INNOVATIONS IN RURAL WATER SUPPLY SUSTAINABILITY

WORLD BANK GROUP
Water

June 2019

RWSN

Glossary

CBM	Community-Based Management
GIZ	Gesellschaft für Internationale Zusammenarbeit (German Development Cooperation Agency)
ICT	Information Communications Technology
LAC	Latin America and Caribbean
REACH	Improving water security for the poor ((UK-funded research programme)
RWSN	Rural Water Supply Network
SABA	Modelo Saneamiento Básico Integral Rural (SDC-supported programme in Latin America)
SDC	Swiss Agency for Development and Cooperation (also known as DEZA, DDC, COSUDE)
SDG	Sustainable Development Goal
SHARE	Sanitation and Hygiene Applied Research for Equity (UK-funded research programme)
SIASAR	Sistema de Información de Agua y Saneamiento Rural (System for Rural Water Supply & Sanitation)
SMART	Simple, Market-based, Affordable, Repairable Technologies
UNICEF	United Nations Children's' Fund
USAID	United States Agency for International Development
UPGro	Unlocking the Potential of Groundwater for the Poor (UK-funded research programme)
USD	United States Dollar
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WSS	Water Supply and Sanitation

CONTENTS

1. INTRODUCTION

1.1 THE CHALLENGE OF RURAL WATER SUPPLY ACCESS, EQUITY AND SUSTAINABILITY

Between 1990 and 2015, access to improved water in rural areas increased from 62% to 84% worldwide. Seventeen countries achieved 100% coverage; and the number of people without access in rural areas decreased by over half a billion during the same period despite an overall population increase[1].

The Sustainable Development Goals raised the bar for meeting the criteria of safely managed drinking water. The challenge for the period up to 2030 will be to not only increase access to basic water services to reach the unserved, but also to raise service levels by improving the availability, accessibility and quality of the water provided, particularly in rural areas, and sustain existing and future water services.

If past trends continue, the world will not meet the SDG for water. 844 million people worldwide still lack access to a basic drinking water service in 2015, with populations living in fragile and conflict-afflicted areas four times as likely to lack basic drinking water as others.

There are considerable inequalities in access to services, not only between urban and rural residents, but also in relation to other vulnerable groups, including people living in poverty, indigenous communities and residents in informal settlements.

Gender inequalities are deeply embedded in every aspect of rural water supply. In many rural communities, women perform most unpaid tasks associated with the provision, management and safeguarding of water, but have less control over decisions about water resources.

Despite lower access to sanitation and drinking water in rural areas, financing for the water sector (both domestic public finance and Official Development Assistance) is still predominantly geared towards urban water services. Urban finance is more than three times rural expenditures globally[2].

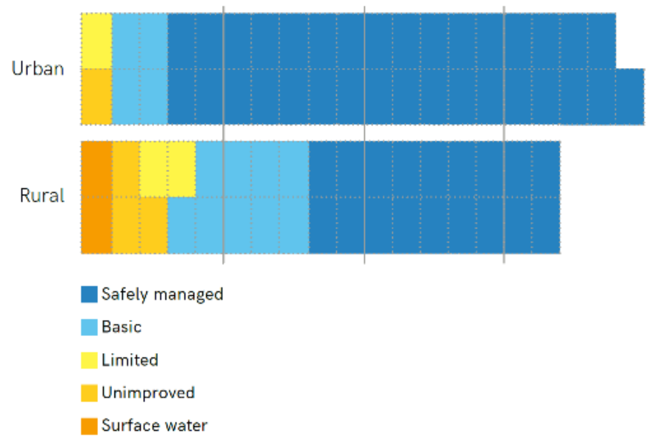


Figure 1: Number of people using different levels of water services in 2015, urban & rural (each unit represents 100 million people) (Source: JMP, 2017)

[1] JMP (2015) Progress on sanitation and drinking water – 2015 update and MDG assessment. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2015

[2] JMP (2017) Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. Geneva: World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), 2017

1.2 INNOVATION IN RURAL WATER SUSTAINABILITY

To address the above challenges, innovation in the delivery of sustainable services in rural areas is going to be critical. Innovation is widely used which can be used in two distinct ways:

1. A new idea, technology, method, piece of evidence;
2. The introduction of something new to a context where it was previously unknown.

The world is a marketplace of diverse and innovative rural water supply technologies and approaches that are at different stages of implementation.

Low cost and affordable solutions that can provide sustained access to rural water services are within reach, yet effective implementation at-scale is lagging. Despite the technological leaps achieved over the past few decades, progress towards improved access to affordable, safely managed services, particularly in rural areas, remains inadequate.

With people's lives at the center of technological innovation and development, technologies have the potential to facilitate a more dignified and humane way of life for all. However, the adoption of technology depends on many factors and contextual drivers. Many great ideas fail to scale and remain a pilot project rather than a mainstream product.

One common reason is lack of understanding of how the technology, or approach, fits within the context in which it is applied. To address this problem, RWSN partners developed the Technology Applicability Framework (TAF) and guidelines for Technology Introduction Processes (TIP) for WASH technologies. International agencies, like GIZ, have used it to transfer a technology that is proven in one context into a new one. Public bodies, like Uganda's Appropriate Technology Centre (ATC), use it to test, approve and regulate WASH technologies for use in the country (Figure 2).

Manuals and case studies available freely at washtechnologies.net

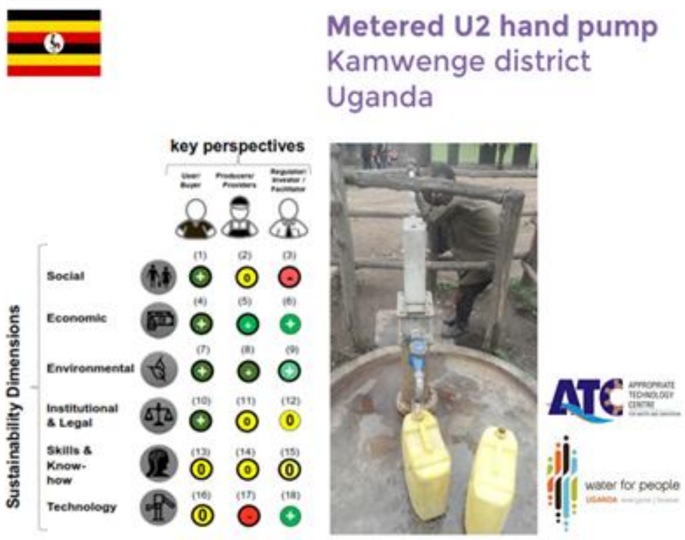


Figure 2: Example summary of a TAF assessment by ATC in Uganda. The traffic light system compares how well the technology fits to context according to 6 sustainability dimensions and 3 perspectives (1. User; 2. Provider/Producer; 3. Regulator/Investor/Facilitator)

1.3 ROLES OF GOVERNMENT IN SUPPORTING INNOVATION

Public agencies and government can play an important active or passive role in enabling innovation at different stages of the uptake and scaling process:

- Research funder
- Investor in scaling-up
- National standards, regulation and quality control
- Local support, quality control and enforcement
- Facilitating innovation partnerships with the key actors needed to ensure successful testing and uptake.

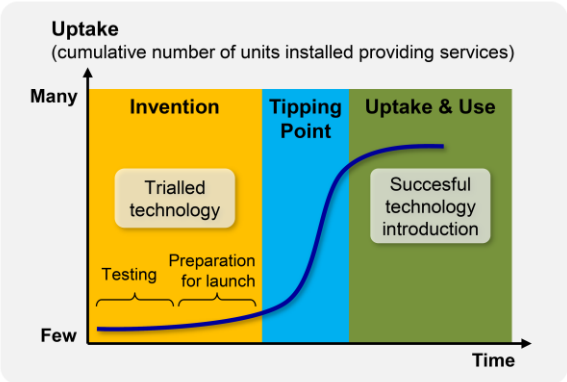


Figure 3: Key phases of (technology) introduction. Government plays a different role in each stage but the overall objective to should be to promote and protect the public good and individual rights[3]

A challenge is often agreeing roles and responsibilities, both between public agencies, and between public, private and NGO sectors. It is important to understand the market that the technology will operate in: more centralized water supply systems often operate in business-to-business markets, whereas in more remote or low-density areas (dominated by Self-supply or community management) households, farms and businesses buy water supply hardware and services (such as drilling) directly to meet their own needs.

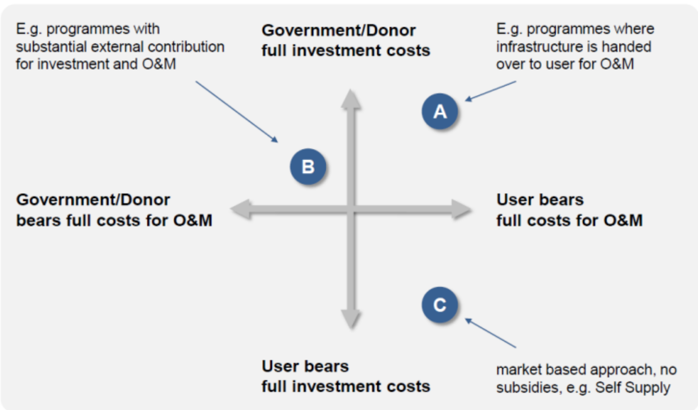


Figure 4: Who pays for rural water services? Three common options[4]

[3]OLSCHEWSKI, A. (2013) TIP (STEP 3) Framework for Technology Introduction Process – The TIP Guide. TIP Guidelines , Skat Foundation and WaterAid UK , WASHTech Project , St Gallen, Switzerland www.rural-water-supply.net/en/resources/details/546

[4] Ibid.

The following stories provide useful insights in rural water technologies that have achieved scale:

Technology	Synopsis	Reference
Thai Jars – household rainwater harvesting, Thailand	Thailand achieved tremendous success in safe water access through domestic roof-water harvesting. "Thai Jar" production was catalyzed by a government program in the 1980s and the private sector took over continued the success - but there were cultural factors specific to Thailand.	Matthias Saladin (2016) Rainwater Harvesting in Thailand: Learning from the World Champions. RWSN Field Note 2016-1, RWSN , St. Gallen, Switzerland https://www.rural-water-supply.net/en/resources/details/759
Manual Drilling (Global)	Manual drilling is lower-cost than mechanized drilling and can produce equally good boreholes. Scaling-up of small manual drilling enterprises has occurred in many countries, like Bangladesh, Nigeria and Chad, with little or no external support - but with little or no regulation or standards.	DANERT K. (2015) Manual Drilling Compendium 2015. RWSN Publication 2015-2 , Skat , Skat , St Gallen, Switzerland https://www.rural-water-supply.net/en/resources/details/653
Various (Sub-Saharan Africa)	The aim of the review was to understand how technologies have been developed, how they were introduced, whether they have gone to scale and to start to explore the reasons why they were successful or not. The review focused on technologies used in Africa in the water sanitation and hygiene (WASH) sector for long-term development.	PARKER, A. (2012) Africa wide water, sanitation and hygiene technology review. WASHTech - Deliverable 2.1 , EU FP7 , WASHTech , Cranfield University, UK https://www.rural-water-supply.net/en/resources/details/520
Handpump (Bangladesh)	The Tara Pump was developed to address an identified problem in Bangladesh with No.6 pumps. It was a successful partnership between government, international agencies and the private sector. However, since this time of this report, the Tara has not replaced the cheaper but inferior No. 6 and Jibon designs and is not as widespread.	KJELLERUP, B., JOURNEY, W. K. and MINNATULLAH, K. M. (1989) The Tara Handpump: The Birth of a Star. UNDP/World Bank Discussion Paper Series , Water and Sanitation Program , The World Bank , Washington D.C., USA https://www.rural-water-supply.net/en/resources/details/437
Handpump (India + Global)	The India Mark II/III, the Afridev and the Zimbabwe Bush Pump are three of the most successful and widespread handpump designs in the world. Over the last 40 years, millions have been manufactured and installed in wells and boreholes around the world. Partnership between research, government and industry was critical.	BAUMANN, E. and S. G. FUREY (2013) How Three Handpumps Revolutionized Rural Water Supplies. A brief history of the India Mark II/III, Afridev and the Zimbabwe Bush Pump , Skat , RWSN , St Gallen, Switzerland https://www.rural-water-supply.net/en/resources/details/475

1.4 REPORT STRUCTURE AND THEMES

This report was commissioned by the World Bank and has been compiled by Skat Foundation, Switzerland, on behalf of the Rural Water Supply Network (RWSN) to inform learning on rural water supply innovations during Water Week May 2019.

The purpose of the report is to present a selection of delivery tools, technologies and approaches that are emerging all over the world. Either they are new ideas of products/services, mostly in development and piloting stage, or they are innovations that already have a track record and look promising for scaling-up or replication elsewhere. The innovations are presented as case studies. It is not intended to be an exhaustive list but rather capture some of the emergent thinking in the rural water sector from our members. We focus on those that have promise for inclusion in government-led, or government-supported, initiatives. Whilst some ideas may seem specialized or niche, in most cases, they are solutions to bottlenecks within more strategic sustainability challenges.

Each case study is labelled according to development stage that the authors think the concept is currently at (as of early 2019):


At development & piloting stage


Solid track record: ready for scaling-up and/or replication elsewhere.

The report is structured around those areas of technology and management development that have produced the most notable innovations over the last few years:

- **Leaving No-one Behind** – tools to help achieve universal access to water.
- **Rural Water Service Delivery Models & Systems** – moving beyond community-management and large top-down programs.
- **Data and digitalization**: technologies and tools for addressing longstanding sustainability challenges.
- **Climate resilience**: Some ways to help future-proof water resources and supplies.
- **Ideas yet to have impact**: What has not lived up to the hype?

2. LEAVING NO-ONE BEHIND: INNOVATIONS IN INCLUSIVE RURAL WATER SERVICES

Gender inequalities are at the heart of rural water supply. The burden of water collection falls disproportionately on women and girls, and yet the control of household and community finances and power is generally held by men[5].

Power imbalances exists not just at the water user level but also permeate throughout decision-making in many governments and other organizations involved in rural water investment, planning and service delivery. Nevertheless, it is not just women that lack power but rural people in general are often excluded from political, economic and legal processes available to citizens in capital cities and urban areas. This exclusion and prejudice is amplified for the elderly, the disabled, religious, ethnic and linguistic minorities[6,7].

Innovation to support inclusion and the "leave no on behind" agenda aims to break down these barriers. It takes rural water supply into the broader sphere of rural development and better-decentralized governance. This makes interventions inherently political, which clearly goes beyond a purely technological or technocratic solution to the water-dimensions of rural poverty.

Box 1: Making Rights Real: The Pocket Guide, The Journey, The Manual

✓ *Available in 7 languages from the Making Rights Real partnership:* human-rights-to-water-and-sanitation.org/

Many countries agree that water and sanitation services are human rights. Governments are the duty bearers to ensure that everyone can realise these rights. The materials for "Making Rights Real" are designed to show local government officials how human rights can improve the way water and sanitation services are planned, delivered and maintained.

The materials for "Making Rights Real" consist of three documents that are intended for use in one-on-one conversations between WASH sector professionals and local government officials, and that can then be referred back to. The materials are purposefully concise and focus entirely on the practical value of human rights.

WASH sector professionals working at the local level will be best placed to put these materials into their particular context. National governments can adapt the materials for their own use for communicating clearly with their citizens and staff.

Figure 5: *the Making Rights Real kit*

[5] OHCHR (2010) Eliminating Inequalities: Towards a Post-2015 Development Agenda, p.19 sr-watersanitation.ohchr.org/en/mediaandpublications_4.html

[6] DANERT K & FLOWERS C (2012) People, Politics, the Environment and Rural Water Supplies. RWSN-IFAD Rural Water Supply Series: Volume 1 , RWSN , RWSN , Switzerland www.rural-water-supply.net/en/resources/details/399

[7] World Bank Group (2016). Water and Sanitation Services: Achieving Sustainable Outcomes with Indigenous Peoples in Latin America and the Caribbean. World Bank, Washington, DC. openknowledge.worldbank.org/handle/10986/25405

Box 2: Violence, Gender & WASH Toolkit

Available in English and French from the SHARE Consortium:
violence-wash.lboro.ac.uk/toolkit/

Women and girls are often victims of violence (including pyschological harassment and shaming, sexual violence, physical violence or exclusion from social or cultural life in the community), either in the home or when going out to collect water. The impact of this can mean that WASH services and programmes can fail because water users feel unsafe to use shared facilities, like water points and latrines.

This toolkit has been developed in response to an acknowledgement that although the lack of access to appropriate WASH facilities is not the root cause of violence, it can lead to increased vulnerabilities to violence of varying forms. Incidences have been reported from a wide range of contexts, often anecdotally but with regular occurrence, with a number of targeted studies confirming the same. By recognising both the risks of violence associated with WASH and the potential benefits of WASH, this toolkit aims to shine a light on this problem and encourage practitioners to recognise their capacity to make programmes and services safer and more effective.

Box 3: Water and Sanitation Services: Achieving Sustainable Outcomes with Indigenous Peoples in Latin America and the Caribbean

Available in English and Spanish from the World Bank:
openknowledge.worldbank.org/handle/10986/25405

Indigenous peoples in Latin American and the Caribbean (LAC) are 10 to 25 percent less likely to have access to piped water and 26 percent less likely to have access to improved sanitation solutions than the region's non-indigenous population. Historically, Indigenous peoples have been marginalized from the development process in their own countries and still suffer discrimination from the mainstream societies today.

Often, Indigenous territories are overlooked or avoided by Water Supply and Sanitation project planners and proponents given their lack of understanding of how to engage or carry out projects in collective or semi-autonomous Indigenous territories, the remoteness of these areas, and the high associated per capita cost of a potential operation, among other reasons. The toolkit provides concrete guidance on to engage effectively for better sustainability.

Box 4: Including Persons with Disabilities in Water Sector Operations: A Guidance Note

Available in English from the World Bank:
openknowledge.worldbank.org/handle/10986/27542

Globally, more than a billion people—approximately 15 percent of the world's population, or one in seven persons—have disabilities. Of those, 80 percent live in developing countries. The note collates recommended strategies and practices in disability-inclusive development programming. It identifies entry points for disability-inclusive water operations in World Bank Group–supported programs, projects and advisory services, and analytics. Case studies, including World Bank Group and external examples, are provided to highlight the use of recommended practices.

Box 5: Empowerment WASH Index (EWI)

In development by the REACH program (SEI, IRC, Queen's University, Belfast, Oxford University)
For more information: www.empowerwash.org/ and *reachwater.org.uk/*

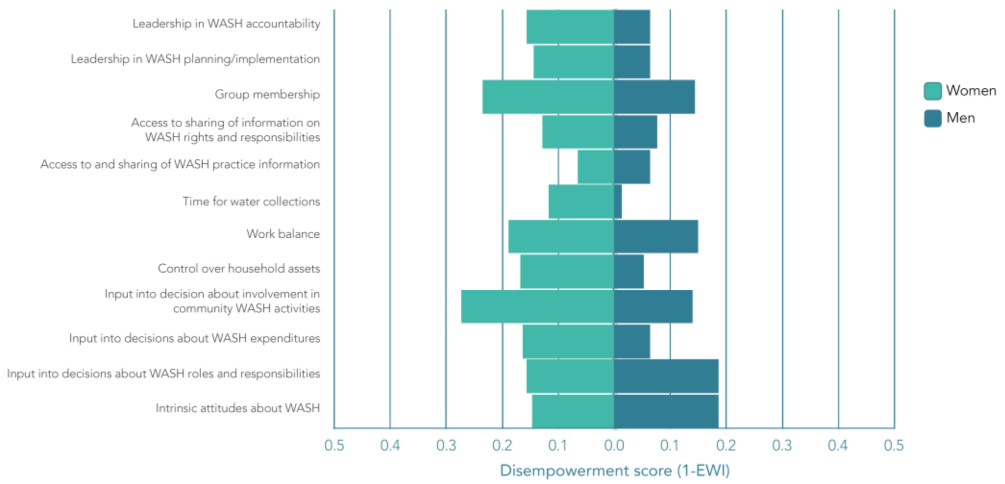


Figure 6: ***Proportion of disempowered respondents not achieving each indicator, in Ghana***[8]

The Empowerment in WASH Index (EWI) is a tool that can be used to measure inequalities at individual, household and wider societal (community and local WASH institutions and authorities) levels.

EWI can be used to monitor gender outcomes of WASH interventions and service delivery or support research on the links between access to WASH, empowerment and wellbeing of individuals.

It aims to close the evidence gap on empowerment of sanitation and water security interventions. Challenges identified by the EWI tool help go beyond infrastructure-oriented solutions and address more structural (shifting discriminatory norms) changes.

[8] Bori, S., S. Dicken, E. Bisung, J. Atengdem (2019) Measuring empowerment in WASH – Policy Brief, IRC/REACH www.ircwash.org/sites/default/files/reach_-_wash_empowerment_index_-_ghana_policy_briefv5.pdf

3. RURAL WATER SERVICE DELIVERY MODELS & SYSTEMS

3.1 SYSTEMS AND BUILDING BLOCKS FOR SUSTAINABLE SERVICES

Rural Water Supply is generally considered part of the Water, Sanitation & Hygiene (WASH) sector. Although, as Huston & Moriarty[9] note:

"In reality, however, the WASH system involves actors working in separate silos. Particularly in rural areas, drinking water and sanitation have often followed quite different development paths, to the extent that they are hardly linked at all. This is most visible in service delivery models that take a communal approach for water but a household approach for sanitation."

However, the links between rural water supply and agriculture and with rural electrification are perhaps even weaker, despite being concerned with the same rural constituency and facing similar challenges and opportunities. Meanwhile, institutional links between water supply and water resources are often not as well developed as they should be for tackling sustainability and climate resilience challenges.

While systems-thinking is not new, research emerging from academia is getting attention and traction among think-thanks, like IRC (Figure 7), and development partners, like USAID, who support the Sustainable WASH Systems program[10]. A similar conceptual framework was used and presented in a recent multi-county study of rural water services (Figure 8)

Figure 7: Nine Building Blocks of the WASH system, as defined by IRC (Huston & Moriarty, 2019)

[9] Huston A., and P. Moriarty (2019) Building strong WASH systems for the SDGs Understanding the WASH system and its building blocks – Working Paper, IRC, The Hague www.ircwash.org/sites/default/files/uploads/084-201813wp_buildingblocksdef_web.pdf
[10] https://www.globalwaters.org/SWS

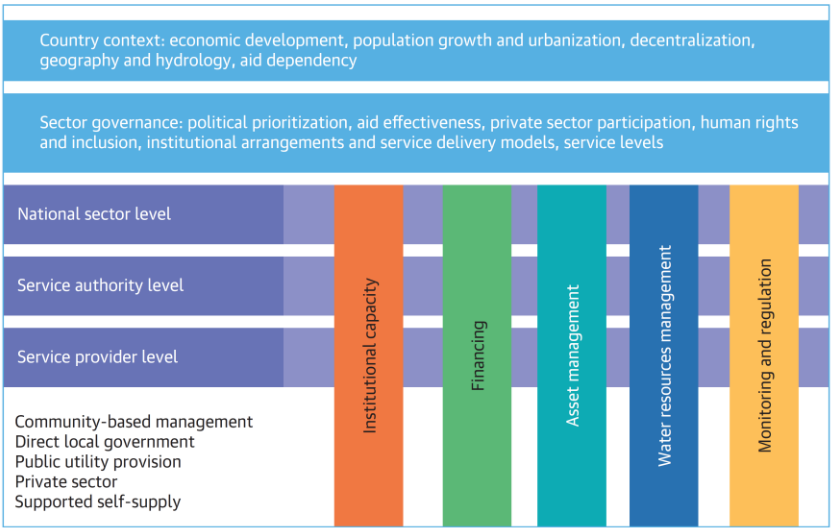


Figure 8: Analytical Framework to Understand Sustainability of Rural Water[11]

Arnold and Wade[12] analyzed seven definitions of systems thinking by applying a systems thinking approach, from that they proposed the following:

> *Systems thinking is a set of synergistic analytic skills used to improve the capability of identifying and understanding systems, predicting their behaviors, and devising modifications to them in order to produced desired effects. These skills work together as a system.*

Systems thinking is therefore a system for understanding and improving other systems. An example of trying to do this is work by Cambridge University, UK, as part of the UPGro research program, which used causal loop analysis of handpump-based water supplies in Uganda (Figure 9) and from that diagnosed that a key failure point is "turn-key" contracting which incentivizes poor workmanship.

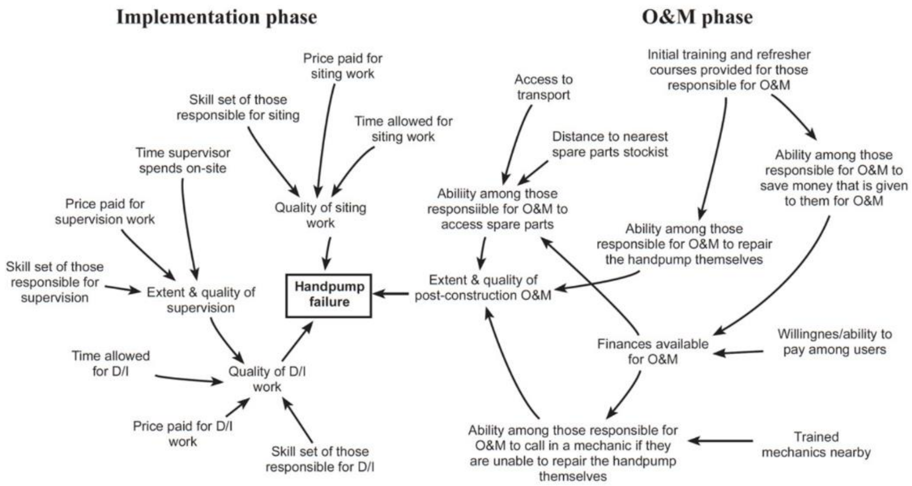


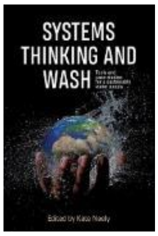
Figure 9: Illustrative example of system mapping of handpump failure, which developed further into causal-loop diagrams (Liddle & Fenner, Chapter 3 in Neely, 2019)

[11] World Bank Group (2017). Sustainability Assessment of Rural Water Service Delivery Models : Findings of a Multi-Country Review. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/27988

[12] Ross D.Arnold, Jon P.Wade (2015) A Definition of Systems Thinking: A Systems Approach, Procedia Computer Science, Volume 44, 2015, Pages 669-678 www.sciencedirect.com/science/article/pii/S1877050915002860

Where to find out more:

"Systems thinking and WASH" edited by Dr Kate Neely, Practical Action Publishing 2019 ISBN: 9781788530262



"Building strong WASH systems for the SDGs Understanding the WASH system and its building blocks" by Angela Huston and Dr Patrick Moriarty, IRC Working Paper 2019 www.ircwash.org/resources/understanding-wash-system-and-its-building-blocks

3.2 SERVICE DELIVERY MODELS

3.2.1 Technical and business training and support for Self-supply and market-based water delivery entrepreneurs

Self-supply is where households invest in their own water supply systems. Commonly these include household wells, rainwater harvesting and springs. Self-supply happens in most countries – including remote areas and islands of high-income countries[13].

Box 6: SMART Centers: Vocational training centers for technical and business skills for water enterprises

SMART Center Group have established training centers in Tanzania, Malawi, Zambia and Mozambique smartcentregroup.com

Simple, Market-based, Affordable, Repairable Technologies (SMART) Centers are vocational training centers that train young men and women to be entrepreneurs: equipping them with the technical and business skills to be able to offer household water supply services, from manually drilled boreholes fitted with low cost manual pumps, to rainwater harvesting systems.

The key element of success and impact is that the investment for building and sustaining the water supplies comes from home-owners themselves and this in turn generates viable livelihoods for the entrepreneur-engineers.

Figure 10: Rope pump manufacture training in Southern Tanzania
Courtesy of the SHIPO, SMART Centre Group

Because the water points are close to the home, there is strong demand based on convenience and multiple uses of water, not just domestic but also livestock and cultivation—boosting household income. There can be water quality risks from Self-supply sources, such as shallow wells, so emphasis is placed on delivering high quality workmanship and customer care.

Their positive track record makes the case for investment in rural vocational training. More exchange is needed between WASH sector initiatives like this and the government departments and development partners involved in education and job creation.

[13] www.rural-water-supply.net/en/self-supply

Box 7: Local Rural Water Supply Resource Center, Training and Consultancy

Water Access Consulting Ltd, Kitgum, Uganda www.facebook.com/wateraccessconsulting.org/

Water Access Rwanda: https://www.warwanda.com/

Water4: Introducing NUMA https://youtu.be/ACHmUlh_Eik

A chronic challenge in many rural and provincial areas is the lack of technical capacity for rural water supply – particularly in pipe hydraulics, hydrogeology, borehole siting and drilling supervision. Skilled people move to the larger cities to be able to make a living. For small businesses to survive in more remote areas, it needs to have a good but diverse offer that meets local demands.

An example is Water Access Consulting Ltd: Justine Olweny is an IT graduate from the town of Kitgum in Northern Uganda. He became part of a entrepreneur training programme run by the US NGO, Water4. After leaving that programme, he was inspired a set-up a resource centre in his town for the many field technicians he met coming in and out working in the refugee camps and areas ravaged by the Lord's Resistance Army, and over the border in South Sudan.

Figure 11: Justine Olweny, WAC Uganda giving a training in geophysical surveying techniques for siting boreholes *(Courtesy of WAC)*

From a small beginning, Justine team now regularly runs training courses on geophysical siting for boreholes. People regularly come to his resource centre to access information, which can be printed out on demand, and to watch RWSN webinars together. Furthermore, the WAC team take part in a weekly WASH radio show on the regional radio station.

His business model successfully combines knowledge sharing, training courses and consultancy services that support the humanitarian aid agencies and national and international development programmes. Water4 have trained, mentored and incubated other entreprenuers, including Ms Christelle Kwizera, Managing Director of Water Access Rwanda, which provides services in hardware, consultancy, training, community development and water point/water kiosk management.

The challenge is how to take this localised NGO-led approach to supporting entrepreneurs and market-based approaches to scale in a systematic way across a given country or region, and to reduce their dependency on international funding.

Box 8: Drilling Professionalisation

Guidelines developed by Skat Foundation in English and French, with online and face-to-face training courses www.rural-water-supply.net/en/sustainable-groundwater-management/professionnal-water-well-drilling

Every well that is drilled, and every pump installed should be undertaken in a professional manner. The drilling data should be used to improve understanding of groundwater resources. Over the last decade, RWSN has published and disseminated guidelines and animated films, hosted several webinars and supported face-to-face training courses to improve professional water well drilling.

The important part of the process of developing these materials is to consider the perspectives of the driller, the client and the end water user. Policies, such as "no water, no pay" contracts have been found to create perverse incentives and higher costs because of the way that drilling companies have to manage the risks to survive.

Figure 12: The 6 pillars of professional groundwater development

3.2.2 Professional Service Providers & Social Enterprises

Water service delivery in rural areas is as diverse as rural areas themselves. Recent publications by the World Bank[14] and WaterAid[15] provide more comprehensive overviews from different countries and regions. Community-based management (CBM) of water points, with or without external support (CBM-plus) is still the predominant model of service delivery in many parts of the world. In many cases these work, with handpump functionality figures in many contexts being around 75%[16], however, such binary metrics are too crude to show the reliability and water safety of a water service quality and the challenge remains to reach the remaining 25%.

CBM is not the sole cause of low water point functionality; the lack of an enabling environment for water services provision, and low quality of infrastructure installation is also to blame[17,18].

Several forms of "CBM-plus" approaches have emerged, which either replace or complement the traditional water committee approach. These can take the following form of:

- Community Management with external support (usually from local authority) and some level of professionalism. Support costs vary, but studies suggest that spending of much less than US$1 per person per year results in ineffective support[19].
- Community-based organizations forming a regional association to provide technical and management services to members.
- Supporting self-supply, for example through micro-finance, business support and regulation.
- Community Management with delegation of some or all functions to a private or social enterprise operator through a management contract. This includes delegation of maintenance services to private operators (e.g. Whave in Uganda, InterAide in Malawi or FundiFix in Kenya). It can also include entrusting the operator to raise funds for capital expenditure asset extension and rehabilitation.

Recent innovations in rural water supply delegation to private operators have been, in part, sparked and supported by ICT innovations, in particular, real-time monitoring of water system use and operations (see Section 04).

Piped water supplies generally require a more sophisticated approach, both from a technical and managerial standpoint, than water points. While unsupported CBM or CBM-plus management approaches do exist for piped water supplies in rural areas[20], they are generally associated with

[14] WaterAid/AguaConsult (2018) Management models for piped water supply services https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/Management models for piped water supply services_0.pdf

[15] World Bank Group. 2017. Sustainability Assessment of Rural Water Service Delivery Models : Findings of a Multi-Country Review. World Bank, Washington, DC. openknowledge.worldbank.org/handle/10986/27988

[16] Foster, T, Furey, S, Banks, B & Willetts, J (2019) 'Functionality of handpump water supplies: a review of data from sub-Saharan Africa and the Asia-Pacific region', International Journal of Water Resources Development, pp. 1-15

[17] Andres, Luis Alberto; Chellaraj, Gnanaraj; Das Gupta, Basab; Grabinsky, Jonathan; Joseph, George. 2018. Why are so many water points in Nigeria non-functional? : an empirical analysis of contributing factors (English). Policy Research working paper; no. WPS 8388. Washington, D.C. : World Bank Group. documents.worldbank.org/curated/en/363491522264585702/Why-are-so-many-water-points-in-Nigeria-non-functional-an-empirical-analysis-of-contributing-factors

[18] Danert K., Gesti Canuto J. (2016) Professional Water Well Drilling. A UNICEF Guidance Note , Unicef , Skat Foundation www.rural-water-supply.net/en/resources/details/775

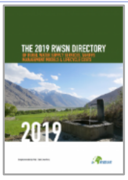
[19] IRC (2015) Direct support post-construction to rural water service providers www.ircwash.org/sites/default/files/084-201502triple-s_bn06defweb.pdf

[20] WaterAid/AguaConsult (2018) Management models for piped water supply services washmatters.wateraid.org/sites/g/files/jkxoof256/files/Management models for piped water supply services_0.pdf

low sustainability. Other approaches include:

- Direct provision of water services by local authority (or authority mandated to provide WSS services). Here the challenges are the same as with urban water supply in similar circumstances: potential for political interference, lack of technical capacity, non-revenue water, difficulty to raise finances and lack of ring-fencing of water tariffs[21].
- Delegation of services by the local authority (or authority mandated to provide WSS services) to public or private operators.
- Delegation of services by the authority mandated to provide WSS services to a utility (public or private). In some countries can be a multi-utility, responsible for other services (e.g. electricity).

A selection of case studies can be found in the **"2019 RWSN directory of rural water supply services, tariffs, management models and lifecycle costs"** ww.rural-water-supply.net/en/resources/details/861 . Some have been established over many years, whilst others are still novel in their use of market-based approaches to delivery a high service quality efficiently and effectively.



3.3 FINANCE

There is increasing debate around blended-finance to enable public finance to benefit more people, or to be better targeted towards the poor. So, how can private sector finance be attracted to more bankable rural water services, and how can the service delivery itself be made more efficient and attractive to investment through market-based approaches? It is an area where some answers are emerging in some countries, but there is still a lot of work to do.

Box 9: Performance based financing for large-scale sustainability

Government of Vietnam / World Bank. Case presented at 2019 World Bank Water Week
https://projects.worldbank.org/en/projects-operations/project-detail/P152693

In 2012, Vietnam had improved substantially the rural water access: from 30% improved water access in 1990 to 88.5% in 2016. Substantial funding for infrastructure (NTP2, NTP3, about US$ 2.5 billion in 10 years period). However, sustainability of the rural water systems was an issue: about 30% of the NTP-financed schemes had limited functionality. The approach adopted included:

- Use of results-based financing, in partnership with the World Bank
- Provide result-based transfers to provinces to linked to improvement of the quality of water schemes
- Reward well-managed water schemes
- Define and measure clearly and credibly "sustainable water services"
- Incentivize better planning, financing and M&E by the provinces

Disbursement-linked indicators were developed not only for infrastructure, but for functionality. Eligibility criteria included efficient design parameters. Independent verification of results pushed for sound technical quality and acceleration of result achievement. Clear performance indicators attracted private sector investors and operators to invest and manage the systems (as long as criteria are followed): 13% of systems under the Program are run by private operators. Sustainability criteria combine few but key elements: financial, operational and institutional. Results-based focus gave flexibility to leverage other funds, and leverage other (i.e.private) O&M. Independent verification pushed for higher quality standards, planning, M&E. Strong coordination among sectors (Agriculture & Health & Education) helped to achieve the indicators.

In the current phase (2015-2021), the approach is being used in 21 provinces, with a budget of USD 200 million. As of March 2019, 60,000 water points are functioning.

[21] Ibid.

Box 10: Performance-based funding of delegated operators

Uptime is a consortium of service providers and researchers that currently comprises Oxford University (UK), Fundifix (Kenya), Whave (Uganda), Water for Good (US/CAR), Water Mission (US/Uganda) and Uduma (France/Burkina Faso) who aim deliver drinking water services to millions of rural people through long-term, performance-based funding. https://www.uptimewater.org/

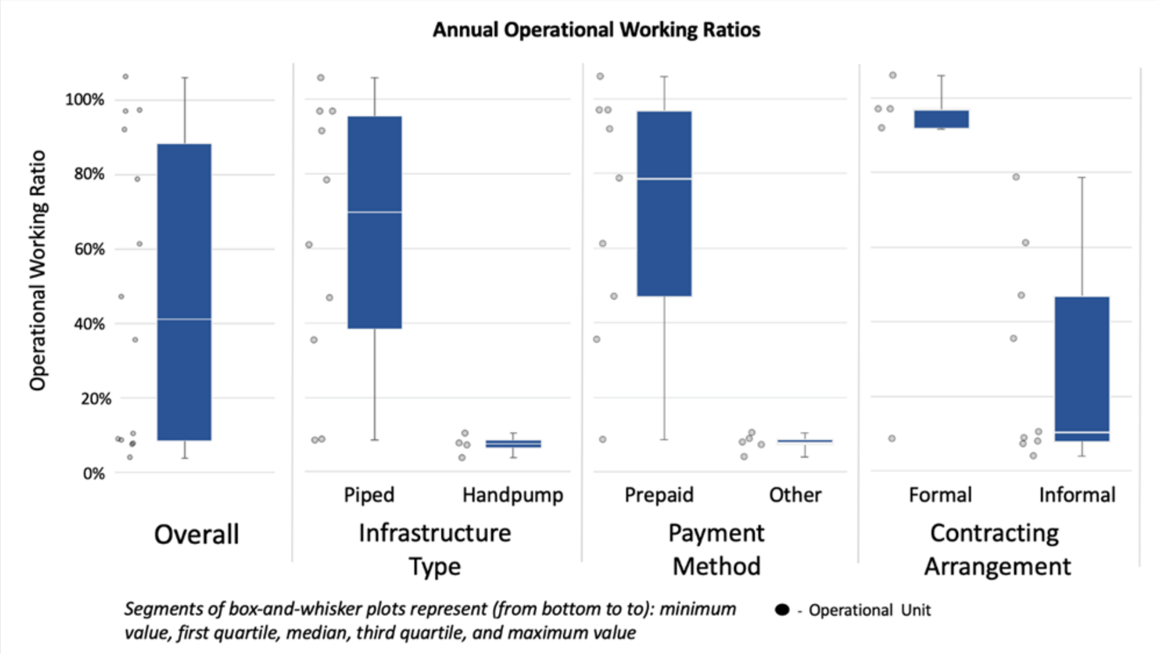


Figure 13: Range of annual operational working ratios (% of cost recovery from tariffs) across considering different types of infrastructure, payment method and contracting arrangement.

The key findings of a 2019 study into the operations run by the Consortium Partners are:

- Waterpoints maintained by service providers were functional over 90% of the time, significantly outperforming the regional average.
- Rural water users paid some but not all of the costs
- Multiple factors influence levels of cost-recovery and most service areas do not break even on operating costs.
- Institutional design is a key determinant of operational and financial performance
- The investment case must consider financial, economic and social impacts.

Sustainable financing of reliable rural water services requires three conditions to be satisfied: 1) appropriate institutional arrangements; 2) effective maintenance contracts; and 3) robust operational data. Fulfilling these requirements and implementing robust revenue collection systems could deliver high-quality services with concessional funding targeted towards areas of greatest need. Their analysis showed that all three requirements are achievable but not widely realized. If policymakers and funders commit to fulfilling these requirements, leaving no-one behind could become a reality.

Performance-based Funding for Reliable Rural Water Services in Africa

- **Executive Summary**
- **Full Report**

Box 11: "Innovate for Water" Forums

Waterpreneuers, Switzerland: www.innovate4water.net/

Waterpreneurs is a global "for-impact organization", supporting the scaling-up of impact investments financing the growth of water and sanitation (WASH) enterprises operating in developing countries, and respecting human rights.

Since 2017, the organisation has been organising "Innovate 4 Water Market" places that bring together investors, incubators and entrepreneurs.

They are attempting to attract funding into the WASH sector from non-traditional source, including impact investment and angel investors.

Figure 14: the Waterpreneurs model of finding, supporting and scaling up WASH enterprises

Box 12: WASH Enterprise Innovation and Scaling-Support

Aqua for All, Netherlands aquaforall.org/

There a numerous innovation support programs offered by public and private agencies, often providing multi-stage support, for example, USAID's Development Innovation Ventures (DIV), but most depend on public or charitable funding. The Dutch organization, Aqua for All, focuses on incubating and scaling market-based solutions for water and sanitation through attracting a blend of private and public investment. They have two complementary programs: VIA Water, which supports early stage enterprises in the country concerns and focused on pro-poor solutions; the second is SCALE, which provides the additional support required to get proven concepts to scale-up. The on-going challenge is to find investible ideas and entrepreneurs at both stages, particularly in rural areas.

4. DATA & DIGITALISATION OF RURAL WATER

"1 in 3 handpumps in Sub-Saharan Africa are broken" has been the most quoted figure from RWSN since a data sheet of estimates were published in 2009. It has been a rallying cry for action, but also a brush with which rural water supply is painted as picture of failure.

In a 2019 paper on handpump functionality[22] it is now estimated that 3 in 4 handpumps in Sub-Saharan Africa are operating at any one time—perhaps indicating improvement in the last decade. However, deeper analysis of a small selection of handpumps and wells in Ethiopia, Uganda and Malawi shows that definitions are functionality are not straight forward and that the proportion of handpumps delivering water of sufficient quality and quantity is much lower[23].

After the 6th RWSN Forum in 2011 it became apparent that water point mapping was changing the conversation around rural water supply sustainability. Instead of rough estimates, there were now national inventories for Sierra Leone, Liberia, Tanzania and Uganda, and growing clusters of water points mapped from Afghanistan to Zimbabwe. They showed that other types of water points or piped schemes were no more reliable the handpumps[24].

Digitalized monitoring has been neglected in rural water supply by comparison with urban, but tremendous progress has been made over the past decade to improve this in many countries, with innovative approaches harnessing ICT, citizen participation, remote sensing and mapping.

Monitoring and mapping activities underpin the success of rural water supply services. Information resulting from monitoring practices provides the evidence for management decisions. Challenges remain however to ensure that monitoring, evaluation, regulation and learning is a country-led process used to inform political decision-making, and goes beyond assessing the functionality of a water point and focus on key performance indicators of service.

The emergence of widespread mobile phone coverage globally over the last decade triggered a lot excitement about disruptive IT-based innovations that help address persistent problems with rural water supply sustainability.

Water point mapping allows assets to be mapped and catalogued, but even in the best case this data provides just a snapshot. Near-real-time monitoring of the functioning of a handpump, or any other type of water systems allows operational decisions to be made for quick repairs, optimized supply chains, and in aggregate it is possible to quantify risks and opportunities and the hope is for proper benchmarking of key service performance indicators.

While such data collection is routine in most urban systems, in rural it has been hampered by poor communications, poor roads, lack of resources and poor (or unknown) returns on investment.

[22] Foster, T, Furey, S, Banks, B & Willetts, J (2019) 'Functionality of handpump water supplies: a review of data from sub-Saharan Africa and the Asia-Pacific region', International Journal of Water Resources Development, pp. 1-15

[23] Bonsor, H. A. MacDonald, V. Casey, R. C. Carter and P. Wilson "The need for a standard approach to assessing the functionality of rural community water supplies" Hydrogeol J (2018). https://doi.org/10.1007/s10040-017-1711-0

[24] Banks, B. & S. G. Furey (2016) What's Working, Where, and for How Long. A 2016 Water Point Update to the RWSN (2009) statistics , GWC/Skat , RWSN , St. Gallen, Switzerland https://www.rural-water-supply.net/en/resources/details/787

Recommended reading:

- Dickinson, N., Knipschild, F., Magara, P., Kwizera, G. (2017) "Harnessing water point data to improve drinking water services" www.ircwash.org/resources/harnessing-water-point-data-improve-water-drinking-services
- WaterAid (2019) "From Data to Decisions" washmatters.wateraid.org/publications/from-data-to-decisions

4.1 DATA COLLECTION TECHNOLOGIES

4.1.1 Water Point Monitoring

Box 13: Water Point Mapping via Mobile Phone App

Akvo FLOW: https://akvo.org/capture-and-understand-data-that-matters/
mWater Surveyor: https://www.mwater.co/surveyor.html

Since the early 2010s, mobile phone applications, backed up by cloud-based data platforms, have allowed governmental and non-governmental organisations to digitilize their water infrastructure mapping and functionality spot-checks. The data generated has been valued by operators, planners, regulators, donors and researchers for different purposes. The two market leading tools are Akvo FLOW and mWater:

Akvo, a Dutch-based organisation, developed a tool called, FLOW that was originally created by the US NGO, Water for People. Its use as a rural water supply monitoring tool has been embedded in many programmes. More recently has been the development of Akvo Caddisfly which is a simple smart phone based drinking water quality testing system.

Also in widespread use is mWater, based in the US. It is used by a comparable number of organisations and users and also offers water quality testing kits and data management and presentation software. WaterAid have found it a useful tool for tracking service levels across their programmes; tracking sustainability of programme interventions up to 10 years after an initial intervention; and to work with local governments to strengthen their WASH monitoring processes[25].

Other, more generic, data collection tools are also used but mWater and Akvo FLOW continue to be the most vibrant and interesting innovators that have expanded their capabilities beyond simple water point mapping into a range of surveying tools and applications.

Box 14: Smart Handpumps

Fundifix social enterprise (Kenya) incubated by the University of Oxford, UK: www.oxwater.uk/oxford-smart-handpump.html

The sensor measures the movement of the handpump handle and transmits the data to a cloud-based platform. As well as helping bringing repair times down to less than 3 days (from 3-6 months), the data has revealed new insights into groundwater levels and water user behavior related to rainfall.

The Smart Handpump work combines scientific advances in engineering, policy, development and entrepreneurship which has led to changing national policy in Kenya and establishment of new business models and finance which benefit over 50,000 people with more reliable drinking water in schools, clinics and communities in Bangladesh and Kenya. In 2018, it won the Oxford University Vice-Chancellor's Innovation Award. Work is currently focused on developing the IT infrastructure for the sensor to be used at scale by other organisations, and to take advantage of 4G mobile phone networks, rather than relying on SMS.

Figure 15: Smart Handpump Sensor fitted to a No.6 Pump in Bangladesh *(Photo Courtesy of Oxford University)*

[25] https://washmatters.wateraid.org/blog/how-can-online-data-platforms-improve-management-of-water-sanitation-and-hygiene-services

Box 15: SweetSense Monitoring Platform

SweetSense enterprise (US) based at the University of Boulder, Colorado, US: www.sweetsensors.com

The SweetSense monitoring system is designed to be a platform for easily and cheaply monitoring a range of activities, including hand and motorised pumps, water filters, latrines and cookstoves.

Like the Oxford Smart Handpump sensor, it works by monitoring the pump handle motion and interpreting that signal to infer numbers of users and estimated water volume.

Data is sent back via satellite or mobile phone link.

Figure 16: SweetSense Monitoring Unit on an Afridev Handpump *(Photos Courtesy of SweetSense)*

Box 16: Afridev V-2 Sensor

Charity: water, New York, US: www.charitywater.org/sensors

US NGO, charity: water have been working on realtime monitoring since 2012. 3,000 Afridev V-1 sensors were installed across Ethiopia in 2015/16 and 1,500 Tapstand Sensors are being installed in Nepal in 2019. 5,000 Afridev V-2 sensors are in production and are planned to be trialled in Ethiopia, Ghana, Malawi and Kenya. Collected data is then made available via an online dashboard. Unlike the other two sensors, it measures the water level, temperature and pressure.

Opensource designs have been made available on Github: **github.com/charitywater/afridev2-sensor**

Figure 17: Afridev V-2 visualization *(courtesy of Mario Milanesa, charity: water)*

4.1.3 Groundwater Monitoring

Remote sensing has the potential to be able to collect one-off or routine data for large or remote areas. For rural water supply, most innovation has focused on applied understanding of groundwater resources to support wells and boreholes.

It is essential that use of remote sensing be combined with ground-truthing. In the past, there have been big claims about discovering major aquifers only for it to be later found that the water was saline or not as plentiful as first thought[26].

One use under discussion is the use of remote sensing for detecting and monitoring remote community water points but this has yet to be developed.

Box 17: Remote sensing for manual drilling suitability

UPGro: Unlocking the Potential of Groundwater for the Poor in partnership with UNICEF: upgro.org/catalyst-projects/remote_sensing_for_manual_drilling/

Extending groundwater supply to more people is expensive using conventional technologies. Manual well drilling offers cost-saving opportunities, but the techniques involved can only be used in specific ground conditions.

A systematic methodology has been developed and tested in West Africa for combining remotely sensed data with direct data from drilling records, to map the potential for manual drilling.

Fussi, F., L. Fumagalli, F. Fava, B. Di Mauro, C. H. Kane, M. Niang, S. Wade, B. Hamidou, R. Colombo, T. Bonomi (2017) **Classifying zones of suitability for manual drilling using textural and hydraulic parameters of shallow aquifers: a case study in northwestern Senegal**, Hydrogeol J DOI 10.1007/s10040-017-1642-9

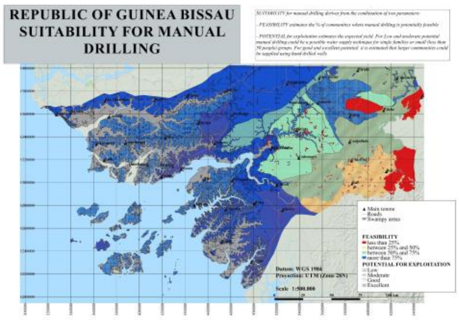


Figure 18: Suitability of sites for manual drilling, Guinea-Bissau

Box 18: Monitoring and Alerting Platform

In development by Water Mission https://watermission.org/groundwater-remote-sensors/

US NGO, Water Mission, collaboration with SonSet solutions and IBM jStart, has developed a remote sensing system that enables effective and efficient monitoring of aquifer sustainability and rural water system functionality. The SatWater communicator can receive real-time data from any type of sensor such as flow rate, pressure, or oxidation-reduction potential (a proxy for chlorine residual) and transmit from anywhere in the world to a web-based data alerting and analysis dashboard called the MAP, or “Monitoring and Alerting Platform”.

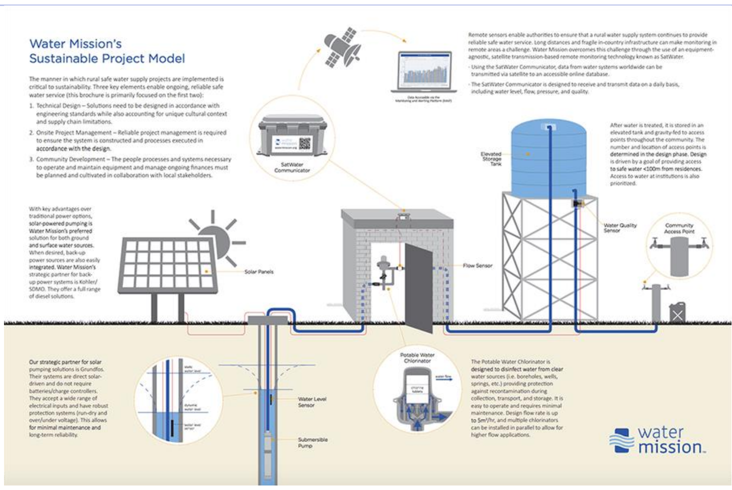


Figure 19: Overview of Water Mission’s Monitoring & Alerting Platform (courtesy of Andrew Armstrong, Water Mission)

[26] https://www.voanews.com/africa/tests-show-kenyas-turkana-water-unfit-consumption

Box 19: ECHO-GPM

In developmeby by Power7Water, an enterprise incubated at Franklin & Marshall College, US
www.power7water.com

ECHO-GPM, developed by researchers at Franklin & Marshall College, in the US, is proprietary algorithm that uses data from NASA Global Precipitation Measurement (GPM) network of satellites to identify groundwater recharge areas.

The technique can be used for groundwater exploration, watershed protection, improving understanding of aquifer dynamics and water balances.

Figure 20: ECHO system uses satellite data to explore and understand aquifers (courtesy of Prof. Robert Walter and Jake Longenecker)

4.1.4 Water Quality Monitoring

The wording of SDG6.1 is very clear – universal access to safe water. This has increased emphasis on water quality and not just quantity.

The challenge is that measuring water quality is so much more complex than water level or volume because there are so many chemical, physical and biological parameters to potentially monitor. Furthermore, many ways of measuring and monitoring water quality are expensive and slow, particularly in rural areas far from laboratories. Details of water quality monitoring can be found on the JMP website[27] and from the WHO[28].

Therefore, there is urgent need for low cost, accurate and robust water quality measuring tools for those parameters that are health hazards.

Box 20: Low-cost incubator

Being developed by the Swiss Federal Institute of Aquatic Science and Technology (Eawag):
www.jove.com/video/58443/construction-low-cost-mobile-incubator-for-field-laboratory

A major challenge to ensuring safe drinking water is the lack of regular access to water quality testing. Therefore researchers at the Swiss Federal Aquatic Research Institute (Eawag) have developed a low-cost field incubator design so that that *E. Coli* testing for fecal contamination can be done. The components cost USD300 when sourced in Switzerland so should be much cheaper elsewhere. It has only been field-tested in Nepal.

It provides advantages of laboratory-based models, in terms of volume, temperature precision, with suitability for field use – low cost, easily transportable, energy efficient and robust to a range of ambient temperatures (from cold mountains to hot deserts)

Figure 21: 3 different variants of the incubator design being tested (courtesy of Eawag)

[27] washdata.org/monitoring/drinking-water/water-quality-monitoring
[28] www.who.int/topics/drinking_water/en/

Box 21: Aquagenx CBT E. coli Kit	
✓	*Commercially available by Aquagenx, LLC, US* www.aquagenx.com/e-coli-test-kits/

The Aquagenx CBT *E. coli* Kit is a field-level test that is optimized for low resource, rural and disaster/emergency areas. It can be used without technical training: colour-match scoring lets you determine Most Probable Number (MPN) of *E. coli* in a 100 mL sample.

The Aquagenx CBT *E. coli* Kit with the Akvo Caddisfly and mWater apps (see Functionality Mapping) allows testing of water quality in the field with a smartphone. All data can be integrated with the online Akvo Flow data platform for rapid data sharing, data analysis, visualization and decision making.

Box 22: Tryptophan-like fluorescence (TLF) - a rapid screening tool for assessing fecal contamination risk in groundwater	
✓	*In development by the British Geological Survey, UK,* upgro.org/catalyst-projects/mapping-groundwater-quality/

TLF in groundwater is a novel *in situ* approach to rapidly detect faecal contamination risk, and has been tested against slower conventional plate counting methods in 5 countries (India, Kenya, Malawi, Uganda, and Zambia) and at >500 groundwater sources.

TLF is most accurate in waters with low dissolved organic carbon and low-turbidity, so is particularly well suited for monitoring groundwater sources[29]. TLF is strongly correlated with current methods for measuring thermotolerant coliforms. TLF technology is a commercially available, easy-to use, reagent-less and a real-time option. Further developing is ongoing to refine its accuracy and bring equipment costs down.

[29] Lapworth, D.J.; Sorensen, J.P.R.. 2018 BGS-UKRI briefing note: tryptophan-like fluorescence (TLF) as a rapid in-situ screening tool for assessing faecal contamination risk in groundwater. Wallingford, UK, British Geological Survey, 6pp. (OR/18/058) nora.nerc.ac.uk/id/eprint/521783/

4.3 DATA MANAGEMENT AND DECISION-SUPPORT

Box 23: Rural Water and Sanitation Information System (SIASAR)

Governments in Central America and the World Bank: www.siasar.org/

The "Rural Water Supply and Sanitation Information System" (SIASAR), is an ICT-based monitoring and decision-making system aimed to strengthen the knowledge base of the rural water supply and sanitation sector and make this critical information accessible for policy makers, national and local planners, and sector practitioners.

It was developed in Central America with support from the World Bank and has extended into other parts of Latin America, and now is replicated in Central Asia, and Africa It is hosted and institutinalized by governments of countries, while SIASAR as application is available as a public good**.**

A recent report on SIASAR improvements is available[30].

Figure 22: the 4 pillars of SIASAR monitoring

Box 24: Africa Groundwater Atlas

Developed and maintained by the British Geological Survey (BGS) in English and French
earthwise.bgs.ac.uk/index.php/Africa_Groundwater_Atlas_Home

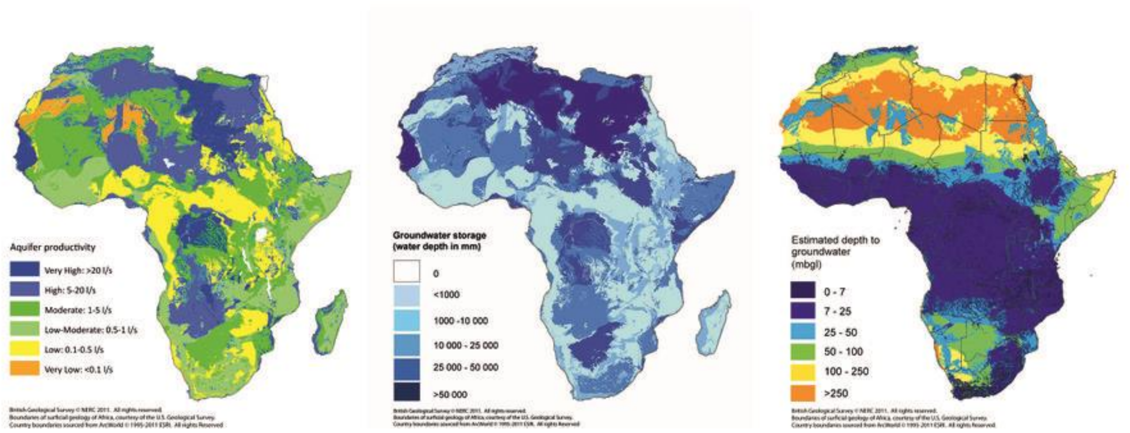


Figure 23: Maps of aquifer productivity, groundwater storage and depth to groundwater *(Courtesy of BGS)*

Reliable information for policy and practiec on groundwater and aquifers is challenging in many parts of the world, but in Sub-Saharan Africa in particular because the systematic collection and curation of data and reports varies considerably between countries.

For many years, the BGS managed a 'Grey Literature Archive' of government and consulants reports relating to groundwater. Over the last 5 years, this knowledge has been consolidated into a country-by-country, Wiki-pedia-style Atlas, with each country page curated in partnership with leading hydrogeologists from the country in question. In 2019, the Atlas has been expanded with downloadable GIS layers and links established with Wikipedia to reach a broader audience. There are also extensive links to groundwater data, organisations, education materials, and strategic overviews on major national and transboundary aquifers.

[30] documents.worldbank.org/curated/en/930481514358304158/Latin-America-Consolidation-improvement-and-expansion-of-the-rural-water-and-sanitation-information-system-SIASAR

Box 25: Water Point Data Exchange (WPDx)

Platform developed and maintained by Global Water Challenge at: www.waterpointdata.org

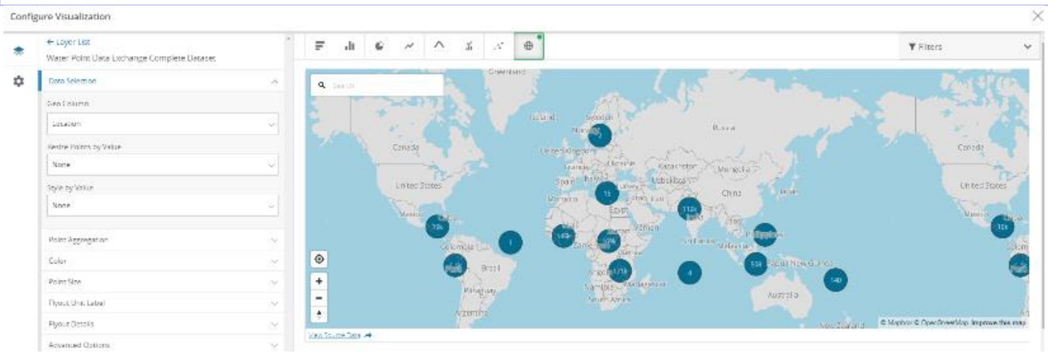


Figure 24: WPDx Data Playground, a range of tools for analyzing and visualizing water point from all over the world.

WPDx is an open data standard for water points and an open online database for water point mapping data. It is proving to be a vital platform for collaboration and research. The Open Standard means that whether you collect water point data with Akvo FLOW, mWater or another tool, that there are sufficient common data fields (e.g. geographical position, water point type) to allow dataset merging and comparison. By establishing a platform for sharing water point data throughout the global water sector, WPDx adds value to the data already being collected. Through bringing together diverse data sets, the water sector can establish an unprecedented understanding of water projects and services.

Box 26: Groundwater Assessment Platform (GAP)

Developed and maintained by the by the Swiss Federal Institute of Aquatic Science and Technology (Eawag): www.gapmaps.org/gap.protected/
www.eawag.ch/en/research/humanwelfare/drinkingwater/gap/

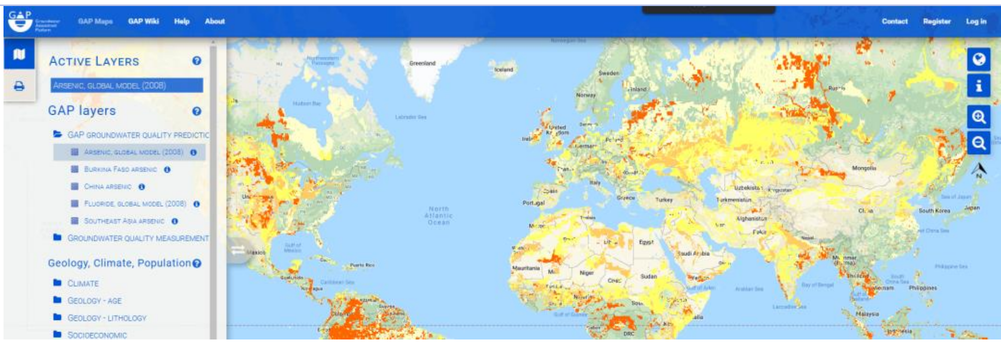


Figure 25: Screen-shot of the GAP online GIS interface showing predicted levels of naturally occurring arsenic in groundwater

Naturally high levels of arsenic and fluoride in groundwater can be cause of chronic health problems to populations with a high reliance on wells, boreholes and springs. High arsenic in Bangladesh and high fluoride in the Ethiopian Rift Valley are well known and documented, however the risks are more widespread globally.

The GAP is a multi-purpose online tool and information portal developed by Eawag over the last few years, which as been applied to the help address the challenge of these geogenic contaminants. The GIS interface allows data from field spot measurements to be compared to the predicted risk areas.

In 2017, the GAP attracted international and national media attention in Pakistan when the predictions of high arsenic levels in the Indus River Valley were confirmed by an extensive field survey[31]. Therefore the tool should be of use to government water and public health ministries in targeting arsenic and fluoride testing and monitoring to guide policy and management of these risks.

[31] https://www.bbc.com/news/science-environment-41002005

5. CLIMATE RESILIENCE

Climate change is happening and all indications are that it is going to hit the poorest and most vulnerable earliest and hardest. The two elements of climate change are reducing carbon emissions and increasing resilience to increasing weather and climate extremes.

In most low-income countries, rural water supply is not a major greenhouse gas emitter because water pumping and collection is often manual. The bigger impact of rural people on climate is through land-use change – particularly deforestation, soil erosion, peat extraction, wetland drainage and other types of agriculture and clearance that unlock long-term carbon stores and reduce carbon absorption capacity of ecosystem services. Such land-use change often impacts rural water security; therefore rural water supply and rural land management are intertwined.

The use of green energy, such as solar, can be a contributor to reduced emissions and address issues with unreliability of electricity generation, high costs of diesel-fueled power generation and the need for off-grid solutions in remote areas.

Box 27: Green Roads for Water

Led by Meta Meta: roadsforwater.org/ Ethiopia: Established in Tigray and scaling-up in 3 other regions; Kenya: being established in 3 counties; Nepal: DFID-funded study in 1 district; Uganda & Malawi: planning and early stakeholder engagement. World Bank manual in review.

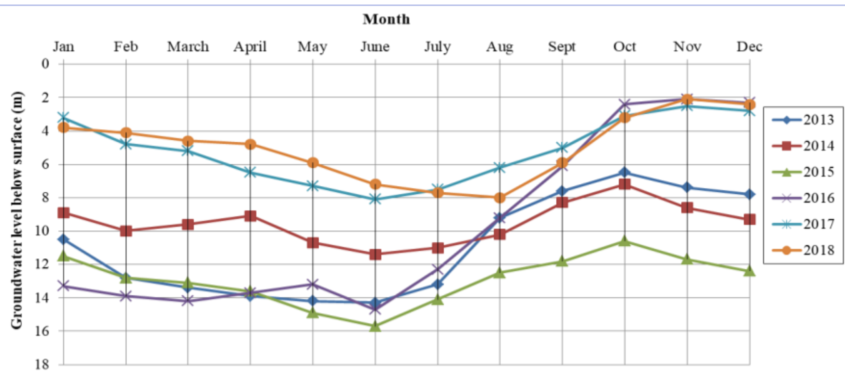


Figure 26: Groundwater fluctuation in Adigudom area (Tigray, Ethiopia) downstream of series of water storage ponds constructed in 2015) show progressively higher dry-season groundwater levels. (Dr Kifle Woldeargay, Mekelle University/Meta Meta Research)[32]

Water is short in many places but roads are everywhere – and when it rains it is often along the roads that most water runs, as roads unknowingly either serve as a dike or a drain. By harvesting the water with these roads, water shortage can be overcome and climate variability impacts mitigated.

The potential to scale up the use of water with roads is enormous – especially with the on-going investment in road building globally – with every area having its own specific best solutions. At present, unfortunately the construction of roads often typically leads to local flooding, gully erosion, water logging, dust and sedimentation.

A paper published in *Nature*[33] in 2019 concluded that in many arid/semi-arid areas of Africa, there is more groundwater recharge with higher rainfall intensity - which is increasing, according to climate modelling and observations. Therefore, maxmising infiltration of storm and floodwater through scaled-up techniques like these proposed for road drainage can play a central role in storing more water in rural areas for dry season use.

[32] roadsforwater.org/wp-content/uploads/2019/10/Brochure-Green-Roads-for-Water_Online-version.pdf

[33] Cuthbert et al. (2019) Observed controls on resilience of groundwater to climate variability in sub-Saharan Africa *Nature* volume 572, pages 230–234 (2019)

Box 28: Sand Dams

Excellent Development, UK have built 325 Sand Dams across Kenya since 1985.
www.excellentdevelopment.com/ ; Cranfield University: www.cranfield.ac.uk/research-projects/sand-dams

Figure 27: Aerial view of a Sand Dam in Kenya *(photo courtesy of: Excellent Development)*

Built across ephemeral riverbeds in drylands, a Sand Dam intentionally traps sand behind the wall so that seasonal river flow is captured and held in the sand, and is not exposed to evaporation. This mini-aquifer stores water for domestic and horticultural use, and in combination with other soil and water techniques can improve the local microclimate and crop productivity.

They are in widespread use in Kenya and there is growing interest and momentum in other dryland regions, however they require careful site-selection to ensure that they work as designed. Investigations into the water quality have shown some indicators above WHO drinking water standards[34] so treatment maybe needed.

Box 29: Flood-resistant water points

Various organisations working on climate resilient WASH, including UNICEF, WHO and GWP, for example: www.gwp.org/en/WashClimateResilience/

In flood prone areas it is essential that water supply infrastructure is protected from contamination and is available for use during time of prolonged inundation when the risk of diseases, like cholera, is high.

The design of such platforms (for handpumps, tapstands or water kiosks) can also incorporate ramps and rails to make them more accessible to disabled people at all times.

Figure 28: Raised handpump water point with ramp and rail for disabled access *(photo: S Furey, HYSAWA Bangladesh 2017)*

[34] Quinn, R.; Avis, O.; Decker, M.; Parker, A.; Cairncross, S. An Assessment of the Microbiological Water Quality of Sand Dams in Southeastern Kenya. Water 2018, 10, 708.

Box 30: Solar Pumping

More information: www.worldbank.org/en/topic/water/brief/solar-pumping

Solar pumping has been around for several decades but the rapid drop in costs has triggered a world-wide expansion. Solar offers many potential advantages for rural areas in terms of service level and the possibility of a piped water supply. However, questions remain about intensive pumping for agriculture and domestic use and what impacts could be caused on groundwater resources, and surface water bodies that depend on them.

There are established international manufacturers, notably Grundfos[35] and Lorentz[36], but also large brands entering the market, like Stanley Black & Decker[37], and small startups like PumpMakers[38] and Ennos[39]. The Global LEAP Awards (supported by DFID and USAID) undertook a competitive assessment in 2018/19[40] and an provide an online database of some solar water pump technical specifications[41].

The RWSN Sustainable Groundwater Development community[42] includes regular member conversations, support and updates on solar pumping and related groundwater topics and in 2019, RWSN (Water Mission/UNICEF/CapNet) ran an online course[43].

Box 31: Solar Desalination

Developed and commercialised by Mascara, France, with some installations in Mauritius and Southern Africa. mascara-nt.fr/ and by Mörk Water, Australia, with installations across Asia-Pacific and East Africa. www.moerkwater.com.au/

Desalination is generally not an attractive option for rural water supply because of the high life cycle costs, particularly energy. Using solar energy offers the prospect of reducing operating costs significantly. French company, Mascara, founded by Marc Vergnet (inventor of the well-known Vergnet HPV manual pump and the Vergnet Hydro company) and Mörk Water, Australia, have developed and commercialised solar-powered reverse-osmosis units for small-scale applications of various sizes. Mörk also work with local vocational training centers or NGOs to train and support system operators.

The solar power drives reverse osmosis treatment of sea or brackish water. An advantage is the modularity and the flexibility to be standalone or with electricity grid connection (if unreliable or expensive). As with all desalination technology, a brine waste product is produced that needs to be disposed of safely. For remote or low intensity use, the environmental risk is low, but a high density of decentralized solar desalination systems could lead to problems that would need to be monitored, managed and regulated.

As both companies appear to be relatively small, further work is needed to understand the management and lifecycle costs, tariffs and financing for scaling-up within a broader rural, or island, water supply improvement programme.

[35] www.grundfos.com/market-areas/water/solar-water-solutions.html
[36] www.lorentz.de/
[37] www.stanleyearth.com/
[38] pumpmakers.com/
[39] www.ennos.ch/
[40] globalleapawards.org/solar-water-pumps
[41] equipdata.efficiencyforaccess.org/products/solar-water-pump
[42] dgroups.org/rwsn/groundwater_rwsn
[43] campus.cap-net.org/en/course/spws37-solar-powered-water-systems-an-overview-of-principles-and-practice/

6. IDEAS YET TO HAVE IMPACT

Some ideas create a buzz, either because they have shown promise or results in other sectors, or because they are superficially attractive water supply solutions that have thus far yet to deliver on their promises for rural water supply, or only in very specific niches.

Box 32: Water from Air

"Water from air" technologies are often touted as an answer to water scarcity, particularly in hyper-arid areas. There are two basic types – active condensers (generally using refrigeration technology) and passive moisture collectors.

Active systems are generally technically feasible and there are commercially available container-based solutions, but the cost per liter is generally very high, the yield low and the overall lifecycle costs unknown or unproven.

Passive systems, such as fog-water harvesting, generally require specific environmental conditions to be viable and the yields are low and seasonally variable[44].

Box 33: Desalination

The installed capacity to treat of brackish or saline water to produce freshwater is growing worldwide[45] in response to growing water demand and scarcity. For rural areas, the life cycle costs are generally prohibitive.

For example, in coastal Bangladesh, the polder areas are facing increasing salinity of freshwater and the threat of arsenic in the groundwater. Therefore, a hybridized system of rainwater harvesting and reverse osmosis is being piloted. However, sustainability concerns remain concerning the energy and maintenance costs and disposal of the brine by-product (which would be magnified and difficult to regulate if scaled-up).

UNICEF Bangladesh is collaborating with Oxford University and the Bangladesh University of Engineering and Technology (BUET) to trial enhanced groundwater recharge, as an alternative.

Solar desalination technology has been developed for commercialisation (see Box 31)

Figure 29: Intake from a pond for a village-level Reverse Osmosis plant being piloted by HYSAWA in coastal Bangladesh (February 2017, photo: S. Furey)

Box 34: Block Chain

Block-chain technology is among the disruptive innovations that attract a lot of attention in many fields. However, in rural water there so far been little visible activity. This is either because any attempts made to date have failed and are not being documented and shared, or because the limited expertise on how to make such technologies and practical proposition are attracted to more lucrative or prestigious applications. The attraction is being able to have a regulatory system that is difficult to corrupt and falsify and so can be used where actors have low levels of trust. In early 2019, IBM and Sweetsense (see Box 15) have announced a trial programme in California[46].

[44] akvopedia.org/wiki/Water_Portal_/_Rainwater_Harvesting_/_Fog_and_dew_collection

[45] World Bank. (2019). The Role of Desalination in an Increasingly Water-Scarce World. World Bank, Washington, DC. openknowledge.worldbank.org/handle/10986/31416

[46] *www.digitaltrends.com/cool-tech/california-uses-blockchain-and-iot-to-manage-groundwater-use/*

Box 35: 3D Printing

3D printing has been mooted as possible solution for supply chain challenges—for example with pump parts. However, the supply chains for the 3D printers and the consumables they need are perhaps no easier, furthermore, such printers require access to IT, a power supply, a skilled operator and the correct design templates. Finally, any spare parts that are made in such a way need to be sufficiently robust to be able to perform efficiently, effectively and safely.

Box 36: Gig-economy business models

Business models where an online platform links demand and supply and honesty is maintained through publicly visible rating systems and centralized payment handling are disrupting many sectors. Is there potential for an Uber or Airbnb for rural water supply? Potentially, there is: a problem is reported, a mechanic takes the job, gets paid for his or her work and the water user gives the mechanic a rating.

This is most likely to work for Self-supply water sources that are privately owned by a household or small group of households. This is because there is ownership and responsibility for the asset and therefore a willingness to pay to get it repaired.

For the installation of new water sources (a manually drilled well or a rainwater tank for example), the problem with a rating system is that the initial installation may look good but faults may only become apparent later, after the rating has been given to the contractor.

In isolation, this approach is unlikely to work, particularly for community water points, because there are wider questions about willingness and ability to pay for repairs, access to information and decision-making within the household and community.

Such platform would require safeguards to prevent fake reviews being posted; to protect the workers to ensure they get paid fairly, and to ensure accessibility to rural and female users. A potentially promising application is in rural water supply hardware supply chains, due to often encountered issues with poor quality spare parts, pumps, pipes, fitting and other materials being used.

7. FURTHER INFORMATION

7.1 RECENT RWSN PUBLICATIONS

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UNICEF et Skat Foundation (2018) Forage d'eau: vers la professionnalisation d'un secteur. https://www.rural-water-supply.net/en/resources/details/796

7.2 RECENT WORLD BANK PUBLICATIONS

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Joseph, George; Andres, Luis Alberto; Chellaraj, Gnanaraj; Grabinsky Zabludovsky, Jonathan; Ayling, Sophie Charlotte Emi; Hoo, Yi Rong. 2019. Why Do So Many Water Points Fail in Tanzania? An Empirical Analysis of Contributing Factors. Policy Research Working Paper;No. 8729. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/31233

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7.3 OTHER SOURCES AND INFORMATION PORTALS

7.3.1 Rural Water Supply Network (RWSN)

- RWSN document library
- RWSN Talks
- RWSN Webinar Recordings & Films
- 7th RWSN Forum - Content

7.3.2 Partner information platforms

- AGUASAN, Swiss WASH Community of Practice
- Engineer for Change – Solutions Library
- IRC
- pS-Eau
- REACH: improving water security for the poor
- SDC Global Programme Water - RésEau
- UNC Water Institute
- UNICEF WASH
- UPGro: Unlocking the Potential of Groundwater for the Poor
- USAID Global Waters
- WASH Agenda for Change
- WaterAid Wash Matters
- WEDC

Produced by:
Rural Water Supply Network (RWSN),
Skat Foundation
Vadianstrasse 42
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Switzerland

First Edition. June 2019

The publication is an output of the World Bank–Skat Foundation collaboration in 2019 for the Rural Water Supply Network (RWSN). Compiled, edited and designed by Sean Furey with support and inputs from Susanna Smets, Clementine Stip, Antonio Rodriguez-Serrano, Meleesa Naughton, Phillip Deal, Dr Kerstin Danert and Matthias Saladin.