WORKING PAPER 4

USING ICT FOR MONITORING RURAL WATER SERVICES: FROM DATA TO ACTION

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WATER SERVICES that last

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CONTENTS

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1 NEW OPPORTUNITIES TO IMPROVE WATER SERVICES

Information and communication technology (ICT) has the potential to help improve rural water supplies and address the systemic problems faced by the sector, but until now this potential has remained largely untapped in many developing countries. Although access to rural drinking water supplies has improved, with more than two billion people gaining access to improved drinking water sources between 1990 and 2010, keeping these water supplies running is becoming difficult. Information delivered at the right time and place can make the difference between a rural water supply that remains broken and unused for years and a water service with little interruption. ICT has led innovations in other service sectors such as health but is often poorly resourced in the rural areas, and in the water sector in particular. Information systems are often available only for specific projects or in limited administrative areas, for example.

Large-scale information systems can provide timely information to stakeholders on such core issues as the level of services delivered and the performance of those who provide the service. ICT can provide access to data management tools in rural areas and improve the quality of monitoring information. Finally, ICT can improve the efficiency of monitoring by speeding up data collection, management and analysis, reducing distances required to travel, and shortening the time between failure of a water service and corrective action. The barrier to ICT is decreasing as the cost of Internet access, phones, computers, and software is falling dramatically.

Developing effective monitoring that will improve the rural water supplies is not a simple task. It implies both improving information systems and ensuring that the information leads to action. Where no monitoring currently takes place, the use of ICT will not offset all the additional costs required to implement monitoring in the first place. But in all cases, the design and choice of information systems can affect who owns the data, how the information is used, and how much service delivery and monitoring costs.

The pace of technological innovation

Digital storage doubles every 14 months per unit cost (Komorowski, 2009; Smith, 2012), and approximately every two years, computer processors become twice as dense and consequently more powerful. Digital devices capable of running advanced software and storing data are smaller, more portable, and cost less than ever before; a sophisticated Android smartphone is priced under US$ 100.

Approximately two-thirds of emerging markets and developing countries have exceeded 50% mobile network population coverage, and almost a third have exceeded 80% coverage. African countries show the fastest growth, but topographical barriers and weak transportation and electricity supply infrastructure still pose barriers for rural areas (GSMA, 2011). Internet access is growing enormously, primarily through these mobile networks but also broadband (ITU, 2012).

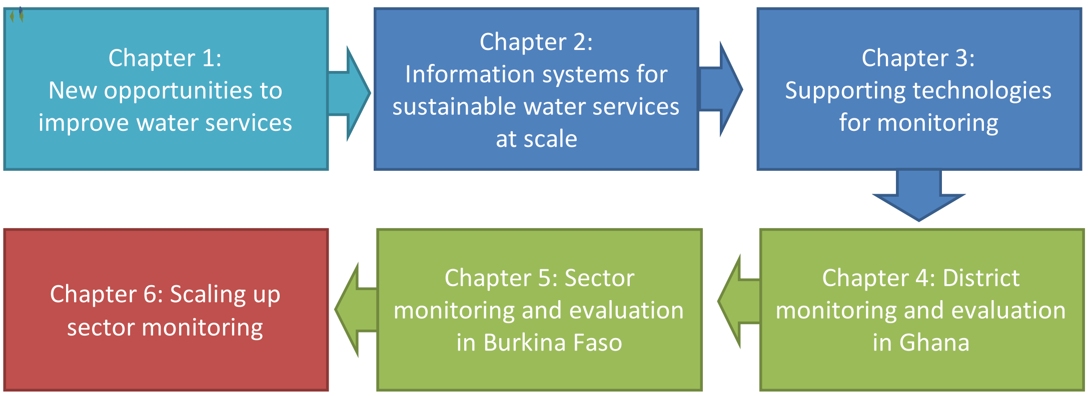
The data connections give device users access to communication technologies at relatively low cost. However, the use of ICT in rural areas will still require travel to transfer data where mobile networks are too expensive or missing.

1.1 OBJECTIVE OF THIS PAPER

In this paper, we provide a conceptual framework for using information and communication technologies to improve service delivery in the rural water sector. This framework defines information systems and the information system users for monitoring rural water supply. We review cases from IRC International Water and Sanitation Centre to illustrate principles and considerations that should help in scaling up the effective use of ICTfor monitoring in the sector.

We build on previous IRC publications on sector monitoring in developing countries, such as the Triple-S Briefing Note "Service delivery indicators and monitoring to improve sustainability of rural water supplies" (IRC, 2011) and "Taking a service delivery approach to monitoring water supply in low income areas and implications for the Joint Monitoring Programme" (Schouten et al., 2011). In addition, the paper takes two cases in Ghana and Burkina Faso to illustrate the conceptual framework and how it can be applied.

FIGURE 1: THE STRUCTURE OF THIS PAPER



1.2 BACKGROUND

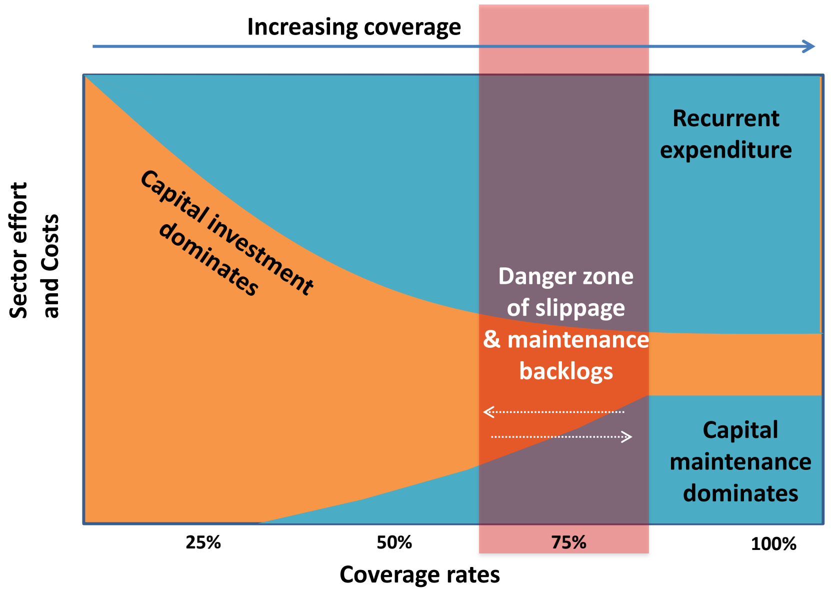
1.2.1 Increasing coverage of rural water supplies and subsequent challenges

As coverage increases, the need to monitor both new and existing rural water services grows. Between 1990 and 2010, more than two billion people gained access to improved drinking water sources, and the Millennium Development Goal for water supply has been met five years ahead of time. Yet 780 million people lack access to safe water (JMP, 2012). Around a third of the unserved are in lower- and middle-income countries, such as Brazil, India and China, where coverage has rapidly increased to 80–95%. Two-thirds of the unserved are in lower-middle and lower-income countries with less than 80% coverage or in countries that have achieved a high level of coverage (80–95%) but where growth is stagnating (Smits, 2012).

Even as water and sanitation systems are installed and coverage improves, the burden of maintaining those systems and services has increased. Estimates since the 1990s have shown that 30% to 40% of rural water supply systems are not working in Sub-Saharan Africa (Evans, 1992; Lockwood and Smits, 2011; RWSN, 2009). This level of failure represents a loss of $1.2 billion to $1.5 billion of investment in the past 20 years, or approximately $60 million wasted per year (RWSN, 2009). Besides maintenance, systems need to be monitored, and service quality standards need to be regulated to address this failure.

Data collection and analysis and follow-up corrective action are critical. Figure 2 provides an idealised picture and suggests how expenditure can change as coverage increases with a certain level of service. A general recommendation for countries in the "danger zone" is to reduce the rate of failure of existing assets by directly supporting service providers (through monitoring and training) and conducting capital maintenance (with rehabilitation and replacement of infrastructure). This implies both higher expenditure and changes in practice. The Triple-S principles framework presented in the next sections provides guidance on how to change these practices.

FIGURE 2: DANGER ZONE



Source: Moriarty, P. 2011. 'Water services in the danger zone'. Blog post at http://patrickmoriarty.org/rural-water-supply-network-6th-forum/water-services-in-the-danger-zone/.

1.2.2 Towards sustainable rural water services

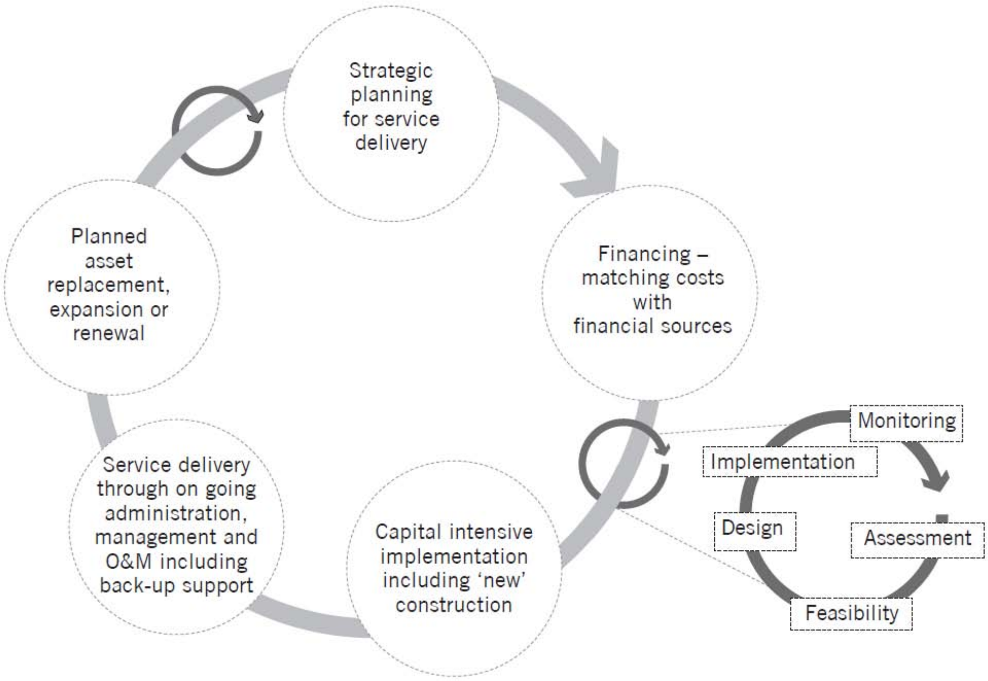
Three guiding principles are the basis of the Triple-S approach to sustainable water services at scale: (1) the service delivery approach, (2) strong learning and adaptive capacity for water service delivery, and (3) harmonisation and alignment (Triple-S, 2011af).

The first principle is the service delivery approach,[1] which aims to provide long-term services at scale, as opposed to stand-alone projects at community level in the following ways:

[1] http://www.waterservicesthatlast.org/Resources/Concepts-tools/Service-Delivery-Approach.

- by emphasising the entire life-cycle of a service (Figure 3), consisting of both the hardware (engineering or construction elements) and software (capacity building, institutional support, financial planning) required to provide and sustain a certain level of access to water; and
- by defining roles and responsibilities of the multiple actors working at different levels and improving coordination and harmonisation among their activities.

FIGURE 3: THE SERVICE LIFE CYCLE



Source: Lockwood and Smits, 2011.

The second principle, strong learning and adaptive capacity for rural water service delivery, emphasises the capacity of stakeholders to fulfil their functions and the ability of sector stakeholders to learn together and innovate on the basis of knowledge sharing, reflection and analysis. The third principle is the harmonisation of water service delivery between donors and the alignment of aid to support government-led strategies. Together, these principles can guide the application of ICT for the monitoring of rural water supplies so that monitoring information systems support the overall goal of sustainable services at scale.

1.3 OPPORTUNITIES IN ICT

Several trends in ICT are starting to influence the monitoring of rural water supplies. These relate to who has access to digital information, how easy it is to use ICT, and how the information systems are governed.

1.3.1 Increasing access to information

Access to ICT by sector professionals and water users is increasing dramatically and will simplify the extension of information systems to monitor services in rural areas, at a lower cost. Mobile phone subscriptions worldwide reach more than half of the world's population, having grown by 70% in developing countries in 2010. The use of these phones can greatly reduce travel costs for sector workers, and voice or text-message systems can let even users without an Internet connection or smart phone report on service levels.

Internet access is also increasing worldwide, with the fastest growth in developing countries, and will play a key role in sector monitoring (ITU, 2011a). For example, in 2010 77% of the population in Ghana lived in areas with access to 2G mobile Internet and 36% lived in areas with the faster 3G mobile broadband Internet.[2] Worldwide, mobile broadband grew by 60% in 2010, and between 2008 and 2010 there was a 22% drop in the price of mobile broadband. In Kenya, Internet use jumped in 2010 because of a competitive market and the appearance of smartphones costing less than US$ 100.[3]

Yet significant differences among countries remain. Per 100 people, there are only 5.3 mobile broadband subscriptions in developing countries compared with 46.2 in developed countries. In developing countries, subscribers pay almost 75 times more for wired broadband and almost six times more for mobile broadband than in developed countries. At the same time, in most developing countries, households, schools, hospitals, and other public institutions located outside major urban areas were not yet connected to high-speed Internet (ITU, 2011b). It is still critical to ensure that information systems implemented today can operate in low bandwidth settings and do not require a constant Internet connection for use in rural areas.

1.3.2 Ease of use

ICT applications and devices are becoming easier to use, and sector workers will require less training than ever before. Mobile devices with touch screens have also become more intuitive and are easier to customise for illiterate users. In addition, some devices, such as Android phones, support hundreds of languages out of the box and have the potential to accommodate still more.

Complex applications with easy-to-use interfaces could revolutionise the sector by increasing the number of workers who can use performance data. Google Search, Facebook, Twitter and DropBox are just a few examples of information services that are helping people communicate and access information without having to understand the underlying complex data and analyses.

A growing body of tools and examples can inform the use of ICT for monitoring rural water supplies. Some tools, including Akvo FLOW for data collection and Really Simple Reporting for project reporting, were created specifically for developing countries. The Pacific Institute report on mWASH reviews the technical features of mobile applications and gives examples of how mobile applications have been applied in the water, sanitation and hygiene (WASH) sectors (Hutchings et al., 2012).

Not all these tools are easy to use, however. Most require training in their use, plus customisation to match different information needs, levels of literacy and languages. Furthermore, many off-the-shelf tools are not specific to the water sector and address only a small part of an effective information system;

[2] Note that the areas of 2G and 3G coverage overlap. This means at least 77% of the population could access the Internet through a mobile data service.

[3] For example, the IDEO smartphone.

mobile phone-based survey tools, for example, are available for data collection, but the data must still be analysed.

1.3.3 Open data

In recent years, government portals[4] such as Data.gov (USA) and Kenya Open Data[5] as well as portals from large multinational institutions, such as the World Bank databank,[6] have set new precedents for sharing digital data. In addition, as governments go online, they are setting policies for the sharing of documentation and public information. The rural water sector will also benefit from sharing data and needs to be aware of these initiatives and national guidelines. Opening the data to all stakeholders can ensure that information is cross-checked and interpreted consistently, and thus gain value. Putting data online provides access without requiring others to use the same information systems. Some e-government policies specify the infrastructure and information systems that ministries are required to use, including those related to rural water supply. Using mobiles for government (mGovernment) promises to make government available, anytime, anywhere, to anyone (World Bank, 2012) and may reduce costs for the development and deployment of apps

Many tools can create information "mashups" from open data, merged sets of data from different sources. Mashups should allow different sector actors to collect data from different sources and use them together. Yahoo! Pipes, for example, introduced a drag-and-drop feature for merging online data in 2008. Newer tools with drag-and-drop functionality are www.poolparty.biz and www.metalayer.com, both commercial, and the non-profit tool www.sparkwi.se.[7] Many of these tools also allow the visualisation of data streams in graphs, charts and other more innovative formats. At the moment, the challenge is to use data and visualisations in such a way that the information is clear, stimulates discussions and learning, and most importantly supports service delivery.

1.3.4 Matching opportunities to rural water service monitoring needs

ICT has great potential to provide timely information on the level of services delivered and the performance of service providers. Although snapshot baseline maps of rural water supplies can be created with mobile phones or GPS units, these maps often do not track core issues over time. Applied appropriately to monitoring, ICT can do more to trace these issues over time and allow previous data points to be updated easily.

A second use of ICT is providing data management tools in rural areas and improving the quality of monitoring information so that it is taken seriously. Accuracy requires reviewing and validating information during data collection and reducing data entry errors. With ICT, data can be checked by an expert in a district office even as surveys are being conducted in the field. Data do not need to be transcribed if they are entered into a phone during data collection. Validated data improve the ability of stakeholders to learn and adapt to new challenges. Additionally, data collected by different agencies can be shared for cross-validation and coordination. If the data are known to be accurate, broken

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[4] See http://datacatalogs.org/ for a comprehensive list of open data catalogues, including government open data sites.

[5] https://opendata.go.ke/.

[6] http://databank.worldbank.org.

[7] http://sparkwi.se/.

infrastructure can be fixed in a timely manner, sector regulations can be enforced, and external support can be provided when necessary.

Finally, the implementation of ICT can lower the costs of existing monitoring activities by speeding up data collection, management and analysis while reducing travel distances and costs. The cost of Internet access, phones, computers, and software is decreasing dramatically while the benefits continuously improve.

1.4 DUAL CHALLENGE: WATER AND DATA

High-income countries and countries with relatively stable institutions and high population densities are often better positioned to establish information systems than lower-income and lower-density countries—a situation often parallel to WASH sector progress. Governments, donors, NGOs and other stakeholders need to tackle the dual challenges of ICT and WASH together to ensure sustainable rural water services for everyone.

According to studies by Triple-S and WASHCost (Smits et al., 2011), governments need to spend US$ 2–3 per capita per year to support service providers and cover the costs of monitoring, training and technical assistance. According to the study, anything under US$ 1 per capita per year is likely to be insufficient.[8] Current expenditure in many countries are not even close to that level. For example, Ghana spends only US$ 0.78 per capita per year on direct support to rural water service providers. This is a real limitation for data collection and the effective use of the results to improve service delivery. If funds for monitoring and corrective action are insufficient, information systems are unlikely to function over time.

[8] Expenditure on direct support (ExpDS).

2 INFORMATION SYSTEMS FOR SUSTAINABLE WATER SERVICES AT SCALE

This chapter sets out the conceptual framework for using information and communication technologies to help ensure sustainable rural water services at scale. The first section examines the role of monitoring in the sector. The second discusses the users of information systems, their information needs and the monitoring information flow. The final section suggests principles for the overall design of information systems.

2.1 THE ROLE OF MONITORING

Rural water service monitoring is the process of tracking progress based on sector policy targets, guidelines, laws and the responsibilities of sector actors, conducted to inform corrective action and learning. More than one sector institution may be involved, possibly operating at different geographic levels with different mandates and diverse information systems. Monitoring consists of on-going activities and incurs recurrent expenditures. Effective monitoring can make the difference between unreliable water service and a well-managed water service available year round.

Monitoring information systems[9] should be designed to improve service delivery through the interaction of ICT, data, processes and people. The three guiding principles for achieving sustainable rural water services at scale, described in Chapter 1, provide a useful framework for design.

2.1.1 ICT for a service delivery approach

The service delivery approach requires information across the life cycle of a service to support the respective roles and responsibilities of sector actors. To cover the whole life cycle, information systems may track the construction of new facilities, the level of service received by users over time, the performance of sector actors and the life-cycle costs of service delivery. To ensure that sector actors meet their responsibilities, the information system must reinforce sector guidelines and work with established structures.

2.1.2 ICT for a strong learning and adaptive sector

A learning and adaptive sector requires genuinely useful information and data in accessible formats for those who are responsible for reflecting and acting on that information. Reports and analysis may need to be widely accessible to ensure that there are opportunities for shared learning across the broadest range of sector actors. Information systems need to be flexible and continually updated to stay relevant in a learning environment, in terms of both the data collected and the reports produced.

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[9] http://en.wikipedia.org/wiki/Information_system.

2.1.3 ICT for harmonisation and alignment

Open data and communication across agencies and organisations can support the principle of harmonisation and alignment. Sector reform is notoriously difficult and can take years, but sharing data can be achieved relatively easily by making information systems transparent. Shared data allow stakeholders to discuss what the information means and how it can help them align strategies and coordinate activities.

2.2 SECTOR MONITORING AND INFORMATION NEEDS

This section describes some basic categories of potential users of monitoring information, the characteristics of the information that might be collected, and a scale to rate the accessibility of data in the sector. All three factors help determine how an information system can support the sector's needs.

2.2.1 Users of monitoring information

We identify six categories of information users—not to be confused with water users[10] —according to the generic functions and institutional levels for rural water:

- International-level users are the donors and large implementation organisations that are accountable for international-level development goals and their own constituencies. These users often have access to broadband Internet and mobile data connections.

- National-level users include policy makers, technocrats, financial and technical planners and administrators who are responsible for achieving the human right to water; set sector policy, norms and regulatory frameworks; define service levels; and coordinate development partners and macrolevel financial planning. Access to Internet varies among countries and offices. It may not include broadband and may be restricted to mobile phones and/or USB modems connected to computers.

- Service authorities are the institutions legally responsible for planning, coordination and oversight of service delivery in their jurisdiction (district, municipality or commune). The more remote and rural an office, the less likely it is to have access to high-speed Internet and smart phones. This is changing quickly, but there are still many areas with extremely poor access.

- Service providers are responsible for the actual service and the day-to-day operation, maintenance and administration of the water system. Community-based service providers generally do not have access to online services, but larger, private sector suppliers have access to computers and ICT expertise. Service providers typically have mobile phones.

- Water users are the households and individuals who receive water services or use the water. Some water users, depending on their age, status and income, may have access to a phone or Internet.

[10] http://www.waterservicesthatlast.org/Resources/Concepts-tools/Institutional-functions-and-levels.

- Civil society and other stakeholders include NGOs, community-based organisations, special-interest groups *and researchers. Internet access and ICT literacy various greatly within this category.*

Those categories may overlap or vary in different countries. Generally, however, as one approaches the level of actual service provision, access to high-speed Internet and mobile services and familiarity with ICT become less common. Designers of information systems should consider the roles and capacities of each user category.

2.2.2 Information needs and indicators for water services that last

The mapping of water facilities[11] has been stimulated by the need to track and pinpoint each rural water supply and its functionality against organisational, national and international targets. Typically, coverage and functionality[12] are two indicators used to set policy benchmarks. For example, the Millennium Development Goal 7, Target 10, is to halve the number of people without access to safe drinking water by 2015. The limitation of functionality as an indicator is it focuses on whether water flows from the tap or handpump and not on the underlying factors that make a service sustainable, such as adequate management capacity, tariff recovery and technical support. Monitoring ideally tracks the level of service received over time in terms of quantity, quality, access (time spent fetching water) and reliability (Moriarty et al., 2011), including the performance of technical, financial and management functions in anticipating and addressing problems [13] (Triple-S, 2011b).

Monitoring requires indicators based on well-defined targets so that the national government, service authorities and service providers can track progress, take corrective action and ensure accountability. However, information needs differ in terms of the content, granularity, frequency and speed of response required. Table 1 gives an overview of what these information needs might look like in a typical rural water sector. ICT has the potential to enable the sharing of information across levels more quickly and innovate new ways of using data as well as adapt the granularity and frequency of data across all levels. The more flexible the information system, the more likely that it will be useful across the spectrum of users and over time.

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[11] For examples, see the WaterAid Water Point Mapper, Akvo FLOW developed by Water For People. Recent examples of WaterPoint mapping using these tools come from Tanzania, Liberia and Sierra Leone.

[12] For example, spot checks done once a year to mark the water point as "functional" or "nonfunctional."

[13] http://www.waterservicesthatlast.org/Resources/Building-blocks/Monitoring-and-service-delivery-indicators.

TABLE 1: EXAMPLE NEEDS ASSESSMENT: DATA COLLECTION AND USE AT DIFFERENT LEVELS

	National level (national and international actors)	**Intermediate level (service authority)**	**System level (service provider)**	**User or household level (users and civil society)**
Objectives of data collection and use	Policy making, resource allocation and prioritisation, medium- to long-term planning	Resource allocation and prioritisation, medium- to long-term planning	Short-term service management, asset management, short-term (mostly annual) planning, billing	Access to water services, user satisfaction, right to water
Nature of data/informati on	Coverage, service level, administrative performance	Coverage, service level, service providers' performance, mapping of facilities	Service level, operations and maintenance, cost recovery, evolution of demand (quantity, quality), asset maps	Availability of water sources, breakdown reports, satisfaction, willingness and capacity to pay
Representative ness of data	Representative sample survey or aggregated data from intermediate level	Comprehensive mapping of facilities, regular monitoring of service providers' performance and service levels	Exhaustive monitoring of water systems and services delivered, regular auditing of accounts	Representative sample or full survey, ad hoc or real-time user reports (crowd sourcing)
Geographic units, spatial reference	National level, with disaggregation for rural and urban areas down to district levels	Precise location of systems, households and community boundaries, subdistrict-level aggregation	Precise location of water systems, households and community boundaries within service area.	User groups based on location of service or (economic and social) status
Ideal frequency	Regular (at least yearly)	Regular (at least quarterly)	Day-to-day	Near real-time information on functionality and user complaints
Granularity	Aggregated	Aggregated to system, provider, and subdistrict	Accurate water system and facility maps	Water users' access points

National level (national and international actors)	Intermediate level (service authority)	System level (service provider)	User or household level (users and civil society)	National level (national and international actors)
Dissemination	Annual sector review publication, online maps with coverage rate a	Annual review, map with service levels, service provider performance reports	Detailed information of "small" area	Summary information of small areas
Typical challenges	Achieving full geographical scale or coverage with information system	Ensuring that data are managed and available at decentralised levels	Ensuring that data are managed and available at decentralised levels	Timeliness of data, access to relevant information

2.2.3 Access to data

Although the users and appropriate indicators or data points may be known, the data must still be accessible to those who need it. As Table 1 indicates, different categories of users have different requirements for the frequency of data. Even if a problem is known by users or service providers, it may not be addressed without additional support. The information system should not only collect data but also provide its users with adequate access to that information.

The scenarios below describe the some typical ICT situations of rural water sectors, from worst to best:

- **No information management.** No digitally organised or indexed database or storage system has been established. No formal assessment has taken place to determine information needs and establish information management protocols. A large effort is required to manage information that is produced so that it is accessible to all users.
- **Limited databank.** A digital or paper database or data storage system has been established and is indexed. It is partially or haphazardly updated by projects and largely unused. Professionals use data from their own projects, and the databank is accessible to very few individuals.
- **Institution-based information systems**. A database that meets the information needs of some users has been established by a sector institution. Data are collected at somewhat regular intervals. The database may be replicated across offices but may have some synchronisation problems. Some project data sets are also available. It is possible to generate some institution-specific reporting formats for stakeholders who request information. Use of the data for corrective action is limited by the role of the institution.
- **Sector collaboration.** A databank designed for some users has been established and is open for collaborating partners. Data are regularly collected and immediately shared. Some documentation (guidelines, standards, FAQs) and project data are available on the web. Use of the data for corrective action is limited to annual cycles and specific problems.

- **Cross-sector collaboration.** An online databank with shared metadata standards enables collaboration with other agencies (including non-WASH sector). Data are regularly collected and immediately accessible. Documentation (guidelines, standards, FAQs) is available on the website or databank. At the district and community levels, access to the data may be shared across different sectors (e.g., health and water). There is potential for some use of the data for corrective action.

- **Open data.** The databank, with metadata on how the data are collected and what the information shows, is accessible online by any third party, including the public and other agencies. Data are regularly collected and immediately accessible. Documentation (guidelines, standards, FAQs) is available on the website or databank. Examples are the World Bank databank, OECD-DAC, AFDB Open Data for Africa, and Kenya open data portal.[14]

Many of the countries struggling with rural water supply coverage can be categorised as the three worst cases—having *no information management, limited databanks,* and *institution-based information systems*. For these countries, assessing information needs and establishing simple information systems are the priorities. The first steps towards improving access to data are crucial to support sustainable services. In the better scenarios, the goal is to open the information to ICT users and those working closest to service provision.

2.3 INFORMATION FLOW

Information and communication systems link different technologies. The function of these systems varies, from enabling communication between professionals to managing data collected in the field. The following flow of information is proposed for the monitoring of rural water services:

- Collection: sensing and rendering data in a format that can be recorded.
- Transfer and communication: transporting data from the field and storing the information temporarily, until it can be stored or used.
- Data management: storing and organising data and enabling access after the information has been stored (e.g., by querying the database) for data cleaning, reconciliation and other purposes.
- Analysis and reporting: manipulating the data and related information to understand patterns and answer questions about rural water supplies and their sustainability.
- Use: applying the information in reports to guide corrective action (e.g., to enforce sector guidelines).

[14] https://opendata.go.ke/, http://databank.worldbank.org, http://www.oecd.org/dac/.

FIGURE 4. INFORMATION FLOW FACILITATED BY ICT FOR SECTOR LEARNING

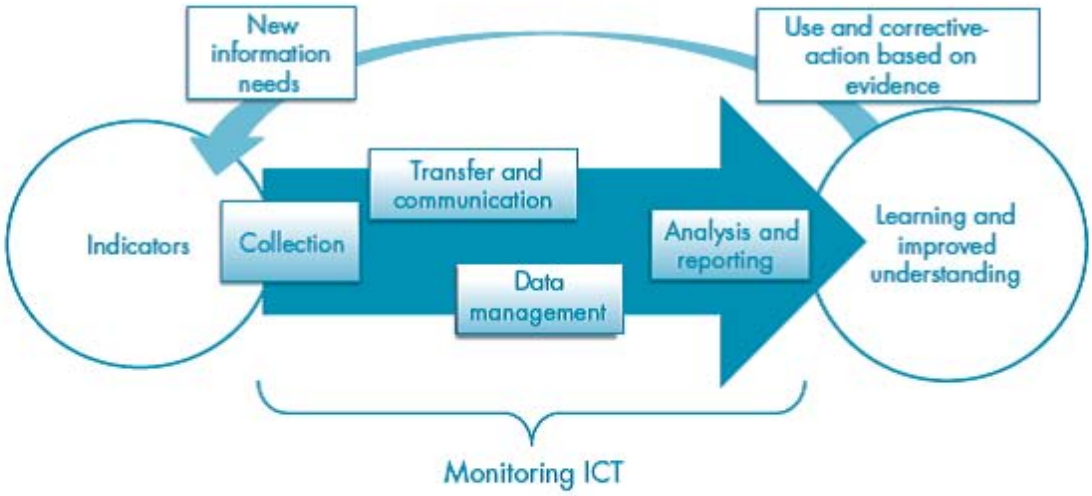

Figure 4 shows how information flow can be part of a cyclic learning exercise through which assumptions about how the sector works are used to guide the monitoring of service delivery. This learning cycle can help improve practices and ultimately services.

The implementation of an information system is ideally an incremental process in which stakeholders constantly refine the objectives of data collection and review information needs in response to sector practices, guidelines and regulations, while linking different technologies into a coherent system. Policies and procedures should not constrain the use of data and information systems, and the costs of maintaining monitoring activities and technologies need to be budgeted.

In the next chapter, we detail the devices and technologies that can support each of the first four steps of information flow: data collection, data transfer, data management, and data analysis and reporting.

2.4 SYSTEM DESIGN

The previous section described information needs and information flow. Those simple descriptions must now be used to design a information system that is effective and useful for monitoring. Of many approaches to information system design, we use the three categories from the mWASH report (Hutchings et al., 2012):

- Social design: the way the system will function in a given social context.
- Technical design: the appropriateness of the technology platform.
- Programme design: aspects that ensure long-term effectiveness.

That approach applies to information systems in general, not just mobile systems. The purpose here is to provide a simple framework for conceptualising elements of design, rather than a comprehensive checklist of design principles. Principles that affect taking ICT to scale in the rural water sector are discussed later in this paper. Readers interested in a clear and simple guide on how to design information system may consider the Human Centred Design toolkit.[15]

2.4.1 Social design

The use of information involves a combination of people, institutions and ICT. The system needs to meet the needs of the people who use it, in terms of the interface and the functionality. According to the mWASH report, social design includes "1) user perceptions – aspects of the context that affect user experience; 2) community participation – incentives and barriers for users to participate in the system; 3) privacy – the importance of protecting users' personal information; and 4) verification – credibility and the usefulness of information" (Pacific Institute and NexLeaf, 2012).

Users should be included in the design process so that their needs and perceptions are taken into account and they can test features before deployment. For sector monitoring, representatives of water users, service providers, service authorities and national-level actors are appropriate participants. Representatives of international agencies and NGOs that are implementing projects may bring additional expertise in the design process and help with harmonisation.

2.4.2 Technical design

Technical design should take into account the whole information flow and, if necessary, integrate different technologies into a single system. There may be local constraints, such as the availability of wireless data coverage or the familiarity and technical literacy of enumerators, that affect the choice of technical systems.

2.4.3 Programme design

Programme design refers to the management of the system and its institutional home. National monitoring systems require technical support, regular updating and some debugging. These services have recurrent costs. Typically, the costs of update and operating information systems vary greatly and are often underestimated; sector monitoring requires an adequate and secure annual allocation. Sometimes, strategic (technical) partners may help provide long-term support for aspects of the system; local telecoms, for example, may receive downstream benefits from the use of the monitoring system.

[15] http://www.ideo.com/work/human-centered-design-toolkit/.

3 SUPPORTING TECHNOLOGIES FOR MONITORING

This chapter examines how ICT can improve the efficiency of sector monitoring at each step in information flow (see previous chapter) and what kinds of tools are available. Each section begins with questions to consider regarding the choice of ICT.

3.1 DATA COLLECTION TECHNOLOGIES AND DEVICES

- *Who or what collects the information and where does it come from?*
- *Are there sufficient capacities and incentives to use the technology and is there a risk of data collection fatigue?*

Broadly speaking, information and communication technologies that support data collection have three components, which are often integrated into a fully functional data collection system:

- Digital sensors and loggers: handheld barcode scanners, GPS devices, cameras, and automated sensors, such as digital water meters and pressure sensors. Satellites provide remotely sensed imagery. Advanced systems may be linked to simple sensors to continuously monitor complex water systems, such as large piped networks and reservoirs, and transmit data to another location in real time.
- Computers and integrated devices: such as mobile phones, smart phones, smart pens,[16] laptops, tablet computers, and data terminals. These devices range from low-cost standardised devices, like simple mobile phones and Android smartphones, to more expensive and specialised data collection devices, such as Motorola MC75A. Many of these devices integrate sensors, cameras, or GPS devices.

Paper-based surveys

Traditional paper-based surveys and censuses are administered by a surveyor, and information is transcribed into a database. Paper saves on the capital and recurrent costs of devices, requires no electricity, and remains a choice for surveys that are filled in by respondents themselves and collected at a later time.

However, entering data into a computer may introduce many errors; rates up to 30% have been reported [citation for figure? or just omit?]. The use of double data entry or two-pass data entry catches errors, and range checks and nonrepeating codes can also increase reliability.

Even without double data entry, entering data is time consuming and increases the cost of data collection. Moreover, the use of paper surveys presents few options for automation or verification of data while the enumerators are still in the field.

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[16] Digital pens, or smart pens (http://en.wikipedia.org/wiki/Digital_pen), have computers that electronically capture what is written and can exchange this information with a computer. Smart pens (e.g. LiveScribe) can greatly facilitate data collection and could enable the use of a smart device together with the advantages of having a paper copy. Depending on the system, special paper is needed.

- Software applications: Akvo FLOW, Open Data Kit (ODK), ODKVoice, OpenXdata, EpiSurveyor, and online tools, such as email and web-based surveys (e.g., SurveyMonkey). These run on computer devices and provide surveying software or computer-assisted interviewing.

The choice of technology often depends on the type of information, the frequency or level of automation for data collection, and the enumerator or data provider, but three approaches to data collection are common:

- Crowd sourcing: water users and/or professionals are asked to voluntarily send reports via short message service (SMS) phones. Reporting is ad hoc and based on the willingness of users to submit reports.

- Administered surveys or interviews: traditionally, monitoring has depended on enumerators going out into the field to collect data. Collection often depends on available resources and planning cycles.

- Automated data collection: digital loggers collect and transmit specific kinds of data on a continuous basis to the information system.

A blend of those technologies may be used in an information system. For example, after a baseline is established with administered surveys, regular updates may use crowd sourcing or automated data collection.

TABLE 2: TECHNOLOGIES FOR DATA COLLECTION

	Digital sensors and loggers	Computers & integrated devices	Software applications	Implications for data
Crowd sourcing	Use of mobile phone towers and GPS sensors on phones to detect location of reports, cameras to capture images, readable water meters	Mobile phones supporting SMS and sim-card applications (USSD) from mobile providers to send reports	Crowd sourcing platforms like Ushahidi, interactive voice response like ODKVoice, SMS systems like Frontline SMS	Quality of data and frequency depends on users' competence and desire to submit reports
Administered surveys	GPS, barcode scanners, cameras, meters (for readings), memo recorders	Mobile phones support java applications, smart phones, smart pens, tablets	Survey applications for smart phones and websites (e.g., Akvo FLOW, ODK, EpiSurveyor, FulcrumApp,	Quantity and quality of data set by number of surveys that can be practically administered, access to remote areas, and

			SurveyMonkey)	training of enumerators.
Automated data collection	Flow and pressure sensors to monitor water use, satellite imagery to track changes in waterbodies	Smart handpumps[17] and other devices with integrated sensors	Platforms and custom software for automated data management and visualisation (e.g., SweetData)[18]	Quantity and quality can be configured; frequency of collection depends on connection to network; malfunctions can corrupt data

3.1.1 Crowd sourcing

Crowd sourcing technologies can be relatively simple. Almost any mobile phone allows the user to send a short text message (say, that a pump is broken) with a unique code that identifies a water point. However, this approach that depends on the willineness of users to submit information. In Uganda, the Triple-S project found that long water-point codes were a barrier to SMS reports: people preferred to phone the handpump mechanic directly (Bey, 2013).

Despite some high-profile crowd sourcing successes (such as monitoring the elections in Kenya by Ushahidi), a high degree of moderation is involved, and a large percentage of crowd sourcing platforms receive very few to no reports (MobileActive, 2012). In Afghanistan, Ushahidi was adapted for use in reporting on water supplies: voice response helped users make structured reports (Baker, 2012). However, that project has ended.

3.1.2 Automated data collection

The more decentralised and automated the information collection and transfer, the more potential there is to lower or share costs and increase the frequency of in-person data collection. Automated sensors and digital loggers can capture (and send) information on the use of pumps, water pressure and reservoir levels without the intervention of an enumerator.

There are a few examples of these systems in rural water supply in developing countries. Many of the technologies are very young and in pilot stages. The Oxford School for Geography and the Environment is integrating motion sensors and mobile phones into handpumps in Kenya to make breakdowns easier to report.[19] Both WellDone.org and SweetLab.org also have small automated data collection devices that are being piloted. The private Grundfos Lifelink system, already in use, integrates monitoring, administration and payment with a high level of automation.[20]

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[17] See WellDone MoMo: http://welldone.org/, Oxford University Smart Handpump: http://oxwater.co.uk/, SweetLabs SweetSense: http://www.sweetlab.org/.

[18] http://www.sweetlab.org/.

[19] See http://www.rdmag.com/News/2012/06/Information-Technology-Mobile-Technology-To-Fix-Hand-Pumps-In-Africa/.

[20] http://www.grundfoslifelink.com/.

The drawback is that when the automated collection fails—whether because of poor connectivity or a broken sensor—the problem could be difficult to identify and require travel and expertise to repair.

3.1.3 Administered surveys

Smart phone and mobile apps have revolutionised surveys. The devices have sufficient processing power to run data collection software, so that data entry is entirely automated and no separate entry is necessary. Their storage capacity ensures that information can temporarily be kept on the device if there is no mobile or wireless coverage.

Even inexpensive mobile phones can be programmed to incorporate data validation rules, context-specific questioning, GPS coordinates, photographs and videos, and barcode scanning. With a good app, it is relatively easy to train enumerators, even those who are not computer literate. Constraints on these devices include speed, operating system, battery life, storage capacity (e.g., size of the SD card) and the features of the data collection software installed.

Even with mobile devices, however, collecting a wide variety of information at the household or the water system level from a district or regional office still requires significant time and travel costs. It is not likely that surveyors will be able to update functionality information on a daily basis.

3.1.4 Mobile data collection systems

There are many choices of mobile data collection systems (MDCS), and the mWASH report reviews some of their uses. Choices range from manufacturer-specific systems for feature phones[21] to operating system–specific systems like Akvo FLOW or Open Data Kit, which run on smart phones with the Android operating system. Standards like OpenRosa and XForms provide some compatibility between the survey forms and data when moving between platforms (e.g., from EpiSurveyor to Open Data Kit).

Another class of MDCS runs on many phone and computer platforms. Some are based on software that has been programmed for multiple platforms, such as Frontline SMS and FulcrumApp. Others are based on a standard web technology that works on all smart phones. Even the simplest phones support MDCS based on voice telephony (calling), text messaging, and applications on the SIM card provided by the mobile phone operators.

The most common technologies are the following:

- mobile java applications (J2ME) for simple feature phones;
- software applications for smart phones, tablets and computers (some of which support standards like XForms);
- website-based forms (both online and offline with new HTML5 standard); and
- systems using standard protocols, such as voice telephony, text messaging and mobile provider applications, such as SIM-based applications and unstructured supplementary service data (USSD).

[21] http://en.wikipedia.org/wiki/Feature_phone.

3.2 DATA TRANSFER TECHNOLOGIES

- *Do users and enumerators have access and sufficient credit (money) to transfer data?*
- *How quickly can the data be transferred?*
- *How robust is the technology if, for example, the network connection breaks?*
- *What do data transfer and communications cost?*

Communication plays many roles and is critical for the transfer of data, the coordination of data collection, and the actual use of the data collected. For continuous data collection to reach its full potential, the data must be easily and quickly transferred to where they can be verified and analysed. Generally, three main forms of communication technologies are used for these purposes:

- physical transport of data storage (e.g., USB drives or memory sticks, delivered by postal service or private vehicles);
- wireless data transfer (e.g., mobile networks, satellite technologies or mesh networks); and
- wired data transfer (e.g., copper and optical cable data networks).

The physical transport of information is needed if no data services are available to transmit the information. For large amounts of data, such as videos and imagery, and slow data connections, it can sometimes be faster to physically transport hard drives and solid state media.[22] However, the data could be physically lost, and transport defeats the value of automated data collection and increases travel costs.

Wireless data transfer through mobile networks is often the most practical way of transferring information to and from the field. This includes mobile phone calls, mobile texting (SMS) services, mobile data services to access the Internet, satellite data, Wi-Fi, and Bluetooth. Data transfer through mobile networks fast, and data managers can conduct external validation regardless of their distance from the field, querying implausible entries while enumerators are still in the field. Worldwide, mobile data G2 or G3 coverage[23] is expanding. In addition, some phone-based collection systems store data on the phone when no network is available, then transfer the data as soon as the phone reaches an area with coverage.

Wired communications include the use of copper-based phone networks, cable-based ADSL and optical cable–based broadband Internet. Although these are useful in areas with broadband Internet, wired communication is not typical in rural areas in many developing countries.

3.3 DATA MANAGEMENT TECHNOLOGIES

- *Who will manage the data?*
- *How are the data organised and retrieved?*

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[22] Sold state media represent new options for robust data storage.

[23] G (for "General protocol"): G2 allows sending and receiving data and voice; G3 hi-speed internet

- *Is the data storage robust (e.g., fireproof) and secure?*
- *What is the data storage limit, and is it sufficient for the future?*
- *How does the storage system keep track of changes in the database? Can mistakes be recovered?*
- *Will the data be accessible online or offline?What policies might affect data management and access to the platform?*

Digital storage systems are made up of three layers:

- **Storage media** have different lifetimes and data loss mitigation options. Examples are DVDs, hard drives and arrays of hard drives (e.g., RAID6, in which one or more hard drives can fail without data loss during regular operation). Ideally, the storage is managed by ICT specialists so that information system users do not have to worry about this.
- **Storage architecture** can vary from a local computer in a district office to a server computer hosted by a local Internet provider to a cloud-based storage provider. Different levels of duplication in different locations decrease the chance of losing data because of theft, fire, floods or earthquakes. Again, if the storage architeture is managed by an ICT specialist, water sector users need not be concerned about it.
- **Software implementation** determines how files are stored on the computer, how backups are maintained, and how data are stored and queried. This can vary from a spreadsheet or database stored on a personal computer to an online dashboard, which allows data to be queried from a web browser anywhere in the world.

The tools used to store and retrieve data determine the robustness, security and privacy of the system. The software used and the structure of the database may affect how easily data can be queried, sorted and reorganised.

The Internet, in particular cloud-based[24] storage, allows data to be accessed from many locations with a relatively high level of data security. Although managing a "cloud" of computers involves an annual fee or requires an ITC specialist, cloud services typically simplify the user experience. The cloud optimises computer power, data storage and bandwidth at large scales, even globally, making this option sometimes less expensive than standalone computers or local networks. There is no need to manage physical servers, and data security is usually the responsibility of the service provider. Some cloud applications require a constant Internet connection; others can work with intermittent connectivity.

The structure of the database can be as simple as a flat file-based list or a complex system that organises data in particular ways. The two most important issues to consider when choosing a database management system are whether it can handle large volumes of data in a reliable way and whether the user can easily retrieve and analyse the data through a query language. Not all formats can deal with a continuously increasing volume of information or provide for easy retrieval and analysis.

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[24] http://en.wikipedia.org/wiki/Cloud_computing and http://en.wikipedia.org/wiki/Cloud_Applications.

Ghana and Burkina Faso (see case studies, below) started with locally stored or distributed Microsoft Access databases but are exploring more modern formats that can be scaled up for country-wide use. Databases should be available online and use standards that allow them to interoperate with new systems, such as the widely used SQL[25] or the less-used ODBC.[26] Modern data exchange formats also include XML[27] and JSON and are often used by online systems. Locked-in propriety formats can complicate the transition to new systems.

3.4 ANALYSIS AND REPORTING TECHNOLOGIES

- *Does the presentation enable users to easily analyse and share information?*
- *Do users have the right tools and capacity to respond to the information?*
- *Can the information system be changed to reflect sector learning?*

A broad range of technologies and tools address the manipulation and presentation of data to generate reports and findings. This part of the information flow may have the most options. Some also provide various levels of automation to support decision making or generate alerts when certain events occur. They include:

- tools for reporting and visualisation (e.g., GapMinder.org, Google Earth, Google Maps, MS Excel charts), including many modules available in business intelligence tools (e.g., Pentaho),[28] which allow different levels of filtering during the exploration of the data;
- analytical tools, including statistical packages (e.g., SPSS[29] or R[30]) and geospatial analysis software (e.g., ESRI ArcGIS[31] or QGIS[32]);
- information and knowledge management systems for interaction and sharing of data among users, including social networks that allow sector actors to create profiles and comment on results;
- *decision-support systems and specialised tools (WASHCost, 2012) and apps allowing different levels of scenario building, assumption testing, and rule-based decision support; and*
- *surveillance and alert systems that generate automated messages or trigger actions based on information in real time.*

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[25] Structured query language, the most commonly used relational database language.

[26] Open database connectivity (http://en.wikipedia.org/wiki/ODBC).

[27] Extensible markup lnguage is an open standard for coding documents but increasingly is used for developing database languages (http://en.wikipedia.org/wiki/XML).

[28] http://www.pentaho.com/.

[29] http://www-01.ibm.com/software/analytics/spss/products/statistics/.

[30] http://www.r-project.org/.

[31] http://www.esri.com/software/arcgis.

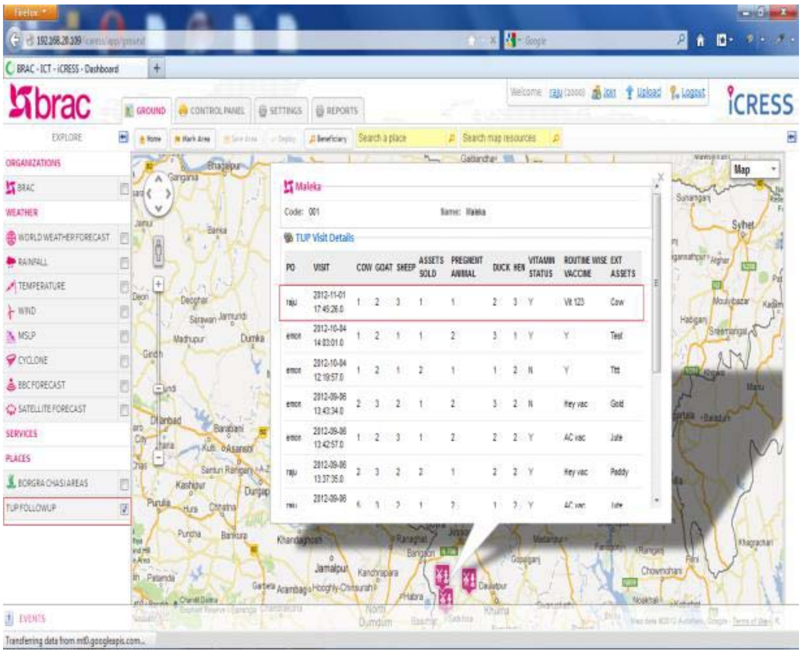
[32] http://www.qgis.org/.

Examples of advanced information systems that can facilitate the analysis and visualisation of rural water supply data are Water For People's Reimagine Reporting and BRAC's iCRESS (Figures 5 and 6). An example of a system that generates alerts based on structured information submitted to a database, such as breakdown reports, is M4Water,[33] used in Uganda; it sends simple text messages to handpump mechanics.

FIGURE 5. WATER FOR PEOPLE'S REIMAGINE REPORTING

[33] http://m4water.org/.

FIGURE 6. BRAC'S ICRESS



The users of analysis and reporting systems cut across all the categories identified earlier, from water users and civil society to international stakeholders. The formats and information generated should improve service delivery and facilitate data analysis in real time, including during repeat data collection. These technologies do not conduct the data analysis itself, however.

The information systems used for data collection, storage, and analysis may need to be interoperable. Systems using standard protocols can often be configured to operate together with minor customisation. However, there is a significant risk, especially with custom software, that the capital and recurrent costs increase with the complexity of the information system, especially if customisation requires reprogramming.

3.5 USE OF REPORTS AND DATA

- *Do the right people receive reports and alerts?*
- *Can people act on the information they* receive?
- *Are their responsibilities clear?*

Good system design matches information with roles and responsibilities so that people can act on the data. The use of information is premised on three conditions:

- targeting—receiving the information in a useful format at the right time;
- interpreting—understanding the content and consequence of that information; and
- acting—being able to take the appropriate action (acting with knowledge).

Targeting may require automated communications and a database that includes contact details to speed the delivery of information through alerts to water users, service providers, spare parts suppliers, district engineers, and government agencies. This shortens feedback loops and enables sector workers to spend more time using the data.

Information must be in a format that facilitates the interpretation of the results. Indicators of performance have to be well defined, and everyone must share a common interpretation of their meaning. This is something that can be partially addressed when developing the standard templates and formats.

Even the most sophisticated ICT system is worthless if mechanisms are not in place to enable corrective action. The development of information systems for monitoring needs to go hand in hand with changes in the sector, typically in an incremental approach that builds trust in the results.

4 DISTRICT MONITORING AND EVALUATION IN GHANA

The service delivery approach is an element of Ghanaian sector strategies and manuals, made explicit in a strategic development plan for the water sector by the Ministry of Water Resources Works and Housing and reiterated in the recent Ghana statement from the Sanitation and Water for All High Level Meeting (SWA, 2012; CWSA, 2012). Ghana is currently using information systems to support monitoring for the service delivery approach. This case study analyses the District Monitoring and Evaluation System and a pilot by Triple-S using mobile data collection and new indicators.

4.1 BACKGROUND

Since 1993, Ghana has devolved policy implementation to local authorities—the metropolitan, municipal and district assemblies, which have the responsibility for social-economic development, including the provision of water services (Local Government Act 1993, Act 462). Each assembly is meant to have a district works department,[34] an engineering department responsible for the implementation of rural water supply, as well as other projects. An assembly may also have a district water and sanitation team comprising an engineer, a community mobilisation officer and an environmental health officer who carry out most activities related to water and sanitation. The number of districts and municipalities in Ghana has increased in the past seven years, from 110 districts in 2005 to 216 districts by mid-2012.

The Community Water and Sanitation Agency (CWSA) is mandated to facilitate the provision of safe water and related sanitation services to rural communities and small towns (Act of Establishment, Act 564). CWSA provides technical assistance to the district assemblies in support of planning, design, construction supervision, operations and maintenance. It often also plays an active role with donors, development partners, implementation agencies and contractors in planning and monitoring service delivery. The National Community Water and Sanitation Programme is managed by CWSA and was officially launched in 1994, under the Ministry of Water Resources Works and Housing and in collaboration with the Ministry of Local Government and Rural Development. Funding for the programme comes from the annual budget approved by Parliament and development partners. However, many projects under the programme are funded by development partners outside the National Community Water and Sanitation Programme budget. There are three goals:

- to provide basic water and sanitation services to rural communities;
- to ensure the sustainability of the services; and
- to maximise health benefits by integrating water, sanitation, and hygiene promotion.

Officially, to be eligible to participate in National Community Water and Sanitation Programme, each district must have a functional district works department, a district water and sanitation plan, and a

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[34] The former district water and sanitation team have officially been replaced by district works departments but are still present in many districts.

budget line with sufficient funds to meet the operational expenditures of the water and sanitation unit of the district works department (District Operational Manual, unpublished). The district works department or district water and sanitation team supports the water and sanitation management team and community-based water suppliers in operating and maintaining facilities and reporting. In addition, the district works department must prepare and update the district water and sanitation plan, work plans, budgets, and procurement plans. These functions are premised on a good understanding of the water resources, the state of facilities, and the demand for services based on population and CWSA guidelines.

Table 3. Overview of rural water sector in Ghana

National level	Ministry of Water Works and Housing / Water Directorate Ministry of Local Government (to communicate to district committees National Development and Planning Commission Ministry of Finance Community Water and Sanitation Agency - Headquarters
Regional level	Community Water and Sanitation Agency – Regional office Regional Coordinating Council (MLGRD) Regional Water and Sanitation Team
District level	Municipal Metropolitan and District Assemblies District Works Department (and other departments District Water and Sanitation Team
Community / service provision level	Water and Sanitation Management Teams (for point sources) Water and Sanitation Management Teams (piped systems) Private operators Community/Water Users

4.2 INFORMATION SYSTEMS FOR MONITORING IN GHANA

Having up-to-date information is essential for developing plans and budgets and providing evidence to justify investments in the WASH sector. CWSA tried various systems over nearly two decades,[35] but they proved unsustainable: they were associated with particular projects and developed by external consultants, and they did not involve the transfer of ICT skills (Kubabom, 2012). In 2000, CWSA began work on a uniform, comprehensive, computerised monitoring and evaluation system with the support of DANIDA. The result was the District Monitoring and Evaluation Systems (DiMES), which was first implemented in 2007.

[35] In the past 18 years, project-based monitoring systems have incliuded PROGRES (AFD), MOM (DANIDA), and AME (World Bank).

Components of DiMES include the following:

- administrative management (districts, area councils, communities, population, etc.);
- coding and descriptions of facilities (community baseline data);
- water and sanitation facility management;
- monitoring of operations and maintenance;
- templates for data capture;
- coverage evaluation;
- strategic investment planning;
- project monitoring; and
- queries and reports generation.

However, data collection was never fully operationalised, and DiMES remains underused. It is based on an MS Access database and is described in more detail below. Several initiatives have been intended to improve data collection.

In 2010, the CWSA western region office tested the use of coded mobile phone text messages in small towns to collect monitoring data included in the DiMES database, including financial transactions of users to purchase water, both daily and at less frequent intervals. This was done under the European Union Small Town Water Supply Project (Akin, 2011). A private company, SkyFox, is testing a spare parts supply system, which is also based on the use of text messages. The SkyFox system will provide alerts when a breakdown is reported, spare parts are ordered, and the repair is completed and paid for.

In 2011, under the Triple-S project of CWSA and IRC, three districts have collected baseline information on the functionality of facilities, the service level delivered, the performance of community-based service providers and the assembly's support to the service providers, all to be evaluated against CWSA guidelines. The CWSA guidelines set norms and standards related to water quality, quantity, reliability and accessibility of water services that should be provided under community management models. Furthermore, guidelines, manuals and a model by-law prescribe the operational, financial and institutional arrangements at community, district and regional levels (Triple-S, 2012).

Some of this performance management information is not yet captured in the current implementation of the DiMES database. This pilot has set the basis for the extension of DiMES to better support planning and implementation activities.

The proportion of functional facilities in Ghana appears to mirror the wider trend in sub-Saharan Africa. WASHCost[36] Ghana research found that in 31 rural communities, an average of 71% of water point systems were functional (BN6, WASHCost Ghana, 2012). Based on the results of the three pilot districts, if service levels are taken into account, less than a third of the people in these communities received a basic level of service as defined by CWSA[37]. In one district, only 2% of the population received a basic level of service (Adank, 2012).

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[36] http://www.washcost.info.

[37] A basic level of service is defined as 20 to 30 litres of water per day, a safe water point source within 500 metres of the household, and no more than 300 people served by that facility (WASHCost Ghana BN 1).

4.3 DISTRICT MONITORING AND EVALUATION SYSTEM

4.3.1 The users and the use of information

It is the responsibility of district staff to collect planning data, monitor the implementation and operation of services, and report to the district assembly and the regional coordinating council. In support of this and the planning of the National Community Water and Sanitation Programme, DiMES was finally implemented by CWSA in 2007.

The primary intended end users of the information system are district water and sanitation staff and district assemblies (service authority users), CWSA information technology specialists and coordinators, and CWSA decision makers (national-level users). DiMES is currently used for two main planning purposes: to generate coverage reports and to support the development of strategic investment plans based on data and projections submitted by the districts. DiMES includes several other reporting features, including CWSA quarterly and annual performance reporting, monitoring of operations and maintenance reports, and project activity monitoring (e.g., daily standpipe income, monthly expenditure, daily production). These reports often suffer from lack of up-to-date data; another challenge is the failure of many districts to use the software.

Other users of the reports are the Water Directorate of the Ministry of Water Resources Works and Housing and other sector stakeholders, such as donors and NGOs, interested in coverage statistics. Service providers provide information to district staff, but it is not clear how they can use DiMES. Water users do not currently have a role in DiMES.

It is possible that a much wider spectrum of stakeholders, such as national ministries (Ministry of Water Resources Works and Housing, Ministry of Local Government and Rural Development, Ministry of Finance), Parliament, the Office of the President, international development partners and civil society interested in coverage statistics, would be interested in the information if it were timely and accessible online.

4.3.2 DiMES current monitoring information flow

Data collection

In principle, field data are collected by district staff, the water and sanitation management teams, and the environmental health assistants and officers with paper-based data entry forms. Data collection is also conducted by the district works department, area and town councils, and the district planning coordination units. Some basic data on administrative areas are available at the national level. In practice, there is no annual or more frequent data collection.

After data collection in the field, paper forms are collated and transcribed into the local version of the Access database in the regional CWSA office. Some districts can also transcribe data in their offices. CWSA and the district assemblies have little opportunity to check the validity of the data during data collection, especially for remote areas.

In reality, district-level data collection takes place infrequently and is not supported in the regular district or regional budgets. Community baseline data on the coding and descriptions of facilities are therefore incomplete, as are the data on functionality and operations and maintenance.

Data transfer

The data are transcribed from the paper-based forms into the PC Microsoft Access-based DiMES database at the district or regional level, an approach that can introduce many errors. From there, the data are sent by email or physically copied to a USB pen drive and integrated by the information technology specialist in the CWSA regional office. At national level, the information technology coordinator in CWSA headquarters integrates the data into the master database by importing the sent file into the regional and national copies of the database.

Data management

Because the database is distributed, each database can be managed independently, sometimes leading to conflicting records, including records on administrative boundaries. An advantage is that access is not limited by Internet coverage, and multiple copies of the data are backed up at different levels. The entry and management of data require training on how to use the DiMES interface. Each CWSA regional office has an information technology specialist who is responsible for data management.

Analysis and dissemination

Analysis of the DiMES data is hardcoded into the DiMES database. Standard reporting tables are generated as PDFs. Trained district staff can generate reports from the district DiMES database, such as a report with community population figures or estimated coverage. However, the interface is not easy to navigate.

Additional manipulation and analysis of the data require exporting the data to a spreadsheet and reimporting it into statistical, GIS or spreadsheet software. This has been done on an ad hoc basis, often in relation to particuilar projects; this enhances analytical competencies but requires time and money. There is limited capacity in local, regional and national government conduct analysis on a regular basis.

Reports are shared regularly as part of the annual strategic investment plans and on request at district, regional and national levels. District works departments then report to the assemblies.

Use of the information

The strategic investment plan is the basis for planning and budgeting of the National Community Water and Sanitation Programme and for developing coverage targets per region. The model used by DiMES and the quality of information in the database affect the understanding of coverage gaps and sector planning at a national level. These components of DiMES therefore deserve a closer examination to ensure they are responding to challenges to service delivery and not just coverage. At the same time, much facility information is missing in DiMES, and information on the status of facilities is severely out of date. These shortcomings, as well as missing sector performance management data, are meant to be addressed during the upcoming reassessment and revision of DiMES.

4.3.3 Mobile data collection with Akvo FLOW to augment DiMES

Through the Triple-S project, CWSA and IRC have been running experiments to update DiMES with the goals of achieving regular data collection, adding service level and performance management indicators, adding visual information like maps and pictures online, reducing the time between collection and use of the information and enabling access to wider groups of stakeholders. The Triple-S project tested low latency updates through mobile data connections in the field, using Akvo FLOW for data collection. This section describes the data collection piloted in three districts by Triple-S.

Data collection

Android mobile phones were used by districts' engineers and environmental health assistants, to fill in surveys using the FLOW field survey app. The phones can collect data without Internet or mobile phone network access. However, this method is dependent on hardware and on electricity for daily charging of the phone batteries. The data collection required travel to all communities. Because district staff are the ones using the phones, a future scaling up of the technology could allow updates to be done throughout the year as part of their regular travel to rural communities. Combining surveys with other activities could reduce the number of trips required and save on travel costs. In addition, contact details for the people responsible for each water point or water system would allow staff to get updated information with a phone call instead of a site visit.

Caption: Prosper Modey, Environmental Health Assistant, learning to administer the surveys on the performance of a small town Water and Sanitation Development Board in Akatsi District using the FLOW field survey app on a smartphone. Photo by Nicolas Dickinson, IRC, 2012

Using smart phone features, staff added photos and GPS locations to the data. For example, financial records of local service providers were photographed and added to the FLOW database.

Data transfer

From the field, data were sent using mobile data connections from the mobile phones to a cloud-based database.[38] Wi-Fi connections in the CWSA regional offices could also be used to send data, or the data could be manually exported to a computer. Once on the computer, the FLOW online dashboard could be used to upload the data. Typically, data were sent once a day, to conserve battery power. Some travel was required to find reliable data connections or purchase additional credit. However, since the phones were all on a single plan, credit was not usually a problem.

Some problems arose when the version of the field survey app prevented uploading of some photos, and data had to be exported from the phones manually. Backup IT support, provided by IRC in the Netherlands during the pilot, was critical for troubleshooting and communicating with Akvo. Most issues were resolved by Akvo in subsequent updates to the app and the dashboard. Local IT support would likely be a critical factor for any scaling-up activities so that bugs do not stop or delay data collection.

Surveys do not require fast or steady Internet connections, but transferring photos and videos is data intensive and may not be possible in some contexts. Setting photo resolution to minimum quality made transfers faster and more reliable. In most situations, low resolution is enough for identification of a water point or a quick visual check of record books. In Liberia, FLOW has been used for baseline mapping of water points without any Internet connectivity; data were physically transported to locations where the information could be copied and uploaded. This complicates verification of survey results and correction during data collection, but the centralisation and digital entry make data collection technically simple.

Data management

Although FLOW is primarily a survey-based data collection tool, it also enables data managers, such as district staff, ICT specialists in regional CWSA offices and IRC staff, to view surveys, validate the data during data collection using the online dashboard and call enumerators when errors occurred. During the pilot, the data from FLOW were exported in an MS Excel format for analysis or mapping. Some new indicators on service levels and performance management have now been added to the DiMES fields. As a result, the current pilot information could not be immediately transferred into DiMES. However, during any scale-up activities, data management and long-term storage of relational data will take place in DiMES..

Analysis and dissemination

The data analysis generated scores for the level of service and performance of the service providers and district, primarily in the form of bar graphs. These were disaggregated at district level with support from Triple-S staff and presented to the district assemblies.

Data were manually exported from FLOW into Excel, and equations and pivot tables were used to generate tables and graphs of the results. Although Akvo FLOW was meant to have a mapping interface, it was difficult to configure. Offline maps were generated using an Excel macro to produce KML files that could be read by Google Earth. In addition, ESRI ArcGIS was used to create print easily

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[38] Amazon S3 for pictures and videos, Google Apps for all other data.

understood figures and additional geographical analysis. It was clear during presentations that sector stakeholders wanted online maps.

Older reports may need to be updated to reflect the new indicators developed by Triple-S on the functionality of systems, service levels achieved per community, and the performance of service providers and district direct support. The overall results have been summarised in a factsheets that can be downloaded from the Triple-S website.[39]

The analytical workflow in the pilot is not easily scalable because of the number of manual steps and the level of support provided. DiMES will most likely need to be extended or transferred to a more flexible reporting system that is accessible online to accommodate new indicators and reporting formats. The current version of FLOW does not have appropriate data analysis components, so this could not be tested during the pilot. For the moment, the Access database is the only way to automate the generation of reports from the data sets, but these reports should become more widely available for online and offline viewing.

Use of the data

When presented to the district assemblies, the results of data collection in the Triple-S pilots prompted several changes in planning for areas where local councils had scored low. In East Gonja district of the Northern Region, for example, three handpumps were repaired on the basis of the survey results, and training of area mechanics, one of the weak points identified, was incorporated into the design of a new project. However, another weak point, the training of local water suppliers, was planned but never implemented. In the Akatsi district of the Volta Region, some handpumps were repaired, and the district decided to seek funds to improve services in neglected area councils. Since the initial exercise, the district has repeated data collection on its own accord and requested some technical support from Triple-S. These preliminary results also suggest that when district assemblies see the potential uses of monitoring data, demand for information grows and corrective action can follow. Although staff in the district works department may know about the service levels achieved by area councils, it is difficult to communicate the disparities in a convincing manner without a strong information system and standardised reports. Several rounds of annual data collection will most likely take place before some core issues may be addressed, however. Politics, funding, and resources are factors that will impede quick reaction.

To scale up, districts will have to take actions based on the information and value the data collection process, and they will need support from CWSA in implementing the guidelines on performance indicators.

4.3.4 System design

Social design

Local community-based service providers, district works departments, district assemblies and CWSA are perhaps the most important users of an information system, since they will determine whether data are

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[39] http://www.waterservicesthatlast.org/Countries/Ghana-Triple-S-initiative/News-events/Triple-S-Ghana-produces-fact-sheets-on-water-service-delivery-in-three-districts.

collected and the results used to service delivery. Both the survey format and the presentation of results should therefore accommodate the needs of these different user groups.

National-level actors—the Water Directorate in the Ministry of Water, Works and Housing, the Ministry of Local Government and Rural Development, the Ministry of Finance and the National Development and Planning Commission—are important users, too: they will read the reports and help define the overall national and regional plans and budgets in the country.

A strong demand for data on service levels and performance exists at district, regional, and national levels. The Akatsi district, for example, has initiated repeat data collection on its own. At regional level, on the request of the Northern Region office of CWSA, UNICEF has financed an extension of data collection to an additional 10 districts, with technical support from Triple-S. At the national level, CWSA intends to roll out further collection with the support of large donors to the WASH sector.

District staff learned to use the FLOW app on Android phones after a two-day training but required ongoing support from CWSA and IRC during data collection and also cross-checking and verification of the incoming data. Proactive verification was appreciated and led to cleaner data sets. In using the system, district staff gained trust in its results. In each pilot district, a Triple-S regional learning facilitator conducted trainings, tested surveys with district staff, supported the data collection, and ensured that technical issues were addressed. In the long-term this support would need to become part of existing structures within CWSA.

Some personal details, such as community-based service providers' phone numbers, are collected but should not be posted online. Other data, such as photos, may also contain some private information that may need to be restricted.

The data collection has been tested, but standard reporting formats and tools are not yet developed and need to be validated with the district assemblies. Currently, it would be difficult to develop a single reporting format because of literacy levels and the multiplicity of local languages. Ultimately, the district water and sanitation team may be responsible for communicating results locally, even in communities that have Internet access. Photo- and illustration-based reporting may address such problems, but this has not yet been explored.

New information on the performance of districts and community-based service providers is likely to have implications for extension workers, technical staff and planners. CWSA and district assembly staff will need to become familiar with the updated DiMES and the new data collection process. As collection continues, indicators may need to be refined, added or removed. Because of these uncertainties—and the as-yet unknown challenges that any new approach presents—DiMES and the data collection process need high-level leadership in CWSA and the assemblies. Training stakeholders, providing support during data collection, and establishing trust in these new technologies will take time. For all these reasons, the new technologies will be rolled out in phases to different regions in the country.

Technical design

The current technical design requires an Android 2.1+ smartphone with GPS, a camera and an SD card when the internal storage is below 2GB. In 2012, the cost of used phones with these features was about € 250 but has fallen dramatically since, and new phones are much more powerful. A minimum price in 2013 is expected to be €150. Such costs can be prohibitive for a district, however, and who will purchase and own these devices in a larger-scale system is undetermined. Like computers, these phones have multiple uses and could handle other tasks besides the monitoring of rural water supplies.

Akvo FLOW is run as a cloud service, with an annual subscription.[40] Technically, this is desirable because software problems identified by other users lead to new features or bug fixes, benefitting CWSA at lower cost than would otherwise be possible. It remains difficuilt to customise FLOW (to change the map interface, for example, or track data in time series across different surveys), so users are limited in how they can manage and visualise the survey data. The next version, FLOW 2.0, will address such problems. Another challenge is synchronizing with an outdated DiMES Access database on individual computers at CWSA headquarters and in some district offices.

In the future, DiMES may be able to retrieve survey data directly from FLOW through customised software that allows DiMES to update remotely. Initially, this will be based on regular, perhaps daily updates between the systems but should ultimately lead to real-time updates. The system must be able to update the data available at all levels—district, regional and national. The sooner DiMES is available online, the easier it will be to deal with this data management challenge. As Internet connectivity improves, regular updating and use of the data should become routine, without the problem of conflicting database versions.

Long-term scaling up will require that the technical design allow migrating the current DiMES database into a modern online system with automatic reporting. Transitioning to an online DiMES database and data collection will be an incremental process. Migrating from distributed local databases to an online database will require retraining, the development of new interfaces and replicating some of the functions built into the online MS Access database. Akvo FLOW could provide a map interface but does not yet provide all the tools and reports found in DiMES—a logistical challenge.

Similar initiatives involving information systems inside and outside the WASH sector include the World Bank–supported development of a sector information system (including both water and sanitation) at the national level. DiMES will be part of this, but it is unclear how.

The government of Ghana has an e-government programme that is establishing infrastructure and guidelines for the management of data. This may have implications for CWSA and ICT budgets. In addition, new ICT systems that may be developed by the various ministries working with the rural water sector could put additional burdens on limited ICT resources in CWSA and districts.

Programme design

District-level monitoring (data collection, analysis and reporting) is typically financed from donor-funded projects. The regular ICT budgets of CWSA do not include funds for the development or extension of DiMES, which will most likely rely on projects currently. There are no actions to address the financial sustainability of the system—a critical issue.

An appropriate financial model is needed so that DiMES can continuously improve to match changing technologies and information needs. It would be most cost-effective to address this in a recurrent budget, and thus avoid the overhead involved in developing projects and tendering on a project basis. Better data and reports and subsequent improvements in service delivery should easily justify the recurrent costs of the information systems, including hardware, software and capacity development.

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[40] At the time of writing, setting up an instance of FLOW costs €7,500 and costs €2,500 per year afterwards, excluding training and support costs.

Technical partners in the pilot have been the developers of DiMES and FLOW and staff from IRC. IRC supported the implementation of FLOW and helped CWSA and the sector in dedvelop the indicators. There are currently no strategic partnerships with telecoms to reduce data costs or take advantage of other mobile services, such as SMS. Establishing local and international partnerships that ensure long-term support for the technology will be essential to the sustainability of DiMES. The choice of technology and partner is inevitably interlinked and should also consider information systems used in other sectors in Ghana.

System costs

The current version of DiMES was built on a relatively static Access database, whose most-used functions are relatively mature and stable. During the pilot, Akvo FLOW was provided at no cost by Water For People. In the future, estimated costs of FLOW are around € 10,000 to €15,000 a year, including support costs. However, the biggest startup items were travel, daily subsistence allowances and meetings, followed by technical assistance for the validation and analysis of data. In the pilot, these costs are approximately € 15,000 per district per data collection. The cost of the hardware, Android phones, was negligible in comparison, €1,500, and the same phones can be used across several districts and several rounds of data collection.

Estimates of the costs for an initial national-level rollout are approximately US$ 0.12 per person for baseline data collection. Integrating data collection into the regular travel of district staff and focussing only on data that need to be updated regularly would reduce the cost. At a national level, the running of DiMES and the mobile data collection system requires funding for maintaining the servers and technical support.

It is not clear how the recurrent costs of monitoring will be covered in existing budgets.

4.4 DISCUSSION

DiMES has faced challenges in scaling up to all districts, updating existing data and responding to new information needs and technologies. Akvo FLOW has proven useful for data collection but there are still significant social, technical and programmatic barriers to scaling DiMES and FLOW. The information system in Ghana is not yet linked to actions that improve rural water service delivery. Three principles for scaling sustainable services are discussed below.

4.4.1 The service delivery approach

Timely mobile data collection with Akvo FLOW gives sector actors opportunity to influence the current round of planning and budgeting. In the pilot, facilities have been repaired and postconstruction support has been planned on the basis of the data. The information system thus has the potential to dramatically improve services through the full life cycle, which is critical for the service delivery approach.

However, access to data and reports is currently facilitated by CWSA and IRC for districts that do not have or cannot use a local copy of DiMES. If the results are to prompt corrective action and inform postconstruction support, data and reports must be directly available to district staff. In Sunyani West district of the Brong Ahafo Region, enumerators have phones with both FLOW[41] and another application (GPS Essentials) so that previously collected data can be searched and displayed on a map. Tools like this need to be standardised and rolled out.

DiMES is still missing some data fields used to track service levels and sector performance. When DiMES is updated to match the new indicators defined by CWSA monitoring and evaluation committee, it will cover the full life cycle. At the moment, CWSA cannot change the database in-house but must depend on external help. The recurrent cost of data collection and information systems needs to be part of sector budgets at all levels; until that happens, budgeting will remain a major obstacle to long-term sustainability of any information system.

4.4.2 A strong learning and adaptive sector

The pilot project has shown how up-to-date information can be used for realistic planning, budgeting and adapting; this presupposes that the information is available to those who need it. The pilot data were analysed at both district and national level with support from IRC staff. Through joint analysis and dissemination at district, regional and national level, the results have been widely recognised by CWSA. Sector platforms like the National Level Learning Alliance Platform, facilitated by the Resource Centre Network, have disseminated results more widely.

Access to the information is nevertheless not universal: the data can be downloaded only by the few people with access to the Akvo FLOW platform or DiMES. There is no public interface to browse the data; only summary results are publicy available. New reporting tools and formats should be developed so that sector stakeholders can get the information they need. Visualisations online and offline can help stakeholders understand the issues and encourage all stakeholders to participate in devising solutions. Ending information asymmetry requires overcoming literacy, language and technical barriers so that everyone can access the information directly.

4.4.3 Harmonisation and alignment

Monitoring, in the long-term, must be owned by the government and not dependent on projects like the Triple-S pilot. In fact, projects and donors should depend on the information system. This would help align the numerous rural water supply projects with government-led strategies. Doing this in the long term will require new reporting tools for project and an easy to use online interface.

Wider access to data and links to other information systems would create additional incentives to maintain and update DiMES. Providing open access online and creating an application programme interface for third-party software to link to the DiMES data would enable other government agencies, donors, and NGOs to effectively work with the same data. It would also allow local groups, such as NGOs and community-based organisations, to use the data for their own activities.

4.4.4 Conclusion

In the long term, DiMES should become part of a sustainable system with at least annual updates. Information needs and technologies will continue to change, and CWSA and districts, the major users, should have the necessary financial resources, capacity and mandate.

[41] The latest version of Akvo FLOW (1.5) is also meant to have a repeat data collection function, which allows updating existing data points using similar functionality. Currently, IRC has been using FLOW 1.0 but will soon upgrade.

The data collected during the pilot have improved the understanding of the functionality of water systems, service levels and the performance of service providers and authorities. While the pilots have shown that the data and subsequent analyses and reports can influence decision makers, rolling out a fully functional system nationally will require an incremental approach to address the many technical, social and programmatic obstacles.

Ultimately, rural water supplies can improve only if sector guidelines are enforced, corrective action takes place and evidence is used in planning and budgeting. An effective information system can be an important tool to help sector stakeholders know where the first steps need to be taken.

5 SECTOR MONITORING AND EVALUATION SYSTEM IN BURKINA FASO

Burkina Faso has an annual sector monitoring process that includes repeat data collection. This case study was intended to see whether ICT could improve the process. After describing the context, we present the new technologies to support data collection, transfer, management, analysis and dissemination and compare them with a WA-WASH project monitoring exercise. Finally, we evaluate the social, technical and programme design of the system and discuss how ICT could be used for service delivery monitoring.

5.1 BACKGROUND

Burkina Faso has a population of approximately 14 million, of whom 77% live in rural areas. A significant number of people – up to 46% in 2004 – remain below the poverty line. The per capita GDP is US$1,304 (IMF, 2010). Current coverage for rural and peri-urban water supply stands at around 52%, but there are significant disparities between regions. The country comprises 13 regions, 45 provinces, 351 communes and about 8,300 villages.[42] In rural areas, people are considered covered if they are within one kilometre of a working water point at the time of the data collection (in urban areas, the distance is 500 metres). Most services are season-oriented, since boreholes are often unused during the rainy season.

Burkina Faso has been undergoing decentralisation since 1998. In 2000, the government began devolving responsibility for water services provision to local authorities at the level of communes. Communes prepare investment plans for water supply and sanitation on the basis of national criteria (PN-AEPA, 2006). To finance the activities and investments, a commune may request funding from the central government through the Regional Directorate of Agriculture and Water (or DRAH). It is DRAH's responsibility to support the communes in project management and implementation of the plans. DRAH also consolidates information from communes before it is entered into the sector information system.

Service providers in rural and peri-urban areas are a mix of community based (water user associations and technicians) and private or public (Zoungrana, 2011). Both kinds of providers handle day-to-day activities and report directly to the communes. In most cases, the communes and DRAH do not have the capacity to establish the lease contracts and run them effectively. The initial setup is often done at the national level by the General Directorate of Water Resources (or DGRE), under the Ministry of Agriculture, Water and Fisheries.

The roles of the various local actors have changed over phe last 10 years. There is sometimes a divide between what legislation prescribes and what is practiced on the ground. Certain information needs are therefore changing as well.

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[42] Triple-S website page on Burkina Faso.

5.2 NATIONAL MONITORING AND EVALUATION SYSTEM

Burkina Faso has developed an information system for monitoring rural water supplies. A 2007 manual describes the comprehensive National Monitoring and Evaluation System (hereafter, "the information system") and a 2008 manual details the National Information System on Water (Système National d'Information sur l'Eau, or SNIEau). Together, the two systems are meant to provide accurate information for planning and decision making at all levels. An inventory of rural water points, taken every year, tracks the status of facilities and national coverage. These are referred to as results indicators. There are also performance indicators, primarily focused on finance and some management indicators. There is little to no tracking of service levels, however.

Monitoring is organised around three main instruments:

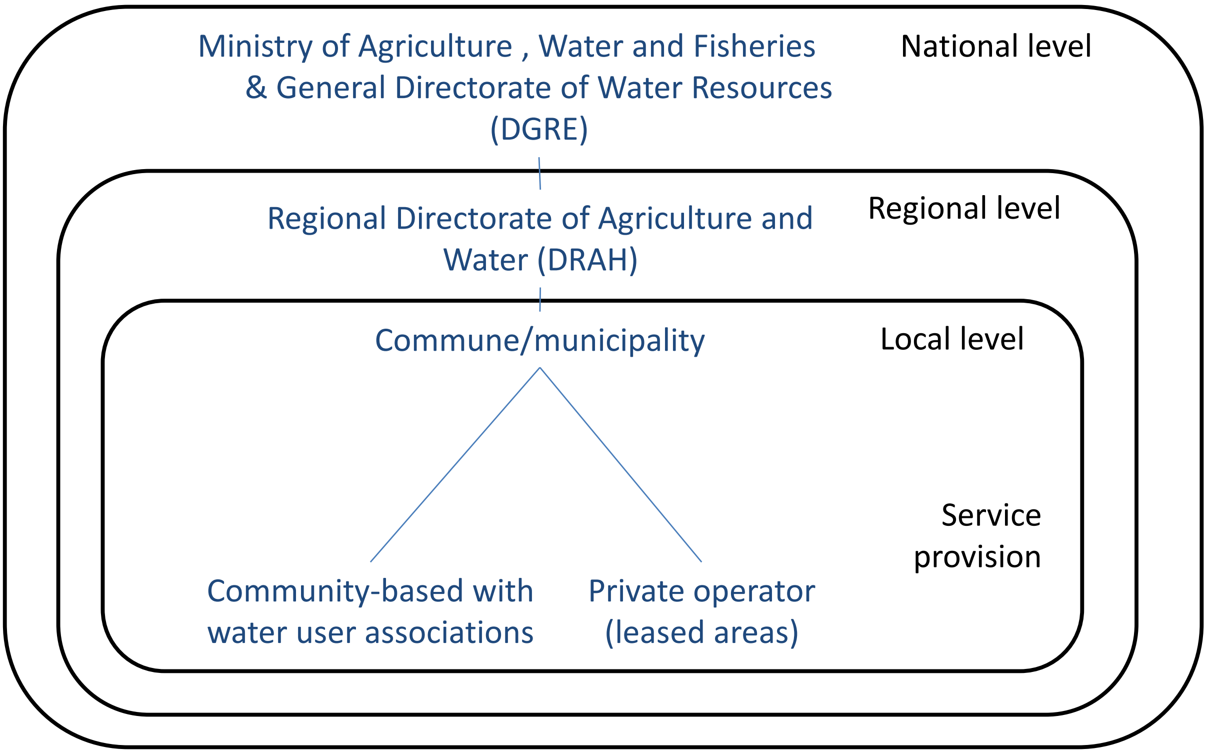
- the national inventory of all rural water points (stored in a database);
- a financial instrument for the planning and tracking of budgets (for each objective); and
- annual and semester reports.

Outputs include communal plans, a performance matrix of indicators and annual public reports on the state of the water sector.

5.2.1 Users and information needs

SNIEau has institutional processes that ensure data collection, management and reporting and already uses the national inventory database. To see whether ICT and, in particular, mobile technologies could improve SNIEau processes, the project began by looking at the roles and responsibilities of users and their information needs.

FIGURE 7. INFORMATION SYSTEM USERS



The primary users of SNIEau at the national level are the Ministry of Agriculture, Water and Fisheries, donors, and other international organisations. Within the ministry, DGRE is responsible for issuing annual sector reports, project evaluations, and procurement reports. DGRE also manages the national inventory database. It enters data received from the regions and sends the latest data to regions and communes on request. An annual sector review lets stakeholders reflect on progress, primarily long-term functionality (defined as no breakdowns for longer than a year) and coverage rates. Currently, SNIEau meets the information needs of the national and regional level as far as the national targets are concerned but omits most information on service levels achieved. Some indicators of the management and financial performance (capital costs only) of sector actors are tracked (DGRE, 2012). Other indicators include the proportion of communities with plans, contruction completed, disparity (equity), the percentage of certified mechanics and the extent of delegation to private service providers.

At the regional level, DRAH is responsible for helping the communes manage services, assets and implementation of new projects. To target its support, it requires up-to-date information on the performance of communes and service providers. It is also a channel through which communes obtain additional funds if their allocations within the national water policy are insufficient. Currently, SNIEau does not track any performance indicators except the proportion of allocations that are spent and the proportion of facilities that are delegated. It is DRAH's task to compile data, based on inputs from the communes and implementers working in the region, and provide that to DGRE.

Communes have a vested interest in keeping track of assets and their functionality and ensuring that private and community-based service providers can maintain rural water services. They need information to support, for example, corrective action when a water user association or private service provider cannot maintain a service of sufficient quality. The office of the mayor receives reports and data from the local stakeholders, such as mechanics and NGOs, as well as data from the national inventory data collection.

Water user associations are the community management bodies that track the operation of facilities and their management and report back to the communes. They supervise and coordinate water point caretakers and mechanics, collect tariffs and compensate the mechanics in accordance with standards set by the communes, and represent household users (USAID WA-WASH, 2012). In areas with private operators (22% of service providers), the water user association's primary role is representing users.

Few water point caretakers are paid; they usually work on a voluntary basis. Water point management committees are meant to manage day-to-day activities and are accountable to water user associations. Currently, there is no clear monitoring framework for these committees, and they are not tracked as part of the information system. In some places without water user associations, they act as community-based service providers.

According to a USAID study (Dubé, forthcoming), tariffs are low and heterogeneous at the commune level. Based on the collection rates, water user asociations cannot afford major borehole repairs. Financial performance monitoring at the level of communities could therefore be very useful for communes and water user asociations.

Although water user associations and private service providers are supposed to provide biannual reports to the communes, many communes lack staff with expertise in water supply and engineering who can interpret and cross-check the data. Information must be presented orally or visually. In some districts, more than 90% of people (often municipal council members as well) are illiterate (USAID, 2012).

Despite their lack of capacity, communes have the authority to set tariffs and royalty fees at water points and they are supposed to support subcommunal structures (USAID WA-WASH, 2012). The capacity gap is now slowly being addressed through hiring and training programs for technical staff and municipal council members.

Service level and performance monitoring

The national standard service level has defined indicators based on benchmarks for water quantity and quality, distance to water points, and crowding. Tracking these indicators together with performance could help meet the information needs of water user associations and communes.

Although SNIEau was designed to include indicators on infrastructure, access, functionality, financial performance and the delegation of service provision (Tome 2, p. 15), there is no established nationwide process to monitor water service levels, performance of service providers or support from authorities. However, some water systems monitor service levels on a smaller scale. For example, in the Sahel region, the main contractor, FasoHydro, has a proprietary system for monitoring operations and services. It can produce detailed reports on a yearly basis for the communes. The water user associations have no equivalent mechanism.

The largest drinking water supply systems in Burkina Faso belong to the National Office for Water and Sanitation, which was founded in June 1985 as a parastatal, independent commercial company fully owned by the state. It has long experience in building, operating and maintaining piped distribution networks and focuses its activities on urban areas. This agency has its own performance monitoring system and database but does not yet use mobile data collection. As it extends into larger and less-dense peri-urban areas and small towns, mobile data collection may become attractive, and in the future, both it and SNIEau should be able to feed service level information into a single national database.

5.2.2 The monitoring information flow

The monitoring information flow in Burkina Faso is described in detail in a DGRE manual. The majority of monitoring indicators are aggregated from the commune to the regional level and then to the national level. Some data are collected at the regional level; a few indicators, related to the financial performance of the sector and good governance, are national level. The following subsections look at the data collected at the level of service provision in the districts.

Data collection

Every year, implementers (e.g., international NGOs) are required to fill out forms on the point sources they will be installing or rehabilitating and submit them to the mayor (or the préfet of the department or province) and to DRAH. Private service providers and the National Office of Water and Sanitation collect information on operations and service levels but only for a small proportion of peri-urban and rural areas. In areas served by private service providers who manage small networks, written reports are submitted to the commune twice a year and provide some information that could be useful for the commune’s own monitoring and reporting. At the moment, there is no standard system for managing any raw data or information provided by these private service providers.

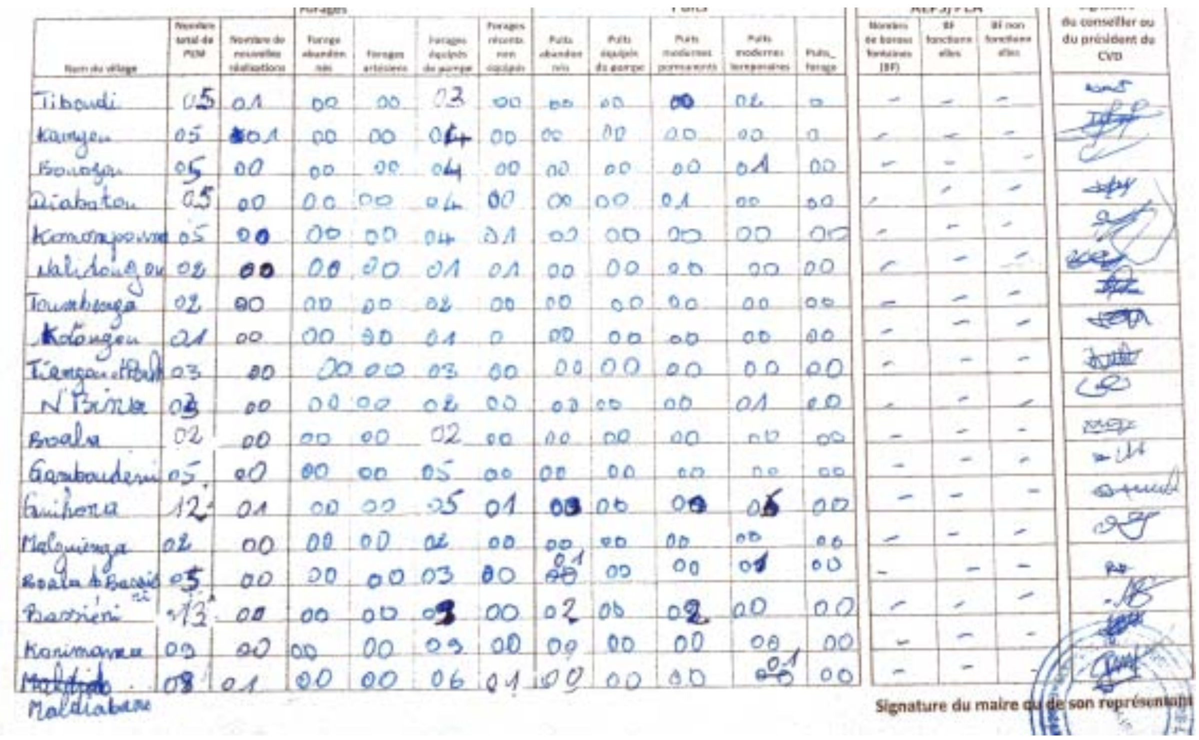
The largest data collection exercise is the national inventory of rural water supplies, which was put in place in 2008. Initially, the national inventory was carried out twice a year, but frequency has been reduced to once a year. It focuses on the functionality of facilities. Information collected on new facilities also includes such information as the named location, type of water point, brand of hardware, and GIS coordinates. Enumerators are hired on an annual basis to administer surveys in each commune about the status of facilities. The entire exercise is done on paper, using forms defined at the national level.

Enumerators must be able to distinguish types of technology. The locations of water points are captured with professional GPS units (e.g., Garmin eTrac), which have a higher accuracy than most mobile phone GPS units. However, the GPS coordinates are captured on paper and thus subject to transcription and data entry errors.

Data transfer

The raw data are physically transported on paper by motorbike or car to a regional center, where they are compiled before being sent on to DGRE. A formal signature is required for approving the data (Figure 8). Although using paper creates a paper trail, the commune may lack a copy of the raw data.

FIGURE 8. SHEET USED TO VERIFY DATA, WITH SIGNATURES OF COMMUNE OFFICIALS



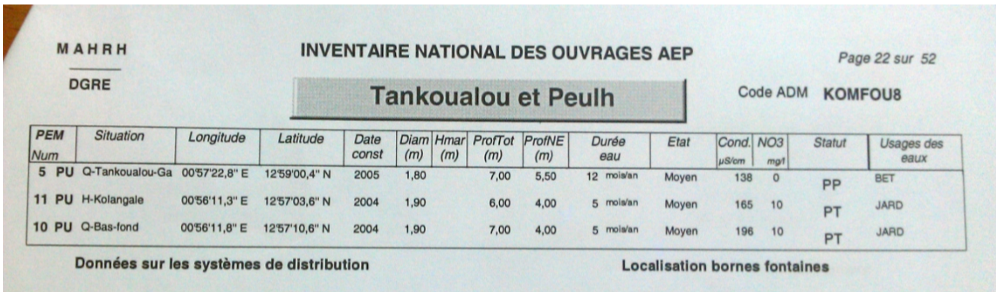
Nom du village	Nombre total de PEM	Nombre de nouvelles réalisations	Forages abandonnés	Forages artésiens	Forages équipés de pompe	Forages récents non équipés	Puits abandonnés	Puits équipés de pompe	Puits modernes permanents	Puits modernes temporaires	Puits_forage	Nombre de bornes fontaines (BF)	BF fonctionnelles	BF non fonctionnelles	Signature du conseiller ou du président du CVD
Tiboudi	05	01	00	00	03	00	00	00	00	02	0	-	-	-	[signature]
Kaungou	05	01	00	00	04	00	00	00	00	00	0	-	-	-	[signature]
Bouroga	05	00	00	00	04	00	00	00	00	01	00	-	-	-	[signature]
Diabatou	05	00	00	00	04	00	00	00	01	00	00	-	-	-	[signature]
Komonjpouna	05	00	00	00	04	01	02	00	00	00	00	-	-	-	[signature]
Nalidougou	02	00	00	00	01	01	00	00	00	00	00	-	-	-	[signature]
Toumbenga	02	00	00	00	02	00	00	00	00	00	00	-	-	-	[signature]
Kolongou	01	00	00	00	01	0	00	00	00	00	00	-	-	-	[signature]
Tiengou	03	00	00	00	03	00	00	00	00	00	00	-	-	-	[signature]
N'Bina	03	00	00	00	02	00	02	00	00	01	00	-	-	-	[signature]
Boala	02	00	00	00	02	00	00	00	00	02	00	-	-	-	[signature]
Gambourdeni	05	00	00	00	05	00	00	00	00	00	00	-	-	-	[signature]
Guihona	12	01	00	00	05	01	03	06	03	06	00	-	-	-	[signature]
Malguinga	02	00	00	00	02	00	00	00	00	00	00	-	-	-	[signature]
Boala A Bassi	05	00	00	00	03	00	01	00	00	01	00	-	-	-	[signature]
Barrieni	13	00	00	00	03	00	02	06	02	00	00	-	-	-	[signature]
Konimonwa	03	00	00	00	03	00	09	00	00	08	00	-	-	-	[signature]
Maldiabari	08	01	00	00	06	01	09	00	00	01	00	-	-	-	[signature]

Signature du maire ou de son représentant

Data management

The data are entered into SNIEau at DGRE in Ouagadougou, the capital city. Without double entry or error checking, the risk of data entry errors is high. Initially, SNIEau was stored in a Microsoft Access SQL database but has since been transferred to another database that can handle the quantity of data.

FIGURE 9. EXAMPLE OF DATA STORED IN DATABASE


MAHRH

DGRE

INVENTAIRE NATIONAL DES OUVRAGES AEP

Tankoualou et Peulh

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Code ADM KOMFOU8

PEM Num	Situation	Longitude	Latitude	Date const	Diam (m)	Hmar (m)	ProfTot (m)	ProfNE (m)	Durée eau	Etat	Cond. µS/cm	NO3 mg/l	Statut	Usages des eaux
5 PU	Q-Tankoualou-Ga	00°57'22,8" E	12°59'00,4" N	2005	1,80		7,00	5,50	12 mois/an	Moyen	138	0	PP	BET
11 PU	H-Kolangale	00°56'11,3" E	12°57'03,6" N	2004	1,90		6,00	4,00	5 mois/an	Moyen	165	10	PT	JARD
10 PU	Q-Bas-fond	00°56'11,8" E	12°57'10,6" N	2004	1,90		7,00	4,00	5 mois/an	Moyen	196	10	PT	JARD

Données sur les systèmes de distribution

Localisation bornes fontaines

Analysis and dissemination

After data input, additional analysis is conducted by two DGRE staffers using ArcGIS. The analysis includes the distance of users from water points, the number of people near the source, functionality and coverage; the data are then combined with population information and results presented to commune through DRAH.

The time lag between the collection and reporting of results is considerable, at least partly because of the use of paper forms. Communes may request a copy of relevant information in the national database. However, the database does not contain temporal or geographical resolution required for adequate planning, monitoring and management of service provision at local level. At national level, the results are compiled in a sector performance report (Rapport Bilan Annuel PN-AEPA) and presented at the annual sector review. In addition, the DGRE has a large plotter with which it can produce ArcGIS maps.

Paper reports and meetings are the most common medium for disseminating results of analysis; there are no public websites where data or results can be accessed.

Use of the information

The national inventory is primarily used for monitoring coverage and progress against targets of the national government, NGOs and mayors. It is also used for budgeting the installation and rehabilitation of water points. The resources for communes are determined by the information on infrastructure and functionality and paid out of the government's sector fund managed, with inputs from donors. The budgeting does not take into account additional funds provided by NGOs and other funds raised by communes from external parties (e.g., twining partnerships).

SNIEau information is limited to annual planning. Because a water point is considered nonfunctional only if it remains broken after 12 months, a long delay may occur between the breakdown, the report of the problem, the allocation of money to fix it, and the ultimate water point repair. In 2011, 29.3 percent of rural handpumps and 15% of rural piped systems were reported nonfunctional. Small breakdowns are meant to be handled at the level of commune and are not monitored.

5.2.3 WAWASH monitoring exercise in the Sahel region

Through a Triple-S initiative financed by USAID WAWASH, IRC and local partner Eau Vive tested new technologies for collecting data and measuring service delivery. The study took place in eight rural communes in the Sahel region of Burkina Faso (WAWASH, 2012). This experience indicates how SNIEau might be augmented with mobile technologies, especially for data collection and transfer.

Data collection

The WAWASH project tested the use of mobile data collection (Akvo FLOW) combined with improved coding of households and facilities to track the level of service provided to each household over time with a great level of granularity. The project used barcodes for each water facility and household to track the use of the water point by different households.[43] The barcodes were read with Android mobile phones equipped with cameras. The mobile phones' internal GPS units captured the location of each household and water point. These data were then stored on the phones. Overall, training enumerators to use the new technology was not difficult, and the barcode reader simplified data collection.

Mobile phones (like any electronic device), however, depend on battery life and access to electricity. Of the backup chargers tested, car batteries were the most convenient sources for recharge in the field. Sun glare on the screens was another challenge.

Data transfer

Mobile phone connections are often available where there are also GPRS mobile data connections. The WAWASH project used GPRS to send the data, but in some cases, a day's travel was required to reach the connections. The data were sent directly from the field to Google and Amazon S3 servers, which store data for the Akvo FLOW application. Sending data directly from the device to servers reduces human processing and transcription errors. Transfer usually occurred before the enumerators left a community. Four supervisors checked the data regularly and called enumerators when problems arose so that they could redo surveys if necessary.

Data management

The online dashboard for the version of FLOW used was rather rudimentary. It was possible to monitor data as they were submitted and to edit records through the web-based dashboard, but options for analysis were limited. Instead, the data were exported to Excel sheets for further analysis. FLOW databases can be linked directly with any other Internet-enabled database (e.g., an SQL server), but for this one-off exercise, the data were shared manually with DGRE.

Analysis and dissemination

Excel was used to compile the data and do basic analysis. QGis, a free open-source equivalent to ArcGIS, was used to do geospatial analysis and generate maps of the results. The WAWASH data set includes use, service level, and performance information and there is a clearer link to practice at the local level. The data and results have been shared with two out of the seven surveyed communes so far. However, due to limited automation of the data analysis, the feedback has been slow and the situation may have already changed in many villages.

For sharing publicly online, WAWASH can provide public access to a map of water points through Akvo FLOW. However, the system is shared with other IRC projects with different data sets and the WAWASH data collection was a one-off exercise, so the map has not been configured for this.

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[43] Durable, oxidised, laser-printed aluminium plates could not be installed in the time so the barcodes were printed temporarily on paper to test the method. Standard aluminium plates are known to wear rapidly in Burkina Faso.

Use of data

Because of the limited scope of the project and delays in analysis, as of December 2012 it is too early to tell how information on service level and performance are affecting practice. Repeat data collection and quicker feedback loops will be required to test this more fully.

5.2.4 System design

The design of SNIEau is analysed below, using the previously defined categories of social, technical and programmatic design. Overall design can help identify gaps where ICT may be able to play a role.

Social design

ICT for sector monitoring is primarily limited to the SNIEau SQL database and ArcGIS. These software packages are used by trained specialists at DGRE, and their analyses serve the needs of the national level. Potential users at the regional and commune levels would need to install software, pay license fees, and have training—difficult to do in a decentralised administration. Other users may request data from DGRE or find the raw data in DRAH or, in some cases, their commune. There is little opportunity to generate maps and standardised reports for local stakeholders.

The national inventory has been successful at measuring coverage and functionality for the purpose of annual planning. However, infrequent data collection and a lack of service level indicators prevent the results from being used to trigger corrective actions throughout the year. To meet the needs of water user associations, other service providers and the commune, the SNIEau would need to include service level indicators and easy tools for collecting, accessing and analysing the data. It would also need to allow standard reports to be generated with a standard phone or computer. The greatest benefit may be achieved by developing information systems that illiterate persons can use; examples are voice-based alerts for mechanics, picture-based surveys for data collection, and the ability to use a voice system or call centre number to report a problem. To address information needs at the level of private water operators and water user associations, SNIEau would have to consider users' different capacities and information needs and ensure wide access to reports.

Under WAWASH data collection, each household had a unique barcode to track members' use of facilities. Once aware of how the data would be used to determine service levels, people were willing to carry the barcodes. A few community members were asked to report breakdowns and even travelled to the next village to make the report, based on the assumption that the facilities would be repaired. This suggests that service level monitoring can improve service delivery if users trust the programme—and that the cost of the technology must not starve the budget for correction action.

Technical design

The national inventory is a locally hosted database: it depends on local installations. Growing coverage of mobile phone networks with GPRS provides an opportunity to develop information systems that can scale across the country, even at the level of the commune. SNIEau has become outdated.

Programme design

Data collection for the national inventory is part of the national agenda and budget, and this information system has been funded and implemented every year since it started.

Using mobile communications has the potential to reduce fuel and vehicle costs, depending on how the technology is implemented and who collects the data (water user associations, communes, hired third parties). If service data were collected locally as part of the regular travel of the commune and service providers, the total costs of an ICT system are not likely to be high. If, however, enumerators are hired to visit every water point in the country, costs will not necessarily decrease.

5.3 DISCUSSION OF RURAL WATER MONITORING IN BURKINA FASO

Burkina Faso has put significant effort into annual sector monitoring and produces comprehensive reports on coverage and long-term nonfunctionality every year. It works on the basis of inputs from actors in a decentralised sector undergoing rapid changes. The sections below use the principles for sustainable services at scale to discuss how to build on this success.

5.3.1 The service delivery approach

The current indicators track the functionality of water points, some aspects of financial and management performance and the level of delegation to private service providers. This is useful for annual planning. However, the granularity and rate at which the data are collected and reported do not promote rapid response to problems in the regions and communes. In addition, the financial data do not encompass the full life-cycle costs. The primary costs tracked relate to capital expenditure and ignore important recurrent expenditures, such as the costs of operations and direct support to service providers. Including indicators for service levels and adding more indicators for the performance of individual communes and service providers would better meet the information needs at district level.

Mobile data collection has the potential to cut the time between collection and automated analysis while also reducing data-entry errors. Online reporting could extend access to any stakeholder with an Internet connection.[44] Automated analysis and reporting can handle larger volumes of data and target different information at different stakeholders.

Improved data collection, transfer, data management and reporting, however, will require new recurrent budget lines and new competencies. The potential time savings, convenience, and reduced errors from using mobile data collection may be worth the investment, especially when coupled with more detailed service monitoring. If information systems are used to trigger corrective action before major breakdowns, the annualised costs of rehabilitation per facility could decrease and service levels would be maintained. Improving corrective action may require an increase in the total operational, capital maintenance and direct support expenditure.

5.3.2 A strong learning and adaptive sector

The longevity of the sector monitoring system and the budgeting and finance agencies' alterations to the indicators suggest that the sector is using the results for planning. On-going data collection and an updated database are excellent signs that Burkina Faso is learning and innovating at the national level.

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[44] Online submission of forms and web-based reporting also may have a role to play in data collection. Currently, implementers are required to submit a form for each new project to report on planned infrastructure. Every six months, the implementer must also report on newly installed infrastructure. These forms could be provided through a web browser. Using web-based forms and generating automatic reports could reduce the administrative work of implementers (DRAH and DGRE) in the long term as Internet access increases.

Ideally, communes, villages and water user associations would adopt the same level of adaptive behaviour. Making the database more accessible at all levels and producing reporting tools that meet the needs of local stakeholders would help them make use of the information.

5.3.3 Harmonisation and alignment

In Burkina Faso, the information system is integrated into sector budgeting, and the results of the inventory are available to government workers at different levels and also to donor partners. The system can promote alignment of donor partners and NGOs with government-led strategies. Putting SNIEau online and making it publicly available would go further to help with harmonisation and alignment between different ministries and donor partners, especially as government workers' access to the Internet increases.

5.3.4 Conclusion

Burkina Faso is an interesting case because data are collected regularly, in a context of decentralisation. However, the country ranks 149 of 152 countries in an ICT development index (ITU, 2011), and communes or other local staff cannot be presumed to have access to or experience with a smart phone. Even an app for a basic phone (e.g., Frontline SMS) usually requires special installation and basic training. As a result, use of ICT for water sector monitoring will still be limited, particularly in rural areas. However, in most communes, some members of communes and water user associations may soon be able to use Internet or voice-based systems with training and technical support considering the pace of ICT penetration. Mobile and online information systems could allow local stakeholders to monitor service but will need to be adapted to their limited experience with ICT. This may happen gradually, as new budget lines and competencies are developed in DGRE and other institutions.

6 SCALING UP SECTOR MONITORING

The case studies of Ghana and Burkina Faso have illustrated how information systems to monitor rural water services involve more than new technology. The long-term sustainability of these information systems depends on the social, technical and programme design of the system. More importantly, the information system will make a difference only if it supports the three pillars of sustainable services at scale: a service delivery approach, a learning and adaptive sector, and harmonisation and alignment.

These cases have also shown the incremental and complex nature of progress, especially where there are several water service delivery models and stakeholders have different roles and responsibilities. We offer the following recommendations for scaling up information systems so that the monitoring data can be used to improve rural water services.

6.1 ADAPTIVE DESIGN AND FREQUENT TESTING

The design and implementation process should be adaptive. In traditional software design and software marketing, features are presented as a long list of specifications. This addresses simple problems in predictable environments, but rural water supply is inherently complex. The development of information systems needs to accompany the scaling up of sector monitoring processes and corrective action in a phased approach. In addition, ICT staff and consultants require time to understand how information systems will fit into the process.

To ensure an adaptive process:

- Use agile software development methods[45]: define simple functionalities with users, implement them quickly, and then test, adjust and repeat.
- Include the stakeholders who will be providing data and using the reports: engage with them and build their trust in the information system.

An agile approach might prioritise functionalities—say, mobile data collection—and then implement these over a month before testing this function with users and refining the data collection process.

User testing can take many forms. To address the high rates of failure of information systems in both industrialised and developing countries, Richard Heeks developed the Design–Realitv Gap model to score implementation (Heeks, 2002; Bass and Heeks, 2011). The design–reality gap measures the fit of a particular information system with real processes based on the following dimensions (Hawari and Heeks, 2010):

- information (data stores, data flows);
- technology (hardware, software);
- processes (activities of users and others);

[45] http://en.wikipedia.org/wiki/Agile_software_development.

- objectives and values (culture, politics);
- staffing and skills (quantitative and qualitative competencies);
- management systems and structures; and
- other resources (time, money).

Asking users to score the gap (1–10) after the major features have been developed may indicate whether the information systems will meet monitoring objectives. This comprehensive framework may be too heavy for regular testing but could be useful at critical junctures in revealing the level of investment required in both people and technology.

Because information systems must also meet the information needs of ICT users close to service provision (in communities, districts and regions), developers should include and test indicators for the full life cycle of services and providing tools and formats for access to the data so that people can act in a timely manner.

6.2 BUILDING FOR THE LONG TERM

Information systems for monitoring are long-term, recurrent investments. Sector stakeholders should be committed to using, financing (on a recurrent basis) and updating the information technologies and ensuring that ICT staff can support use of the information systems.

Data exchange and interoperability

A single information system may not be the right choice if different stakeholders can manage their own systems. Often, agencies more readily agree to share data if they do not have to migrate to a new, single information system that may not yet even exist. The best way to share data is to ensure that different systems are interoperable.

It can be useful, however, for stakeholders to agree on data exchange formats and metadata so that the information across systems is consistent. These formats should not be so rigid that new indicators cannot be added. From a technical perspective, the system should use as many open standards as possible[46] to ensure its longevity and the transfer of data when new technologies arrive.

Using the same tools, such as mobile phones, across sectors simplifies use of the technology and helps control training and support costs. A district environmental health officer, for example, should have just one smart phone that can host apps for both health and water. National e-government policies could promote such coordination and harmonisation across ministries.

Technical support and software as a service

For programme design, technical support and expertise must be available, and software updates and changes to the information system should be part of normal operations. This expertise can come from an in-house ICT team or it can be outsourced. Software as a service and cloud-services can be a useful way to outsource some technical support and bug-fixing, since these services typically have a large user base and

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[46] Examples are IATI, JSON, RSS, XForms.

the costs are divided over all users. It could also be helpful to identify ICT resources used in other sectors and in e-government programmes and find strategic ICT partners, such as mobile phone companies.

Ensure the quality of information

Higih-quality information establishes trust and promotes regular use of the information system. Including all major service[47] and performance indicators to match sector guidelines is the first step. To track changes over time—and make the technology easier to use, identifiers for water facilities, households and service providers should be unique (Davis, 2012)[48] and robust,[49] and the indicators should be well structured.

Some sources of information may be less reliable than others. Validation of the data—through verification by a third party or repeated data collection—is therefore important.

Covering recurrent expenditure

Recurrent expenditures for ICT systems must be budgeted by government institutions. When information systems appear as new budget lines for agencies with financial constraints, resistance is likely. Even so, the total cost of monitoring in most cases is almost negligible compared with the costs of installing new rural water supplies or replacing broken infrastructure country-wide.

The cost of corrective action and achieving standard levels of service will likely exceed the cost of sector monitoring. For example, the WASHCost benchmark ranges for sustainable direct support are (2011)US$ 1.00–3.00 per person per year (Fonseca and Burr 2012), which surpasses monitoring expenditure by at least an order of magnitude, based on the Ghana case study. Some WASHCost research indicates that the total costs of achieving sustainable services will decrease with better monitoring and corrective action. Therefore advocacy for information systems is essential.

6.3 CONCLUSION

In this paper, we provided a conceptual framework to examine how the use of information and communication technologies for monitoring can contribute to sustainable rural water services by meeting the information needs of sector stakeholders. The framework explicitly links information systems for monitoring with the goal of achieving sustainable rural water services at scale. The brief cases of Ghana and Burkina Faso were used to illustrate how this technology can improve the information flow.

In the service delivery approach, information from across the life cycle of a service supports sector actors in their respective roles and responsibilities. Useful, timely data in accessible formats also support a learning and adaptive sector by enabling people to reflect and acting on the information. Finally, opening data and improving communications across agencies and organisations encourage harmonisation and alignment.

The cases showed the basis for using data to improve service delivery:

- Useful monitoring reports can be generated only if the right indicators are collected and reporting formats are standard.

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[47] Defined as the quantity, quality, accessibility, and reliability of the water service (Moriarty et al., 2011).

[48] http://rwsnblog.wordpress.com/2012/09/24/why-physical-unique-identifiers-on-water-points-will-improve-sustainable-services-2/.

[49] That is, it will not change over time, when administrative boundaries or other factors are used to generate an ID change.

- Information improves service delivery only if it is targeted to those charged with taking action, their roles and responsibilities are clear, and the costs of maintenance are covered.
- An information system will be sustainable only if the recurrent costs for its management and analysis of data are budgeted.

Flexible information systems for monitoring rural water supplies can be developed to meet sector information needs. It may require a shift in thinking on the part of governments, donors and other sector actors to ensure that money and staff are reliably available. The growing reach of the Internet, mobile networks and cloud services will allow people collect the information they need to improve services in even the most remote rural areas. However, it is up to sector stakeholders to ensure that these information systems are funded, designed, and used to reach sustainable rural water services at scale.

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