanzania Water Point Database (accessed 10 March 2022)

Water point source type for Makambako Township Authority LGA

Name	Total Water point Num	shallow well	borehole	spring	rainwater harvesting	river/lake	dam	other
Kitandililo	98	0	76	0	0	22	0	0
Lyamkena	16	0	0	16	0	0	0	0
Mahongole	147	23	52	13	2	57	0	0
Mjimwema	0	0	0	0	0	0	0	0
Mlowa	64	0	64	0	0	0	0	0
Mwembetogwa	0	0	0	0	0	0	0	0
Ubena	0	0	0	0	0	0	0	0
Utengule	99	0	8	91	0	0	0	0
Total Makambako Township Authority LGA	**424**	**23**	**200**	**120**	**2**	**79**	**0**	**0**

Select details of water point extraction type:

- rope pumps – 86; gravity – 202; nira/tanira – 127; electricity-powered – 0; submersibe -0

Table A3.6 compares the numbers of rope pumps and submersible pumps surveyed with the national database for the three districts covered by the survey. Given that there is a disparity between the alleged number of rope pumps in the country and the national database (discussed in Chapter 3), it is not possible to determine how representative the survey is of rope pumps in the respective districts.

Table A3.6 Comparison of number of rope pumps and submersible pumps in Tanzania Government Database with main source of drinking water reported by survey respondents

Tanzania Government Data		**Household Survey data**	
Source Type: Rope Pump		**Source Type: Rope Pump**	**No**
Njombe District council (rural)–	68	Njombe District council (rural)–	29
Njombe Town council	42	Njombe Town council	11
Makambo Town council	86	Makambo Town council	23
Total	196	Total	63
Source Type: Submersible Pump		**Source Type: Motorised Pump**	
Njombe District council (rural)–	111	Njombe District council (rural)–	13
Njombe Town council	55	Njombe Town council	6
Makambo Town council	0	Makambo Town council	4
Total	166	Total	23
		Rope and bucket	
		Njombe District council (rural)–	32
		Njombe Town council	4
		Makambo Town council	7
		Total	43

The span of age of the tope pumps sampled in Tanzania was from 2005 up to 2021 (Table A3.7). The Tanzania survey thus included much older installations compared to Zambia, where the oldest installation was 2016. (Table A3.7).

Table A3.7 Breakdown of year of installation of rope pumps surveyed in Tanzania

Survey (main source is rope pump)		
Year of pump installation	No	Proportion
2005	2	4.1%
2006	3	6.1%
2007	6	12.2%
2008	8	16.3%
2009	4	8.2%
2010	2	4.1%
2011	0	0.0%
2012	9	18.4%
2013	3	6.1%
2014	3	6.1%
2015	0	0.0%
2016	1	2.0%
2017	0	0.0%
2018	4	8.2%
2019	0	0.0%
2020	1	2.0%
2021	3	6.1%
Total	49	

In conclusion, the Tanzania surveys can provide valuable insights into experiences of rope pumps, as well as submersible pumps and rope and bucket sources. However, the sampling, does not provide the basis for quantitative comparisons between different source types. With survey data from 52 owners or owner family members of rope pumps, and 26 sharers, the household survey is able to provide insights on their experiences including acceptance, payments and impacts. While insights can be drawn from the 19 owners of traditional wells with a rope and bucket, there is insufficient corresponding data with respect to the and sharers of traditional wells, solar pumps or stand posts.

Annex 4 Focus group discussion methodology

Tanzania

In each of the ten communities covered, participants comprised well owners and sharers, and included men and women as summarised in Table A4.1. The discussion explored the water supplies that people have, how they function, how they have changed their lives and the problems and benefits they present. Key findings of the discussion were summarised.

Table A4.1 Overview of focal group discussions in Tanzania

Community	No of people in discussion	Water sources used as mentioned by the community (note that there may be more that were not mentioned)			
		Community Gravity	Traditional wells with rope and bucket	Rope pumps	Springs
Ikuna village	11 (5 female) (5 owners; 6 sharers) (3 female owners)	✓ (under RWASSA, Government owned)	✓	✓ (some)	
Mahalule Street, Nyombo village	13 (8 female) (3 owners; 10 sharers) (0 female owners)		✓	✓(some)	
Kisilo village	10 (4 female) (4 owners; 6 sharers) (2 female owners)	✓	✓	✓	
Uwenba village	13 (9 female) (3 owners; 10 sharers) (2 female owners)			✓	✓
Ikelu	10 (3 female) (5 owners; 5 sharers) (1 female owner)	✓ (supplied by a government project called TOVE)		✓	
Itunduma Mtwango	16 (6 female) (4 owners; 12 sharers) (2 female owners)	✓ (TOVE)		✓	
Kiumba	14 (8 female) (5 owners; 9 sharers) (3 female owners)	✓ (TOVE)		✓	
Kichiwa	11 (3 female) (8 owners; 3 sharers) (1 female owner)		✓ (most)		
Kidegembye	27 (14 female) (9 owners; 18 sharers) (0 female owner)		✓ (private wells dominate)		
Kahimbi Street - Lupembe village	14 (7 female) (3 owners; 11 sharers) (2 female owners)	X (No)		✓	✓ (and rivers)

Additional insights:

- Residents of Ikelu and Kidegembye are supposed to pay TZS 50 per bucket (20 litres) but the consensus is that this is too high. They would pay for the TOVE water if the price were to be TZS 20 per bucket, or if there was a flat fee of between TSZ 1,000 to 3,000 per month.
- In Itunduma Mtwango, they pay TZS 12,000 per year for the TOVE water, but some households cannot afford this due to financial difficulties.
- One resident noted that they do not think 'researchers' like the team from SHIPO can help them in any way because there has been a wave of people who come into the village often introducing themselves as researchers, who look for ways to solve the water challenge; just to disappear without any feedback in the end. So they warned the team from SHIPO from doing the same.

Zambia

Focus Group Discussions were held in a total of four locations. with communities in Lundazi and Chipata Districts. The Focus Group Discussions aimed to understand the water supplies the community members have; to learn from them, how these supplies are functioning, how or whether these have changed their lives or not and also the problems and benefits they present. In one case, where the groups were particularly large, three smaller groups were formed, with a common report prepared.

Table A4.2 Overview of focal group discussions in Zambia

Community	No of people in discussion
Katandala village, Chasefu	**11 (3 female)** **(7 owners; 4 sharers)** **(3 female owners)**
Nthembwe village, Mwase	**17 (10 female)** **(14 owners; 3 sharers)** **(8 female owners)**
Matamba village, Mwase	**25 (13 female)** **(15 owners; 10 sharers)** **(7 female owners)**
Kagunda Chipata	**6 (3 female)** **(1 owner; 5 sharers)** **(male owner)**
Feni Chipata (primary school)	**8 (5 female)** ***(no breakdown of owners and sharers)***

Annex 5 Water Quality Testing Methodology

The bacteriological sampling survey that was undertaken within this assessment was carried out at the start of the rainy season 2021/22. Analyses were carried out by SMART centre staff and existing water quality data was also collected from all centres where available. Analytical methods were those with which the staff were most familiar - membrane filtration and lauryl sulphate.

For Zambia, additional data (January – March 2021) was also available for the end of the previous rainy season (2020/21) in which rains were good to heavy throughout.

Water analyses for the review were undertaken in Tanzania and Zambia in association with source and household surveys. Sanitary inspections and scoring were also carried out.

Unfortunately, only the Water Quality data for Tanzania could not be used in its the assessment due to inconsistencies with respect to the data that could not be reconciled

Annex 6 Key Informant Interviews

The assessment set out to undertake 20 to 30 semi-structured interviews with key informants (i) in the eight SMART Centre countries and (ii) operating at a regional or global level. The key informants were selected from a long list of over 100 stakeholders from national and local government, NGOs, development partners, UN organisations, training and academic institutions, the private sector and the SMART Centre management. The interviewer prioritised, trying to strike a balance between countries, and types of organisations. Given the importance of public opinion and public awareness, the interviewer tried to reach a small sample of individuals within each country. The interviews do not provide statistically significant results, but rather insights for the assessment.

A series of short, 40 minute interviews (via Skype/WhatsApp/Zoom) using an interview guide were undertaken. The time needed to prepare, set up the interviews and analyse the results, meant that no more than 30 interviews in total were envisaged. However, finally only 13 could be undertaken, as the interviewer developed Covid-19 in the Key Informant Interview period, including losing her voice and thus had to cancel several planned interviews,

Initial selection of interviewees was be based on the stakeholders that have been proposed by the staff of the SMART Centres and SMART Centre Group. Additional suggestions for interviewees were taken through a snowball sampling method. The interviewer has developed a semi-structured interview guide that sets out to confirm/challenge the findings of the assessment so far, and draw out the attitudes, concerns and ideas of the interviewees.

Ethics

The interviewer sought to create a safe environment in which interviewees can freely share their experiences, practices, and knowledge without fear of repercussions. Informed consent, permission from superiors, and respondent anonymity are all important. She ensures that all interviews are booked in-advance via phone or email. In these emails/phone calls, the researcher will explain the purpose of the study, the type of questions that will be asked, and the expected time commitment. These aspects are re-explained before interviews begin. The anonymous nature of the research will be discussed with participants before interviews begin and consent gained from the respondent before questions were asked. There will be no audio-recording. Furthermore, where necessary, the researcher will obtain permission from the necessary authorities before contacting the respondent of interest.

All interview data was treated in a professional manner; confidential information remained confidential, and participant anonymity was maintained throughout. Respondents were classified instead of using personal or organisation names. References to organisation or other organisations will be excluded from the notes

Annex 7 Overview of SMART Centres

Ethiopia - Ethiopia Water Technology Institute (EWTI) SMART Centre[80]

Location: Addis Ababa **Website**: http://www.ewti-ethiopia.com/

Institutional set-up: The SMART Centre is hosted by the Ethiopian Water Technology Institute (EWTI), and was established in 2018. It is actually one of four units/departments, i.e. research and technology transfer, alongside: training, competency assessment and the laboratory.

(a) Rope Pump and EMAS Pump

(b) Rope pumps with rainwater harvesting facilities in the background

Figure A7.1 Demonstration of SMARTechs at the Ethiopian Water Technology Institute (photos: Akino Kitazume)

Staffing: The Centre does not have a dedicated team and budget to run, and has not yet been included in the organisational structure of EWTI.

Activities: The centre is used to demonstrate different water technologies for regular trainees at the courses run by EWTI and visitors to the institute. The technologies on display are an seven handpumps (Afridev, Access, 4 Rope pump models and EMAS pump), solar pumps, wire brick cement tank, underground water tank, tube recharge, SaTopan latrines and household water filters (Gochem, 2022). The Mzuzu toolkit for manual drilling is also on display. At the demonstration site water is used to grow crops like onion, tomato, chili, beat root, maize, potato, lettuce and cabbage (Gochem, 2022).

To date, two rounds of training were provided in 2019 for woreda/District government staff; the first one was at the institute (EWTI) involving 12 trainees, and the second one was in the Southern Nations, Nationalities and People Region (SNNPR), Dilla involving 31 trainees on manual well drilling, rope pump manufacturing and installation. In addition, in 2022, there were several training sessions of EWTI staff in different aspects of solar technology for water supplies.

Funding: Government funding and from donor projects.

Outcomes:

Ideas and plans: There are ongoing efforts to include the Centre in the EWTI organisational structure and ensure that there is a dedicated, and capacitated team to run it.

[80] Mekonta (2022)

Ghana – Pumping is Life SMART Centre

Location: Wale Wale **Website**: https://www.pumpingislifewash.org/

History and institutional set-up: In Ghana, the SMART Centre is hosted by the organisation Pumping Is Life and its activities has its origins back in 1997, when manual drilling technology (specifically cable-tool drilling) and the rope pump for boreholes was introduced in the north of the country. Pumping is Life was incorporated as a company limited by guarantee in 2009 before becoming an NGO in 2020. Historically, Pumping is Life filled gaps in water services for deprived and difficult to access communities, but has witnessed a broadening of its scope (which grew to include sanitation), and the number of communities served. Between 2004 and 2020 the, organisation has worked in about 57 rural communities spanning 3 regions in the North of Ghana (Abdul-Rahaman, 2021). Training of staff and partner organisation under the guidance of several Dutch experts[81] has been undertaken in 2008, 2010, 2011, 2014 and 2016.

Figure A7.2 Solar system as promoted in Ghana (source: Abdul-Rahaman, 2022)

Staffing: Five members of staff – coordinator, assistant coordinator, facilitator in charge of entrepreneurship and accountant, plus one external facilitator from Tamale Technical University (Abdul-Rahaman, 2021). There are also 25 temporary staff members (Abdul-Rahaman, 2022).

Activities: Over the years the organisation has undertaken projects involving tube wells, household latrines, rainwater harvesting and hand dug well rehabilitation (Abdul-Rahaman, 2021). Ghana was also host to the first Rope Pump Workshop in 2010. Training programmes cover geophysical surveys (for borehole siting), manual drilling, rainwater harvesting, rope pump manufacture, general welding, marketing and distribution of household water treatment and safe storage technologies including Tulip Filters. Pumping for Life also undertakes training in collaboration with the Tamale Technical University on plumbing and borehole mechanisation (Abdul-Rahaman, 2021).

Funding: Pumping is Life is funded through projects as well as the sale of goods and consultancy services including the solar systems, geophysical surveys and training (see above). Water is also sold for revenue. Currently, funding is for project of short duration (e.g., in 2020 from FloorGhana and Wilde Ganzen). There are currently no multi-annual funding arrangements.

Outputs and Outcomes: In the two years prior to March 2019, a total of 78 entrepreneurs were trained on various modules (see activities above). The Centre reports that its efforts have benefitted over 190,000 people (Table A1.1).

Table A7.1 Overview of outputs and beneficiaries for SMART Centre Ghana (Abdul-Rahaman, 2022)

Programs of the Center	No. of Facilities	Number of people benefiting/Services
Rope pump/Tube wells water supply	430	93,978
Hand dug wells rehabilitation projects	56	10,520
Rain water harvesting systems	146	51,100
WASH i-Maintenance centers	4	
Household managed irrigation	32	17,100
Household latrines	145	1,885
Household handwashing	700	9,100
Household water treatment and safe storage	296	3,848
Community Solar Water Supply	7	2,850
Grand total of beneficiaries	1,809	190,381

[81] Including Henk Holtslag, Dolf Heubers, Arjan van der Wal, Gerrit van Roekel, Arnold van De Kamp and others.

Kenya - Aqua Clara SMART Centre

Location: Kisii Website: https://www.aquaclarakenya.com and https://aquaclara.org

History: Established in 2008, Aqua Clara is a social enterprise with two core sites in Kenya and Nicaragua focussing on water and sanitation[82]. The organisation states that it has enabled more than 300,000 people to improve their access to safe drinking water (Nyamboki and Nyakundi, 2022). The mission of the organisation is to "increase access to safe drinking water in Africa by building local capacity, providing effective solutions and implementing sustainable approaches". [83]

Figure A7.3 Demonstration facilities at Aqua Clara in Kenya (source: Nyamboki and Nyakundi, 2022)

Activities: Aqua Clara International / Kenya has designed and produces hollow fibre water filters. The Aqua Clara SMART Centre uses a market-based approach, working with enterprises and local communities, with a focus on the following technologies:

- bio sand and hollow fibre membrane filters (10 and 15 liters for households) as well as community filters.
- Rope pumps and solar pumps
- Rainwater harvesting (including a first flush system to direct away the dirt and materials away from the storage when the first rains arrive)
- Groundwater recharge systems
- Ecosan latrines, ventilated improved pit latrines, SaTo products (pans, flex and stool)

Funding: The website does not contain annual reports, and the assessment team were not able to obtain comprehensive information about funding or funding sources. Funding sources are Rotary clubs via the Canadian organisation Transform International (Holtslag, 2022b).

Outcomes and impact: One of the activities of the Centre, in collaboration with PAMIGA has been to facilitate access to water and solar energy through loans within a microfinance programme (Wakenya Pamoja Sacco Society and Aqua Clara Kenya, 2018). Further details of this initiative are summarised in section 4.2.

[82] Detailed in https://aquaclara.org/who-we-are/learn-more/ (accessed 15 August 2022)
[83] https://www.aquaclarakenya.com/about-us

Malawi – Church of Central African Presbyterian (CCAP) SMART Centre

Location: Luwinga, Mzuzu Website: https://www.smartcentremalawi.com/

Institutional set-up: The SMART Centre was initially established in 2012 as a partnership between the Church of Central African Presbyterian (CCAP) and Mzuzu University. However, since August 2015, it operates entirely under the CCAP Synod of Livingstonia Department (SOLDEV) . The executive director of SOLDEV oversees operations (CCAP SMART Centre, 2021a).

Figure A7.4 SMART Centre in Malawi with demonstration site (Photo: H Holtslag)

Staffing: In 2021, the Centre had six staff – manager, procurement officer, two monitoring officers, office assistant and gardener/demo ground (CCAP SMART Centre, 2021a). However, this had reduced to two by March 2022 due to a lack of funding. All staffing was paid for through projects.

Activities: Technical training of local artisans, entrepreneurs and local NGOs and private clients in:

- low cost technologies (manual drilling, rope pump and drill set fabrication, pump installation and maintenance, construction of latrines, construction of storage tanks).
- business (basic accounting, book keeping and financial management.

The Centre has a certification programme to encourage quality and assists newly trained entrepreneurs by: 1) linking them with clients, 2) renting out equipment and 3) when funds allow, offering soft loans to purchase equipment (CCAP SMART Centre, 2021a). Periodically, the centre checks to see if the skills are being used by the entrepreneurs, and those with problems to use the skills are enrolled in another training (CCAP SMART Centre, 2021a). Research on SMARTechs is also undertaken, and advice is provided to NGOs and private client on water supply and sanitation options. The centre also provides the service of conducting yield tests on newly constructed boreholes. There is a demonstration site at the office premises to showcase the technologies and services available (CCAP SMART Centre, 2021a).

Funding: In March 2021, the Centre had three ongoing income sources, all from the Netherlands i.e., one-year funding from Healthy Villages of USD 1,500, two-year funding from YEP programme (USD 20,000) and one-year funding from Wilde Ganzen (USD 30,000). Currently, the Centre does not have any multi-annual funding. In the past, larger amounts of funding were initiated through Henk Holtslag or the SMART Centre Foundation (Netherlands). Funders have included Aqua for All (Netherlands), Rotary Clubs (Netherlands, USA and Malawi) and the Presbyterian Church USA, PumpAid and SouthPole (CCAP SMART Centre, 2021a).

Outcomes and impact: The CCAP SMART Centre website[84] lists 28 entrepreneurs who were all trained and certified at the centre and have set up their own companies, specializing in one or more of the SMARTechs. Lack of resources make it very difficult to undertake systematic monitoring although in early 2022, about 20 entrepreneurs kept in contact with the centre. The SMART Centre reports that it has created demand for low-cost SMART technologies, as evidenced by the fact that whereas the technologies were not previously supported by Government and other stakeholders, there is an in interest by NGOs who want to use SMART technologies or have their staff trained at the Centre.

[84] https://www.smartcentremalawi.com/index.php/entrepreneurs/ accessed 3 January 2022

Niger – Eglise Evangelique de la Republique du Niger (EERN) SMART Centre

Location: Niamey

History and Institutional set-up: The Eglise Evangelique de la Republique du Niger (EERN)'s development department, Coordination d'Appuis au Développement et à la Réhabilitation (CADR), focusses mainly on medical and agricultural activities. EERN requested support from the Presbyterian Church in the USA to establish a WASH programme, which, in 2019 led to the construction of the EERN SMART Centre workshop for training and demonstration Figure A7.5 This Centre is still being established (Anon, 2020a).

Figure A7.5 The SMART centre and container in Kobontafa, Niamey (Photo: J. McGill)

Staffing: The Centre currently has a staff of three (Head of WASH Section, Advisor/Coordinator of Training and Marketing and a Technician), as well as a volunteer who assists with proposal, grant writing and training facilitation. None of the staff members are full time, and the Centre is currently building the capacity of the staff (McGill, 2021b).

Activities: In FY 2019/20, demonstration toilets for good menstrual hygiene management were constructed in two schools, followed by training on latrine construction on an individual basis. Further, 150 women were trained in making handwashing devices (Dip-taps) and good hygiene as part of COVID interventions, and support was provided to build up supply chains for table top (candle)[85] and siphon filters, as well as SaTo pans (imported from Katsina, Nigeria) as well as for no-touch washing stations for institutions/businesses (Anon, 2020a). The Centre has also reached out and made contact with manual drillers[86] and pump manufacturers with a view to supporting the professionalisation of their services. By early 2021, activities of the Centre were mainly in peri-urban Niamey, plus water supply construction largely for church institutions in other regions (McGill, 2022). COVID led to the temporary cessation of most SMART centre activities in 2019/20.

Funding: To date, finance for the Centre has depended on Church funds within Niger and from the USA. Recently, funding was sourced from Wilde Ganzen Foundation via the SMART Centre Foundation, which was matched by the Niger Mission Network (totalling USD 37,000). This, coupled with about EUR 40,000 per year from Church funds, provides the basis for future programme development.

Ideas and plans for the future: The Centre aims to raise the professionalism of manual drillers and pump producers in Niger, which currently have no formal association or cooperative. Further, it would like to promote low cost methods which can improve the deep concrete-lined hand-dug wells on which many households and livestock depend and replace handpumps with solar powered pumps combined with elevated storage. Additional plans include the promotion of technologies such as toilets for improved menstrual health and hygiene, water filters and handwashing dispensers, as well as innovations in low-cost irrigation.

85 With components imported from China.

86 The efforts of Lutheran World Federation and Enterprise Works in the 1908's and 1990s to promote manual drilling for irrigation form an important backdrop to the recent establishment of a SMART Centre.

South Sudan (Juba) – Presbyterian Relief and Development Agency (PRDA) SMART Centre

Location: Juba

History and institutional set-up: The PRDA SMART Centre is managed by the WASH section of the Presbyterian Relief and Development Agency (PRDA), which was set up in 2014[87]. The Board of PRDA is elected by the Presbyterian Church of South Sudan (PCOSS)[88], and mandated to undertake all Health, Relief, and Development related work for PCOSS (McGill, 2021a). The WASH section of PRDA has its own management and sources funds specifically for WASH training for development rather than for emergency/relief activities. Jim McGill, Water, Sanitation and Hygiene Advisor for the Presbyterian Church (PC), USA, has established the centre, commending in 2017 with missions to the country[89] with the first training & build demonstration SMARTechs in 2017 (Anon, 2017b) the construction of the Centre in 2018 following a change of location (McGill, 2018).

Staffing: There are currently six members of staff (all part time) – manager for trainings, administrator, financial officer, coordinator of trainings, fabrication trainer and drilling trainer. The trainers also run their own businesses. When the first trainings were undertaken in 2017, there were no permanent members of staff.

Facilities: The Centre consists of a container-based workshop (Figure A7.6 located on church land[90], plus the Centre is sometimes able to use PCOSS meeting rooms and office facilities. Permanent displays of drilling and pump technologies, handwashing and household water treatment options, solar pumps and latrine prototypes are set up at the Centre.

Figure A7.6 SMART Centre workshop, Juba South Sudan (Photo: J. McGill)

Activities: At the time of the assessment, the Centre was implementing specific projects, and had performed SMARTechs fabrication, manual drilling training and had run a short introductory course on Self-supply technologies. The Centre has also given presentations to the WASH Cluster of South Sudan and has actively reached out to Government as well as many other NGOs operating in the country (McGill, 2021a). due to the Covid-19 pandemic and related travel restrictions, there was a hold on planned projects in Pochalla County[91]. There are plans for a second Centre to be established in Wau (in partnership with a local NGO), where a vocational training centre is established (Anon, 2020b).

Funding: All finances come through PRDA. Current funding sources were the PC (USA) and, more recently a Rotary Global Grant. The SMART Centre Group advisor as well as Transform International (USA and Canada) have provided support to fundraising efforts. Some courses are paid for by participants. Between 2018 and 2020 there was a baseload funding of about $23,000 from the PC, of which PRDA received 10% for accounting services and donor reporting.

[87] Water supply activities were triggered by an initial request for assistance came for provision of water to Akobo hospital. However due to instability in the area, the funding raised for that project had to be redesignated to Pibor and Pochalla.

[88] The church plays a very important role in the country, and nationally, just under two-thirds of the population of South Sudan is Christian, one third animist, with 6% Muslim.

[89] A series of visit reports and two annual reports document the process of establishing the centre from 2017. o

[90] It was relocated from a previous location due to land ownership issues.

[91] Presbyterian Hunger Programme (PHP) agreed a reallocation of funds to drill three boreholes at Primary Schools within the city of Juba and provide adequate water supply at the schools.

Tanzania - SHIPO SMART Centre [92]

Location: Njombe **Website**: https://www.smartcentretanzania.or.tz/ and https://shipo.or.tz/

History and Institutional set-up: The SHIPO SMART Centre operate as a unit within the Southern Highlands Participatory Organisation (SHIPO), a Tanzanian NGO that was registered in May 2001. Since its inception, SHIPO has worked with WASH SMARTechs, and is mainly known for these despite its work in other areas including education, agriculture, environment and microfinance. SHIPO started to train drillers and pump producers in 2003 via a project called TAZAMO, and the e concept of a SMART Centre commenced in 2006.

Figure A7.7 SHIPO Premises in Njombe (source: SHIPO 2020a)

Staffing: Full time - one employee, two volunteers and two labourers (Head of SMART Centre and Skat Coordinator, SMART Centre Coordinator and Plastic Recycling Coordinator, Resources Mobiliser, Plastic recycling workshop labourer and greenhouse keeper). Part time – three employees and one labourer (Skat project assistant, garden keeper, finance manager and cashier). There are also occasional tasks undertaken by other members of staff in SHIPO including project development, monitoring and evaluation (PDMER), secretarial services, community development, administration, driving, general management and security.

Activities: The SHIPO SMART Centre carried out many projects in the past. In 2021, the Centre was running two main projects: (i) annual four-week training courses for artisans on technical aspects of pump production, manual drilling, digging and business skills, followed by two to three weeks of monitoring their work. The project also undertakes advocacy work on the dissemination of SMARTechs, targeting government institutions. (ii) Njombe Beyond involves the development of a plastic recycling network to reduce plastic waste in Njombe town, making use of SMARTechs for plastic recycling. Includes the production of an injection and compression machine which is operated at the SHIPO workshop, with local production of moulds for several products. Products made to date include washers for lampshades, face shields and the alphabet.

Other ongoing and planned projects are supporting farmers with monitoring, turning waste into animal feed, and training trainers in designing piped water supply networks (SHIPO SMART Centre, 2022). SHIPO has a demonstration plot behind its office to showcase WASH SMARTechs. It includes wells, different models of the rope pumps, EMAS pump, Afridev pump, tanks, rainwater harvesting technologies and drip irrigation. Gardening activities are in development, including a greenhouse. The Centre also connects individuals with trained artisans, or, in the case of larger projects hires a group of artisans to execute projects.

Funding: Previously, SHIPO received around EUR 1 million from DGIS via Connect International. This was for a 5-year WASH project covering Tanzania, Zambia and Mozambique (TAZAMO). Some funds were used to train the first drillers and pump producers. Subsequently, training and well were funded by Aqua for All, De Oude Beuk, Winrock and Simavi. Since, 2012, SHIPO has received funding from Skat Foundation to build the capacity of artisans on SMARTechs for WASH. This funding was initially on a two-year, and subsequently on a one year basis. SHIPO actively contacts potential partners and seeks out funding opportunities, and has a donation button on their website. Water filters and drip irrigation kits are also sold (at cost), as well as organic produce. Further funding comes from downloadable mould designs for plastic recycling by pay what feels right, and environmental consultancy services, hall hire and office space.

[92] Unless otherwise stated, all information has been summarised from SHIPO SMART Centre (2021) with additions by Holtslag (2022b)..

Zambia – Jacana SMART Centre

Location: Chipata Website: https://jacana.help/

History and Institutional set-up: There are currently three Jacana SMART Centres - Chipata (established in 2015) and Lundazi (established in 2019), with a new centre in Petauke (established in mid 2021). In June 2021 Jacana Chipata moved into a new business centre, with its own building which also accommodates the drilling cooperative (described in Box 19).

Figure A7.8 The Jacana SMART Centre buildings in Chipata, Zambia

Staffing: Currently 19, i.e., 1 director, 1 resource manager, 2 branch managers, 3 field officers, 7 watchmen (Haanen, 2022).

Activities: Jacana follows a four-step approach which (1) provides training to entrepreneurs who make SMART water produces such as pumps, manually drilled boreholes and groundwater recharge systems. (2) In show case areas, Jacana sponsors a few pumps so that early adopters can use the new technology, show others how they are used, and the economic benefits, as well as provide opportunities for welders and drillers to gain experience. Jacana monitors the quality of the work. (3) demand creation - the concept is that after some time, people in the area will start buying pumps directly from the welder without the need for sponsorship. (4) Once there is a show case area where the pumps are made and used, Jacana invites people from other areas to visit and experience the impact of the SMART approach, and Jacana can help them to start a similar approach in their area (Haanan, 2021a; Jacana Business Empowerment, 2021a).

It should be noted that Jacana trains what they believe is needed to serve the market (for example: 4 borehole siters, 8 drillers and 4 welders in a radius of 2 hour drive), so that everybody trained can generate an income (Haanen, 2021a). Haanen (2021b) has pointed out that if Jacana trains too many in one area, nobody will have enough income from the new skills to actually continue with it in the long run.

Funding: In March 2021, Jacana was running projects funded by Crowdfunding, Stichting Westberg, Wilde Ganzen, Transform International, Rotary International, stichting Leo Bijl, Solon foundation, stichting Tikondane, MOV, Drink and Donate, SKAT, Marie-Stella-Maris, Karibu Tanzania. With one exception (Marie-Stella-Maris), all funds are for one year only. According to Haanen (2021b), most donors provide less than EUR 10,000 each per year and only usually with an annual commitment. Dependence on small funds is perceived as constraining growth but a strength is that if a donor drops out the activities are less affected than if a large donor does. Previous funding was provided by Castricum helpt Muttathara and Aqua for All.

Ideas and plans for the future: Given the growing amount of solar energy equipment entering the market but the lack of expertise on design and installation, the Centre is planning to conduct training on the design and sizing of solar systems, targeting installers (Haanen, 2022a).

SMART Approach by Jacana: supported Self-supply and Family Based Management in Show case areas

Prepared by Haanen, 2022b)

"Jacana is implementing in the SMART approach as follows. They ask funds from donors, for instance for 20 wells and pumps a total budget of 20.000 Euros so on average 1000 Euro per well. With this fund a "show case area" is created. This means that in a certain rural area they select 20 families who are willing to co-invest with material, labor and some cash. Another condition is that they prove with a simple action/business plan, that they will use water for productive use /income generation. Jacana than subcontracts well drillers they have trained, wells are drilled with the SHIPO drill method and combined with rope pumps. The 20.000 Euros include quality control, and monitoring with mWater. This approach has several effects.

- 1 Maintenance; There is clear ownership, experience is that families maintain the pumps. The local production of pumps guarantees local skills and affordable spare parts.
- 2 Communal supply;. The experience is that families with a well share water with an average of 40- 50 other people so family owned wells serve small communities. The cost of basic water service with this model is on average 20-25 Euro/capita
- 3 Food and income; Water is used for productive uses so for this family has food security and increased income
- Creation of market for full self-supply: The examples of subsidized low cost wells and pumps create a market for full Self-supply. Somehow richer families can and do pay 100% themselves. Some 30% of all rope pumps installed in Zambia are already fully paid for by families.
- Sustainable, commercial supply chain of affordable Water technologies; The Wells and pumps are produced by the local private sector who will go on after the project since they can sell to families, NGOs or even Government."

Annex 8 Water and Sanitation Data

Table A8.1 Number of people with different levels of access to drinking water in rural areas for select countries in millions (Source: WHO/UNICEF, 2020)

Country	2000[93]						2020					
	Surface water/ no facilities	Unimproved	Basic	Limited	Safely Managed	Improved	Surface water/ no facilities	Unimproved	Basic	Limited	Safely Managed	Improved
Ethiopia	21.35	27.46	4.63	3.02	0.30	7.65	5.66	21.15	36.04	27.17	4.72	63.21
Ghana	2.99	1.12	5.75	0.95	-	6.70	1.48	0.66	9.53	1.58	2.13	11.11
Kenya	9.26	4.94	9.58	1.82	-	11.40	9.34	4.85	20.05	4.48	-	25.53
Malawi	0.85	2.70	4.61	1.37	-	5.97	0.41	1.01	10.52	3.86	-	14.37
Niger	0.23	6.38	2.48	0.42	-	2.89	0.98	6.46	7.90	4.84	-	12.74
Tanzania	5.53	14.14	4.40	1.96	-	6.35	7.49	8.21	17.58	5.41	-	22.99
South Sudan	1.81	1.17	3.12	1.95	-	5.08	0.90	1.26	3.00	3.77	-	6.77
Zambia	1.91	2.59	2.00	0.29	-	2.28	1.20	2.22	4.19	0.85	-	5.76
Total	43.93	60.5	36.57	9.83	0.3	48.32	27.46	45.82	108.81	51.96	6.85	162.48

Table A8.2 Proportion of the population with different levels of access to drinking water in rural areas for select countries in percentage (Source: WHO/UNICEF, 2020)

Country	2000[74]						2020					
	Surface water/ no facilities	Unimproved	Basic	Limited	Safely Managed	Improved	Surface water/ no facilities	Unimproved	Basic	Limited	Safely Managed	Improved
Ethiopia	37.81	48.64	8.21	5.34	0.05	7.65	6.29	23.50	34.78	30.19	5.25	70.22
Ghana	27.69	10.34	53.15	8.81	-	61.97	11.17	5.00	55.81	11.93	16.08	83.83
Kenya	36.16	19.31	37.42	7.11	-	44.53	24.13	12.52	52.78	11.57	-	63.53
Malawi	8.89	28.35	48.38	14.38	-	62.67	2.62	6.38	66.59	24.41	-	91.00
Niger	2.39	67.14	26.08	4.39	-	30.47	4.87	31.99	39.15	23.99	-	63.14
Tanzania	21.25	54.34	16.89	7.51	-	24.40	19.35	21.11	45.45	13.89	-	59.43
South Sudan[74]	22.47	14.51	38.77	24.25	-	63.02	10.13	14.11	33.59	42.16	-	75.76
Zambia	28.16	38.20	29.41	4.22	-	33.63	11.83	31.61	48.23	8.33	-	56.56

[93] Data for South Sudan is for 2011

Annex 9 SMART Centre Resources

Resources available on SMARTechs on the Jacana (Zambia) website https://jacana.help/resources/water/ are listed below.

- Tutorial (video): Manual drilling, Vertical Electric Sounding for Borehole siting, Storing Groundwater with Tube recharge, Mzuzu drilling to make a well deeper, Developing the well: Swabbing and Pumping, Making a Mzuzu Drill, making & using a Soil Punch, Pumps – standard EMAS handpump using pipes,
- Manuals: SHIPO Drilling, Making a SHIPO Drill Set, Borehole Siting, Making VES Equipment, Tube Recharge, Mzuzu drilling, Making of Mzuzu drill, Electrical pumps selection and installation, Rope pump, EMAS pump, Wire cement tank, Rope pump (windlass model) and SMART Hygiene Solutions. Note that to download a manual, users need to provide their name and email address, and the manual is subsequently sent to them by email.

Resources that are available on the website of the SMART Centre Group https://smartcentregroup.com/

- Manuals – SMARTech Catalogue, SHIPO Rope Pump Model 1, SHIPO Rope Pump Model 2, SHIPO Rope Pump Model 3, SHIPO Rope Pump Model 4 plus some of those available on the Jacana Site. Manuals can be downloaded by clicking on the link.
- Presentations and papers published by the SMART Centres between 2012 and 2021.
- Promotional materials – SMART Centre Brochure, SMART Centre Approach and SMARTech Catalogue
- Videos – Rope Pump, How SMART Centres contribute to SDG6, COVID-19 response project by SMART Centre, Malawi, Global Handwashing Day 2020 – SMART Centre Malawi, Making a Wash Bottle, Webinar – Booklet "SMART WASH solutions in times of Corona", Announcement of the 2018 SMART Symposium, Mr. Feces, championing sanitation solutions, Low-cost rural water supply in Tanzania, SHIPO drilling, Smart Water Solutions – An update on Low-cost water technologies and Rope pumps in Malawi: Water, Food and Income

Papers and reports - https://www.smartcentremalawi.com/index.php/resources/

Annex 10 Further reading

Source: Prepared by Holtslag (2022b)

Engineering for change 2017. Six ideas for SDG 6, https://www.engineeringforchange.org/news/six-practical-ideas-to-reach-sustainable-development-goal-six/

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WEDC 2015. The Tube recharge. Rainwater storage at a cost of 1 US$ per cubic meter, https://wedc-knowledge.lboro.ac.uk/details.html?id=22185