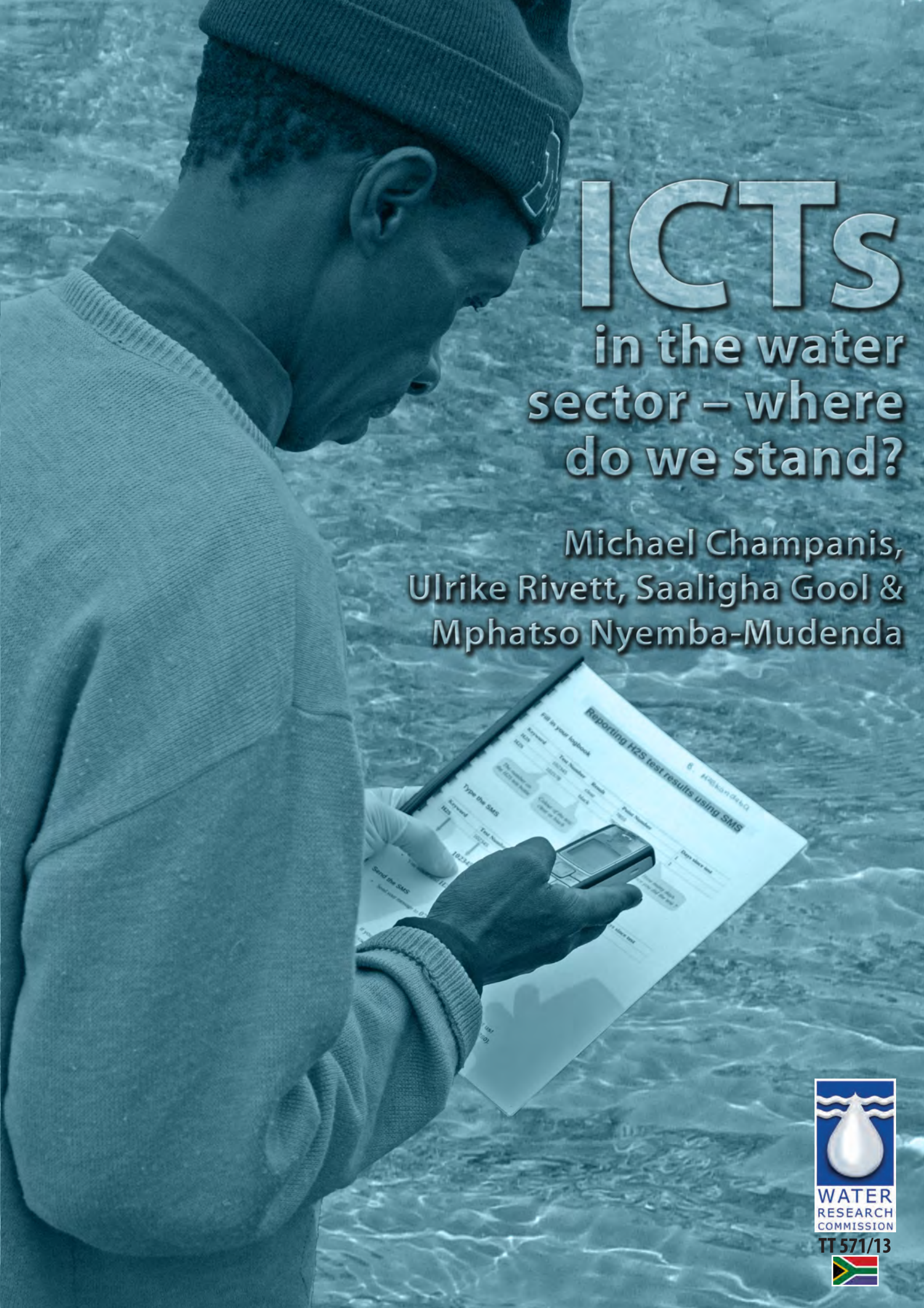

ICTs in the water sector – where do we stand?

Michael Champanis, Ulrike Rivett, Saaligha Gool & Mphatso Nyemba-Mudenda

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ICTs in the water sector – where do we stand?

Report to the
Water Research Commission

by

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Executive Summary

Introduction
Over the last decade Information and Communications Technologies (ICT) systems have become known as a potential solution for developing countries and their information needs. The wide distribution of mobile phones in even the most rural environments has created the suggestion that cellphones are far more than a mere communication tool. Cell-phone systems used for data collection, mobile payment and crowd-sourcing initiative to improve governance and other applications are offering a new way of using technology to improve access and might have the potential to improve service delivery.

The WASH (Water and Sanitation and Hygiene) sector has also seen an increase in ICT applications mainly for the purpose of improving data collection, information flow between decision makers and engagement with the wider public.

This research project was undertaken in order to assess the status-quo of ICT solutions in South Africa. The aim of the study was to understand in more detail the potential for ICT in the South African water sector, to learn from the successes and failures of existing systems and understand the enablers and barriers for ICT implementations.

One of the aims of the study was to identify how the South African water sector could benefit from the use of ICTs in order to establish national research needs and to initiate an agenda for the development of a long-term strategy of the use of ICTs in the WASH sector in South Africa.

Literature Review
As part of the literature review, 111 papers from a variety of journals, conference proceedings, agency reports and the internet were reviewed in order to answer the following questions:

- What can we learn from ICT projects in related sectors?
- What is the status quo of mobile applications in the water and sanitation sector?
- Does smart metering or smart grid technology provide real cost-effective benefits?

An abundance of literature was found in the ICT4D and health fields, but significantly less in the water sector, particularly for South Africa.

In the related sectors, key findings were that long-term evaluations of ICT and mobile projects are urgently needed in order to improve existing systems as well as develop new systems more appropriately. Some authors suggested that improving the evidence base for mobile applications is the greatest challenge to widespread adoption. Currently there is no substantial and rigorous assessment that provides proof for the tangible benefits at a reasonable cost that new ICT solutions might offer.

Another highlighted shortcoming was the notion that the sector as a whole has little understanding on how to measure success of an implemented projected. Common frameworks and a strategy to integrate existing and new systems into a single platform were highlighted by most authors.

When looking at successful projects in related sectors, several common factors were highlighted, such as:

- program goals were clear and realistic

- users were involved in planning and design
- project focus was on benefits rather than on the technology
- buy-in from all stakeholders (particularly government)
- appropriate solutions (social, and technical)
- long-term monitoring and evaluation strategy present
- understanding the socio-cultural context
- ensure systems are easy to use
- fulfil a key need

It was found that the majority of ICT systems in the public sector are used for information gathering and sharing or co-ordinating actions and rely on technologies such as SMS, voice or form-based data collection. Factors contributing to successes were realistic programme goals with solid knowledge of problems, early engagement with users and a clear assessment if the technology was the solution to the problem.

In the WASH sector, it was highlighted that mobile phones have not yet been leveraged to their potential and that ICTs could transform the sector if ICT solution are assessed for their use in monitoring, planning and management.

Mobile payments in the water sector might offer in the future a realistic alternative to current payment methods, particularly by reducing the costs associated with traditional billing methods. Aspects such as the probability of consumers paying their bills when the amount of time and energy required is reduced were mentioned as an incentive to investigate this area further.

The literature of smart water metering projects and implementation showed similar conclusions as the health sector. There are no formalised or long-term evaluations or studies providing sufficient evidence to counteract the high implementation costs that come with such systems.

Stakeholder Survey
The second part of the study focused on stakeholder survey in order to contextualise the findings from the literature review.

Practitioners and experts were interviewed through semi-structured interviews. Findings from a workshop held with 30 participants in the water sector were integrated in the report.

The analysis of the data was based on the following themes:

1. Benefits of ICT systems as experienced or perceived by the respondent
2. Negative aspects of ICT systems as experienced or perceived by the respondent
3. Barriers to ICT implementation
4. Readiness of organisations and government for ICT implementations
5. Value of ICT research

Based on the responses and the theme analysis, findings regarding the following objectives were formulated:

1. Challenges in the WASH sector in South Africa
2. Identification of current ICT practices in South Africa
3. Mapping of stakeholder expectations, experiences and needs
4. Identification of enablers and barriers to ICTs
5. Identification of research needs and water sector strategies for ICT

Findings and Analysis
Over the last five years there has been a substantial increase of ICT usage in the South African water sector. Broadly, the applications currently implemented, in development or envisaged can be categorised into the following areas:

- Customer Management
- Operational Management
- Financial and Control Management

In all of these areas, ICT applications are used to collect information, streamline information flow and improve work processes. The majority of the systems highlighted as successful showed two key aspects, namely, the system integrated into existing structures and the municipalities had made financial commitments to maintain the system. This correlates to the findings of the literature review of what makes ICT systems successful.

Experts in the field were concerned about the sustainability and the “wear-off” factor of the new and unproven technologies. Aspects such as not being able to measure the real impact were seen as a clear hindrance to the adoption of ICTs.

Integration with existing systems was probably the greatest concern. Past experiences of maintaining multiple systems, the resulting data duplication and increasing cost have resulted in a resistance to implementing new technologies without a clear strategy for systems integration.

Similarly, aspects such as institutional challenges, resource limitations, budget constraints, were identified to be a major hindrance to the progress of the water sector and participants felt, that ICT systems would not be able to address these issues sufficiently.

Municipal feedback suggested that the South African government is perceived to be ready for implementation of new technologies, which consultants in the private sector did not agree with.

Barriers to successful ICT adoption were identified as:

- misuse of the technology
- bureaucracy of procurement
- failure to understand project incentives
- uncertainty about how much effort a new system will result in
- politicising of new technologies
- shortage of technical skills
- risk avoidance

Enablers were identified as:

- increase in job satisfaction
- moving away from paper
- consistency of records
- better management and collection of data

Conclusions
The analysis of past and present ICT project in the water sector and related fields has shown that ICT development and implementation is complex and its success and failure are dependent on three dimensions which were highlighted in the reviewed literature:

1. Social Design – this comprises the social component of an ICT design. Aspects such as the social context of the implementation, organisational structures, stakeholders and the way in which information is shared are key concerns in this dimension.

2. Technical Design – the system appropriateness and technical correctness for the problem at hand

3. Program design – the support structure for scalability and sustainability of the project

There is a clear experience that ICT can assist in management functions of the WASH sector and the literature is optimistic about the value of ICTs in terms of development and incorporation thereof into the various development sectors, but conclusive proof of such assertions, however, remains elusive.

Key findings regarding enablers mirrored in the survey and the review were the following:

- program goals were clear and realistic and solid knowledge about the needs on the ground existed
- buy-in from all stakeholders (particularly government)
- appropriate solutions (social, and technical)
- understanding the socio-cultural context

The literature raised additional points regarding successful implementation of projects:

- long-term monitoring and evaluation strategy must be present
- users are involved in planning and design
- project focus was on benefits rather than on the technology

Barriers identified by both areas included:

- lack of policy, guidelines, or frameworks to work in
- failure to correctly understand project incentives
- stakeholder relevance incorrectly identified
- inadequate design methodology and evaluation

Recommendations for future projects and research
Three areas were identified which the findings suggest to be of benefit for the ICT sector in South Africa:

1. Development of a framework to analyse ICT projects in order to allow long-term evaluations and impact assessment of ICT projects
2. In-depth investigation to map the current IT practises within government which would allow a clearer understanding of the current use of IT as well as the strategy and vision for the future.
3. Developing an ICT community to connect networks across different sectors, such as academia, government and industry.

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1 Introduction

1.1 Background

With the world's supply of clean and fresh water decreasing, it becomes vitally important to understand and effectively manage water shortages, wastewater processing, and basic sanitation services. Accurate and consistent information appears to be an obvious starting point to providing sound water supply and sanitation services, as regulators, service providers, policy makers, and communities alike rely on good data to make informed decisions. Experiences across all industries globally indicate that IT systems are currently understood to be the best solution for the increasing information needs, yet it is not always apparent how to best utilise these advanced tools and how to evaluate the appropriateness of one system over another (e.g. an enterprise system over a more agile mobile phone system). In order to effectively future-proof systems, there is a need to understand how complex systems evolve over time, and how to meet changing needs and expectations. Whilst certain areas in the water sector already benefit from the use of IT systems (e.g. integrated laboratory management software and asset management systems), in recent years there has been an increase in the development and design of less rigid and more agile ICTs (information communication technologies), for example, using mobile phones for data collection. These systems are often spoken about with great enthusiasm as solutions for improving monitoring, communication and information flow. Cell phone applications in particular are seen as offering a number of new opportunities, such as improving communication and engagement within communities, and facilitating real-time, low-cost data and information transfer (as an example: the local monitoring of water sources and distribution of test results). The high dispersion of mobile phones within the developing world is seen as bridging the digital divide and a real opportunity to engage with remote rural villages and the most under-resourced communities.

The rapid advancement of technology and a lack of full understanding for technical constraints as well as unsustainable ("flash in the pan") solutions have led to a landscape in which pilot ICT studies are rapidly and frequently started, and just as quickly discarded, leaving little chance for reflection or sharing of knowledge and experiences. Projects independent of each other repeatedly encounter similar issues and problems. This might be avoided if there was a greater opportunity and culture of knowledge sharing within the field. With the disparate nature of projects and technologies in the sector it is often difficult to understand available opportunities and the progress, which has been made in a particular area.

1.2 Rationale for the research

Current global trends suggest that ICTs might substantially contribute to an improvement in the WASH sector and it is therefore important to understand the possibilities that ICTs might have to offer for South Africa and its neighbouring countries. South Africa has currently no formalised ICT research initiative or agenda within the water sector.

This report provides an overview of the current trends and developments globally in the ICT sector and by positioning current expectations and experiences within the South African context, guidance for future research needs and policy requirements are given.

In order to increase the understanding of opportunities and barriers for successful use of ICTs in the water sector in South Africa, this study analysed past and present ICT projects by describing the context and mapping their successes and failures. In order to learn from sectors where ICT has been established for longer, projects in mobile health and eGovernance were reviewed. The current understanding, perceptions, best practices and

experiences of local experts were assessed through a stakeholder survey and a subsequent analysis.

Another aim of the study was to identify how the South African water sector could benefit from the use of ICTs in order to identify national research needs in the sector and to initiate an agenda for the development of a long – term strategy of the use of ICTS in WASH. This was done by categorising the use of ICTs, identifying barriers and enablers as well as gaps and opportunities.

2 Literature review

2.1 Introduction

The aim of this literature review was to examine current and past ICT projects in the water and sanitation sector and "state of the art" systems in related sectors (mHealth, eGovernance) in order to analyse their successes, failures, barriers and enablers (cf. SWOT analysis).

Through this analysis the intention was to begin to unpack and understand what role ICTs might play in the South African water sector. By providing insight into documented ICT systems, it is highlighted what makes a project successful and sustainable, and how success can be measured.

The research questions posed in the literature review were the following:

- What can we learn from ICT projects in related sectors?
    - The ICT4D (information communication technologies for development) field has grown tremendously in the past few years – what lessons can be learnt from it?
    - More specifically, the health sector faces challenges that can often be analogous to problems face in the water sector – how has ICT use played out in the mobile health (mHealth) sector, and has it lived up to its promises?
    - Government is already implementing systems to better engage with citizens and to provide better access to relevant and up to date information – what benefits does this offer over traditional methods, and can they be applied to the water sector?
- What is the status quo of mobile applications in the water and sanitation sector?
    - Which systems have been documented in the sector, and what benefit do they provide over traditional methods?
    - Is there a relevant application of mobile money, or mobile payments, to water billing?
- Does smart metering, or smart grid technology, provide real cost-effective benefits?
    - What are the current state of the art systems globally?
    - What benefits does smart metering offer the water sector?

Methodology
Overall 111 papers from a variety of journals, conference proceedings, agency reports, and the web were reviewed. The publishing dates range from 1999 to 2013, with 83 papers published after 2010.

A database search was performed using the following platforms: ACM Portal, Engineering Village, Scopus (SciVerse), EBSCOHost, SpringerLink, and Google Scholar. Additional papers were also sourced by following citations in papers we had obtained, searching the WRC Water SA archives, and by sending out a request to an ICT research mailing list.

It was initially decided to define a strict set of search criteria, i.e. research time periods, paper rating (citation count, impact to field), specific databases, and a narrow set of keywords. We established that the criteria were too stringent and a broader approach to identifying appropriate literature was taken based on the field being still relatively young and not having become a mainstream research topic as of yet (cf. mobile health). It was also

noted that there is a shortage of formal rigorous research on the topic, and that the search was expanded to include case-studies, reports, and working papers.

Keywords (and combinations thereof) were: IT, ICT, water, LIMS, laboratory, information systems, mobile phone, communication, monitoring, cellphone, cellular phone, engagement, community reporting, management, review, mHealth, sustainable, WASH, mWater, eGovernance, tele-medicine, web, needs-assessment, intervention, water point, development, computer, safe water.

The title and abstract were read in order to ascertain relevance to the research. The review yielded an abundance of literature in the ICT4D and mHealth fields but notably less in the mWASH and mWater fields.

Papers that were obviously produced as advertorial content were not included in this literature review. This included self-produced product or system reviews.

Due to the large amount of papers found an initial analysis was performed in order to determine their relevance – this was done by categorising their topic areas, location, users, methods, and conclusions. After this analysis, 25 papers were chosen that were particularly relevant to the project and contained valuable insights (full list available in Addendum A).

Prior to beginning work on the literature review it was envisioned that the review would use the systematic process popular in the medical and scientific fields. As noted above, it became necessary to switch to a more traditional narrative style of review due to the narrow coverage and strictly prescribed methods of the systematic way which failed to turn up any significant amount of material due to the nature of the field. The narrative approach was generally comprehensive and covered a wide range of issues within a given topic, providing a good background to the subject to bring the reader up to date. The study maintained academic rigour in the narrative approach taken, at least as much as possible in such a new and changing field.

2.2 The South African Water Sector and the Potential for ICT

The South African water sector has over the last decade moved towards developing structures, policies and governance systems that allow the sustainable access to safe water and sanitation to all citizens.

Whilst the efforts and strides made are substantial, the country is still experiencing a number of key challenges, such as:

- Disparate access – 99.1% of households in the Western Cape has access to piped water, while only 77.8% of households in the Eastern Cape enjoy the same access – it should be noted that this percentage includes access to community taps located more than 200 m from dwelling or institution, which is considered a below basic level of service (Statssa, 2012)

- Issues with respect to water quality – the 2012 Blue Drop Report for Mpumalanga included the following notice: “[t]he Department hereby issues a warning to all residents and visitors to the Bushbuckridge Local Municipal area not to consume the tap water without taking appropriate measures to improve the drinking water quality” (DWA, 2012)

- Operation, maintenance and infrastructure – the recent water shortages experience in the North West are understood to be caused by “the lack of proper maintenance, leaking and ailing infrastructure” (SABC, 2013). Furthermore, a study conducted in

2003 found that “70% of the boreholes in the Eastern Caper were not functional” (Mackintosh & Colvin, 2003 cited in Montgomery et al., 2009).

- Cost-recovery issues: “Many water service providers (WSPs) are unable to keep pace with rapid urbanization and population growth and remain trapped in a vicious cycle of poor operational performance and low cost recovery. A major driver of this spiral of decline is under-collection of revenue.” (Foster et al., 2012)

- Insufficient skills capacity: “In his article, ‘The water crisis in South Africa’, Herold (2010) rates the loss of essential skills as a major threat and states by way of example that only 39% of DWA’s engineering posts were filled in 2008 and that the situation will deteriorate further with the retirement of senior personnel.” (Pitman, 2011)

- Water resource management: knowledge of water resources and water resource management are crucial in the context of the water stresses experienced in the country. (Mauree, 2010)

It must be understood that incorporating ICT solutions in the water sector alone cannot hope to resolve the water sector problems.

“The communities least likely to be able to maintain their water systems without outside support in the first place may well be the least likely to effectively use a new type of reporting system.” (P. Thomson et al., 2012)

According to Heffernan et al. (2012) ICT4D is defined as “[i]ndividual or groups of communication technologies, whose adoption or impact supports ongoing and/or future development aims and objectives”. By this definition, it is clear that ICT4D is relevant to the water sector in South Africa, especially for programmes located in rural settings. Rural communities are largely impoverished and suffer from a “lack of affordable access to relevant information and knowledge services” (Bhavnani et al., 2008). The key aims of ICT4D projects was to alleviate poverty, stimulate local growth and assist in overcoming the ‘digital divide’ (Bhavnani et al., 2008).

Bhavnani et al. (2008) also described several underlying causes for digital divide/information poverty:

- institutional environment constraints
- rural infrastructure constraints
- rural population constraints
- rural poverty reduction strategy constraints.

A crucial aspect of ICT4D projects was that they have to incorporate local contexts in order to stand a chance of succeeding. Developing country ‘audiences’ can have varying levels of comprehension/understanding and as such, have to have specially targeted/context specific solutions.

“Innovation does not lie in the design of high-tech or sophisticated technology, but in the use of an appropriate and disruptive technology such as an SMS services: appropriate in the sense that it is suited to the environment in which it is used [Schumacher, 1973]” (Poblet, 2011).

Furthermore, if a technology is not acceptable/appropriate for the setting and there is inadequate demand, adoption of the technology may not occur (Heffernan et al., 2012).

ICT4D has suffered numerous failures in the process in the public sector over the last two decades and has been plagued by countless impediments that result in failure and subsequently literature has emerged concentrating on sharing these failures and providing recommendations for future endeavours.

2.3 ICT and the global development sector

Over the last decade ICT initiatives in the global development sector have boomed. Realising the proliferation of phones and the penetration of network services coupled with the "bottom of the pyramid" approach to market development, mobile phone initiatives became prevalent in all sectors of society in developing countries.

The perception has been that mobile phones are particularly well suited for development given the already large and still increasing spread of mobile phones in developing countries, "… in spite of still-prevalent difficulties with low education, low access to electricity and low income levels" (Bhavnani et al., 2008). Furthermore, the "[m]ajority of mobile users worldwide live in the developing world" (Gurman, et al., 2012) and mobile phones were found to positively impact GDP (Deloitte, 2008 cited in Bhavnani et al., 2008).

"Evidence from selected studies carried out by the United Nations Conference on Trade and Development (UNCTAD) shows that mobile phones have become the most important mode of telecommunication in developing countries. For the vast majority of the low-income populations mobile telephony is the sole tool connecting them to the information society… The benefits of mobile phones might be proportionally greater in resource-constrained settings, e.g., the poor and rural populations." (Patil, 2011).

Kinkade and Verclas (2008) presented an assortment of mobile ICT4D initiatives, inter alia:

- text messages to monitor election related violence in Kenya
- a mobile platform to monitor air pollution in Accra
- GPS collars to track elephant movements in Kenya
- text messaging service to disseminate critical information after the 2006 earthquake in Java

"There are two distinctive features applying to the vast majority of these solutions. First, they are SMS-based and, therefore, do not necessarily need to be connected to the Internet to operate, which is a critical asset when, as is frequently the case, networks are down or shut off for either natural or political reasons (it may obviously happen with mobile networks as well, but in this case is easier to re-establish the services or search for technical alternatives). Secondly, the applications considered so far focus primarily on information gathering and sharing and on coordinating direct political actions, but less on decision making for public policies and other political deliberations [Hellstrom, 08]" (Poblet, 2011)

Lately concerns regarding the single focus on mobile application as the solution for all problems have been raised. "The issue of access is a strong argument why mobile phones cannot be seen as the only solution for improving communication in governance. Traditional channels (physical visits and meetings, billboards, radio, information brochures, various e-government initiatives etc.) that build on an effective back office still need to be functioning – mobile solutions just add an extra dimension." (Hellström et al., 2010)

Some of the barriers and impediments to mobile technology solutions are:

- cost – cost of handsets and call rates and network coverage
- information carrying capacity

- impact of illiteracy on SMS capability
- device shortcomings – battery life and memory shortage

Global network coverage statistics obscure the fact the not all network coverage is created equal. Whilst voice calls might work well in a region, some operators will prioritise this voice channel over any other, leading to situations where application data cannot be transmitted reliably. 'Asynchronous communications, or store and forward and off line [methods] that enable sending information through less reliable networks when connections are stronger, must be assumed.'" (Mechael, 2010)

"[T]he continuing lack of universal coverage in some rural areas weakens the ability to implement mHealth initiatives at a national scale. While pure market forces have driven, and continue to drive, the global wireless explosion almost entirely, it is likely that some government incentives to extend network coverage may be required to ensure coverage for remote populations where such services stand to have the greatest impact" (Mechael, 2010).

Further challenges become apparent when attempting to deploy one solution to multiple locales – mobile platforms which use specific symbols and language to communicate to the recipients may not translate to another context. This is especially important for interventions hoping to foster behaviour change using targeted messages – "creating targeted and tailored content which engages the user in two-way communication" (Atun et al., 2006; Mechael et al., 2010 cited in Gurman et al., 2012) and the timing of this communication – increase the likelihood of participants being receptive.

"As Walsham (2001) pointed out, ICT tools containing explicit knowledge must work to connect with the user's tacit world in order for them to meet their objective … a protocol to classify the quality of information provided is necessary and should include different levels of quality assurance, preferably conducted by an extended peer community … the driving force behind this emphasis on information pedigree is that availability of reliable and accessible information may enhance public trust in the process and also make public involvement more appealing by improving tangible elements and overcoming suspicions and disinterest." (Pereira et al., 2003)

SMS-based systems have shown to be a reliable and relatively easy application in system deployments in the developing world. "At present, other than voice, SMS is essentially the only fully functional capability of mobile phones that is operating system neutral, and there is nothing at present that approaches the open nature of, for example, the Internet." (Patrick et al., 2008).

But still, the SMS platform has shortcomings – limited 160 text characters, with no support for images to counteract illiteracy and to increase comprehension. "SMS is the most widely used form of communication globally" (Gurman et al., 2012). However, it is important to note that mobile companies' pricing structures can make different communication methods more attractive – for example, a programme in Ghana broadcasting weekly health messages found that 99% of consumers preferred to receive voice messages over SMS (Grameen Foundation, 2011 cited in Gurman et al., 2012). Voice calls can also allow for greater privacy whereas SMS may not (Gurman et al., 2012).

The overarching concern of cost has resulted in a host of pilot projects which never went to scale and terms such as "pilot-itis" have recently been formed to describe that phenomena in the ICT sector (Chamberlain, 2012).

"The costs of developing and deploying mobile technologies are often onerous for organizations, explaining, in part, why projects are small in scale." (Kinkade et al., 2008).

"Challenges: Managing an Effective 'Infoline' Service – For groups with limited funds, text messaging info-line services can be expensive to set up and maintain. Gathering and compiling comprehensive data that are reliable, well indexed, and ready for queries are not simple tasks. In fact, all of the services profiled here already had data compiled and available through other channels, such as in print or on the Web … another cost to consider is the fee to the vendor that provides the delivery platform" (Kinkade et al., 2008).

When reviewing recommendations from the literature, a number of common themes can be identified when projects have been assessed as successful and sustainable:

- program goals were clear and realistic and solid knowledge about the needs on the ground existed
- mobile solutions were assessed as "appropriate" to the environment
- users were involved in planning and design, and were incentivised appropriately
- focus of the implementation was on benefits rather than on the technology for the sake of technology
- innovation and implementation was fostered through regulatory governmental ICT policies and frameworks (Kinkade et al.,2008)

Other aspects that were highlighted as crucial to the success of projects were:

- the appropriateness of the technical solutions
- the appropriate social solutions
- thorough public participation
- governmental support to ensure sustainability
- partnerships between stakeholders
- and a long-term monitoring and evaluation strategy.

Buy-in/adequate investment from government was also highlighted as one factor to reduce the chance of failure. "Selanikio realized that switching from a consultant-based solution to a country-owned process using EpiSurveyor would provide a more sustainable solution." (Kinkade et al., 2008)

"Possible interventions could include the public sector taking a role in:

(a) creating an enabling environment for competition of service providers;
(b) developing the communication infrastructure;
(c) developing locally relevant content which meets the needs of the poor, and
(d) providing education and training programs in IT enabled services to boost skills and training." (Bhavnani et al., 2008)

A key shortcoming of ICT projects in the development sector is the fact that there are currently little or no indicators or tools available to measure the actual success of implemented projects.

"At micro level, performance measuring tools need to be developed to dictate appropriate design, planning, implementation, and monitoring criteria so that relevant programmes could really become essential component of society development, and at the same time contribute to human development." (Rahman, 2007)

"However, it is important that claims regarding the impact of ICT4 on development are both accurate and measurable. By creating a construct to assess the impact of ICT4D based on widely accepted development indicators, we intended not to simply offer a methodology per se but rather to practically illustrate the intersection between the tools themselves and

accepted measures of development, however flawed. From the exploration, it is clear that ICTs will contribute to, but rarely directly forge, such impacts. And it is the very essence of ICTs as technologies that delineate this relationship." (Heffernan et al., 2012)

When looking at the learnings that can be taken from the sector – particularly in light of research needs on which South Africa should focus on when developing an ICT strategy – it is obvious that the impact of mobile applications and ICT systems must be assessed using evidence based methods. Developing such methods should form part of the research agenda of ICT systems in the WASH sector.

"[S]trong evidence- based information about the widespread impact of mobile initiatives on international development goals is elusive. In our review of organizations' work and relevant literature, only rarely did we find solid impact assessments that evaluate whether an empirical link exists between a technology solution and the achievement of a social or international development goal." (Kinkade et al., 2008)

2.4 Learning from other sectors – m(obile)Health

Mobile health initiatives (mHealth) in the developing world fall within the ICT4D setting. Mobile technologies increase communication and collaboration between health professionals and community health workers in LMICs (low and middle income countries) and are therefore suggested to improve patient care (Mechael et al., 2010).

The benefits of mHealth programs are described to fall within the following categories:

- "increased access to healthcare and health related information, particularly for hard-to-reach populations
- increased efficiency and lower cost of service delivery
- improved ability to diagnose, treat, and track diseases timely, more actionable public health information
- expanded access to ongoing medical education and training for health workers" (Vital Wave Consulting, 2009 cited in Mechael et al., 2010).

Kinkade et al. (2008) state that "[m]obile technology has been piloted in a range of health-related areas, including improving dissemination of public health information (e.g., disease outbreak and prevention messages); facilitating remote consultation, diagnosis, and treatment; disseminating health information to doctors and nurses; managing patients; monitoring public health; and increasing the efficiency of administrative systems. In all these areas, evidence exists that mobile phones can play a significant role."

Mechael (2010) analysed 172 mHealth articles and found five core themes/topics:

- treatment compliance
- data collection and disease surveillance
- health information systems and support tools for health workers
- health promotion and disease prevention
- emergency medical response systems

mHealth data collection studies (which have parallels in the water sector) focus on "comparing data quality, accuracy, time, training required, and cost between traditional paper and pen methods and mobile technology" but "[r]esults were found to be inconclusive with effectiveness varying depending on the type and complexity of data being collected." "Data collection using mobile technology was found to be implemented using SMS, voice, and electronic forms" (Mechael, 2010). A study evaluating different data collection methods

determined that “the voice method [has] the lowest error rate, followed by electronic forms and SMS” (Patnaik et al., 2009 cited in Mechael, 2010).

“The most successful mHealth initiatives to date have been built on one of the less technically complex and widely used applications, SMS, which has been the prime communication medium for service delivery of health behaviour change interventions.” (Patil, 2011)

“Another study sought to investigate whether text messages could be an affordable option to improve outreach communication and information dissemination between community practitioners … findings suggested that the use of text messages was a viable communication medium for information exchange between field practitioners” (Gomez, 2008 cited in Mechael, 2010).

Despite some reporters’ claims of mobile’s significance in the health sector, others state that there have been no conclusive studies demonstrating the effect of mHealth data collection programs in improving or strengthening outcomes and health information systems (Mechael, 2010).

“While health workers did not object to the need to collect information and report on their activities, a chief complaint by all health workers and some administrators was regarding the lack of feedback and follow-up based on the paper reports submitted to higher levels of the health system. Many also wanted to have more supervision, progress monitoring, and activity planning based on their reports.” (Mechael et al., 2012).

Similarly to the shortcomings mentioned in the development sector in the previous section, the mHealth sector literature shows that study methodologies to evaluate success are often not adequate. As stated by Mechael (2010) study methodologies fall short due to:

- very small sample sizes give statistically insignificant results
- weak study design
- no long-term data evaluation
- few randomized controlled trials.

“Although there has been impressive growth in the quantity of evidence for Mobile Health, the commonly held view amongst key healthcare stakeholders is that the evidence does not address the key issues that support the widespread adoption of Mobile Health: the efficacy of clinical outcomes; cost comparisons; and the influence of mobile health on the wider healthcare system (i.e. reduced hospital attendance, resource utilisation, or improved access). Instead, the research has predominantly focused on demonstrating that the technology for mobile health works from a technical perspective and that patients like to use mobile health solutions. Kearney performed an analysis of all published scientific evidence for Mobile Health which supports this view … one of the major issues identified for the slow uptake and adoption of Mobile Health [is] the lack of relevant and robust evidence to support the reimbursement of Mobile Health.” (Votano et al., 2012).

This lack of coordinated research and evaluation methods does not instil confidence in the process or the outcomes. “Evidence can be found to both support and refute the proposition that fixed and mobile telephones is, or could be, an effective healthcare intervention in developing countries. It is difficult to generalize because of the different outcome measurements and the small number of controlled studies … convincing evidence regarding the overall cost-effectiveness of mobile phone ‘telemedicine’ is still limited and good-quality studies are rare.” (Kaplan, 2006). Kaplan (2006) goes on to assert that the literature is inconclusive regarding the cost-effectiveness of telemedicine.

As Mechael (2010) highlights, possible suggestions to target this gap in rigorous research include:

- comparison studies
- cross-country studies
- studies that show the role of integrated technologies
- replicable study design
- rapid stage evaluations
- cost-benefit studies
- use of standardized indicators

Despite the general perception that mHealth is an established field, Mechael (2010) asserts that mHealth is still "in its infancy" and "runs the risk of not realizing its full potential due to small-scale implementations and pilot projects with limited reach …the review identified significant gaps in mHealth knowledge stemming from the limited scale and scope of mHealth implementation and evaluation" (Mechael, 2010).

The same notion is expressed by Kinkade et al. (2008): "Yet much of the published evidence about the use of mobiles in health remains in the proof of concept stage."

"The field of mHealth has made significant advances in a short period of time, demanding a more thorough and scientific approach to understanding and evaluating its progress" (Mechael et al., 2012)

The mHealth sector has also been plagued by the pilotitis syndrome identified in the developmental sector, with "key decisions makers often being unaware of the complete picture of mHealth activity across the country" (Mechael, 2010) Therefore mHealth planning and policy development is often missing and aspects such as monitoring and evaluation are left to individual projects or research teams.

"Even further, the nature of the technology is such that by the time projects are completed and evaluations are conducted, the technology has changed, often resulting in outdated conclusions. As such both the evidence base and the business model for mHealth remain weak." (Mechael, 2010)

Other gaps highlighted in the sector with regards to the major ICT projects include:

- *data collection* – "little work detailing the use of the data to affect health outcomes and programs after collection"
- *health information systems* – literature that is "anecdotal and fragmented"
- *health promotion and disease prevention* – "[a] [b]etter understanding of context and culture" and means of overcoming with language, literacy and comprehension needs (Mechael et al., 2010).
- *disease prevention and health promotion* – "having sufficient technical and mobile phone provider support in remote areas (Toth, 2008) … other challenges mentioned in the mHealth-related prevention interventions included technical problems, costs, and financial sustainability" (Mechael, 2010).

Shortcomings of projects as well as barriers to implementation can be categorised as follows:

- Technological appropriateness

“some reasons for clinician resistance included dissatisfaction with the physical characteristics of digital technologies, uneasiness with its use, and ineffectiveness of the technology. Furthermore, staff workload may be too complicated such that multiple technologies need to be used and / or technologies are unable to be easily integrated into the workflow. For understaffing, the introduction of a HIS may create more work, thus overextending the staff further.” (Mechael, 2010)

- Absence of common architecture/framework

Another shortcoming, widespread in the mHealth sector, is the absence of comparable data, design and evaluation practises and the prevalence of information silos – prevents integration and co-ordination through mutual learning. “What is needed is a common technical architecture that enables interoperability and scale” (Mechael, 2010).

A reality in current IT systems in developed countries comes from the inability of the new ICTs to successfully and painlessly be incorporated into the existing framework/information system. As such IT systems are experiencing “major difficulties in deriving the full benefits from a new, highly disruptive technology like mHealth. In the developed world we are now paying an enormous price to create interoperability and standards, and impose them on resistant legacy infrastructures and political and service delivery environments … what is lacking is a guide for countries on how to integrate mHealth into existing eHealth and overarching health and ICT policies and then how to practically put such policies into operation” (Mechael, 2010).

- Lack of policy and guidelines

Viewed as a major contributor to the countless barriers and gaps and serves as an impediment to mHealth success (Mechael, 2010).

Policies related to ICTs need to “coordinate the objectives of mHealth initiatives with nationally defined goals and objectives … as will be discussed in more detail in the section to follow, more rigorous research to evaluate costs and benefits, quality of care, and impact on health outcomes is needed to fully enable governments to make well informed investments in mHealth. Similarly, there needs to be more evidence of the business value of mHealth to drive private investments. The absence of such policies and related studies hampers mHealth scale and sustainability” (Mechael, 2010).

“But as with usability and affordability, whether high-quality coverage is available in all settings such as low-income, rural, and remote areas might require a policy-level solution to ensure optimal outcomes.” (Patrick et al., 2008).

- Need to incorporate relevant stakeholders

“Currently, governments are relying on NGOs to test how mHealth works and fits into national systems. The risk with this approach is that if mHealth is seen as being largely driven by external forces, then it may begin to be perceived as a technology searching for problems, and foisted on governments as another expensive, hyped, “silver bullet” that does not fulfill expectations. Instead mHealth should be driven by a country’s health priorities and targets so that donors and mHealth implementers are collectively contributing to them in a

systematic and structured fashion. Similarly, it may be driven by the private sector. Much of health care in the developing world is private (even in rural areas, such as those in India, where out of pocket expenses are the largest single source of health payments). Governments should consider encouraging private employers, private providers, and operators to work with NGOs, health experts, and others to develop, trial, and evaluate solutions with an emphasis on costs and benefits to assess mHealth value." (Mechael, 2010)

"The various stakeholders within the system have different primary concerns which will need to be satisfied before they support the widespread adoption of Mobile Health. Issues that are typically considered to be most important by these stakeholders are safety, benefit, cost, and their combined effect on the overall healthcare system impact. However it should be noted that the relative importance of these issues often varies in different contexts." (Votano et al., 2012)

- Inadequate design methodology and evaluation

"The overall lack of well designed, randomized clinical trials with economic evaluation to confirm or refute clinical and economic benefits with mobile phone/healthcare interventions is an evidence gap that should be addressed in a systematic way" (Kaplan, 2006).

"However, the geographic location, scope of the implementation, sample sizes, and methods used do not provide statistically significant results that would inspire governments, industry, and donors to make the investments needed to truly capitalize on the reach of telecommunications infrastructure and the widespread uptake of services in LMICs." (Mechael, 2010)

"The review also found that only 13% of the available evidence for mobile health has been derived from research methods that are sufficiently robust to be applicable within the context of the formal appraisal mechanisms used in healthcare systems within the developed world." (Votano et al., 2012)

Research needs identified in the mHealth sector respond to the above mentioned shortcomings and address the challenges of pilot-projects. In order to maximise the impact of findings – but equally the impact of projects – aspects such as consensus on research priorities, open communication and sharing of experiences is becoming crucial. (Mechael, 2010).

"Future research should focus on the issues that address the key hurdles to adoption ... the quality of the evidence and the strength of the recommendation (for adoption and payment) are critical components of this. Consider the following questions when planning a mobile health research project:

- does the mobile health research claim address an appropriate hurdle to adoption?
- what existing literature or evidence supports the claim?
- what analysis or research is needed to substantiate the claim?
- is the proposed research methodology correct?

Improving the evidence base for mobile health will help overcome one of the most challenging barriers to the widespread adoption of mobile health." (Votano et al., 2012:2)

"In many developed countries with structured reimbursement frameworks, the study of cost, effectiveness, benefit or utility is institutionalised as a formal process that must be considered before considering the uptake of new interventions, technologies or services. Only when a Mobile Health solution has been deemed to achieve a tangible benefit at a

reasonable cost, is it likely to be adopted by providers or reimbursed by healthcare funders." (Votano et al., 2012)

Votano et al. (2012) make the important point that a solution should be assessed by how well it achieved its intended purpose. The impact of a solution should be measured by its impact on the clinical benefits rather than on the ICT adoption itself. The proof for such impact must be based on "robust, non-biased, statistically significant evidence.

"Therefore, for Mobile Health to be considered valuable, it must not only provide a 'service' that is proven, but also ensure that the provision of this service through the 'mobile' channel confers an additional advantage over other conventional channels. This is particularly important, as services that are proven to work through existing channels (i.e. face to face) cannot be assumed to work through different channels (i.e. Mobile Health) without further evidentiary support." (Votano et al., 2012)

2.5 Learning from other sectors – mGovernance

To assist in the deployment of services and to foster better engagement of hard-to-reach citizens, e- and m-governance systems have emerged "in the domains of citizens' participation, public awareness, management of emergencies and crisis, provision of public services, information, etc. to reach wider population segments" (Poblet, 2011).

"Recent case studies show that while more and more government agents publish information on their activities and budgets, they may do so 'in ways that are not easily accessible or comprehensible'" (Sasaki, 2010 cited in Poblet, 2011).

The prevalence of mobile devices over PC and internet connections in developing countries is a popular driver of the assertion that mGovernance has greater potential than eGovernance (Poblet, 2011).

mGovernance systems are currently being implemented in a number of developing countries, the Philippines being one such example "[a]bout half of Philippine government agencies offering e-services have incorporated SMS as a service delivery mechanism and in enhancing political participation" and main purposes are to "provide information, to set-up feedback mechanisms for stakeholders either in form of complaints or suggestions, and to make service delivery faster and more convenient" (Lallana, 2006 cited in Poblet, 2011).

Furthermore, Mwololo (2008) as cited in Poblet (2011), reported that half of the Kenyans surveyed had "used their mobile phones to access government websites".

mGovernance is not however, without its limitations – it should be understood that:

"[M]any developing countries are finding it extremely difficult to divert scarce resources towards ICT-led-development when faced with pressing priorities of reducing poverty; as such providing basic health and education. Furthermore, lack of technical skills and policy building capacity are other barriers to establish effective e- government, e-participation and e-service delivery system at the grass roots" (Kovacic, 2005; Groznik & Kovacic, 2006 cited in Rahman, 2007).

Other identified challenges of adapting and implementing mGovernance applications include, but are not limited to:

- "costs, payment, revenue sharing – who should pay for the services?

- content, who should produce and update content? Can this also be done by ordinary citizens? Generally, people tend to be consumers of the available services and applications rather than provide and create content themselves
- usability issues and the limitations of mobile phones – small screens, short messages, complicated commands. Advanced phones with bigger, colour screens that are GPRS enabled are still too expensive for the East African masses.
- some services are tied to a specific operator – interoperability issues between operators and roaming between countries must be solved. Compatibility and a variety of platforms are related challenges.
- how to promote mobile penetration and increased accessibility in areas that are not commercially viable? Universal funds and Rural Communication funds are used but they are not efficient enough.
- regulation and legal aspects of mobile applications and use of the services are lagging behind in East Africa." (Hellström et al., 2010)
- difficult to get public participation regarding maintenance issues and fixes (Thomson et al., 2012).

When looking at mGoverment systems in the water sector, the philosophical notion of the good reasons for ICT applications becomes quickly clear:

"Water governance – with improved information and communication systems to collate basic water use data, more accountable and transparent decision-making is likely to improve a) understanding of dynamic water use patterns, b) predictive capacity to identify and mitigate systems under pressure, c) objective information to shape negotiations where resource allocation is required, and d) mitigate expenditures where failure is predicted resulting in significant or irreversible damage to society, growth or ecosystems." (Hope et al., 2011).

A number of mGovernance systems have been implemented in South Africa, such as the reporting of service faults by SMS in the City of Cape Town, requesting information on the water quality at any location in the country (My Water) or rate billing system through a cellphone application. However, these systems are not yet evaluated and no information was found to establish how many people make use of these applications. Additionally, the South African mGovernance systems are not rolled out country-wide but rather rely on the initiative of individual departments or local governments to develop a strategy for ICT implementation. In 2012 the South African Local Government Association developed a municipal guide/roadmap to successful ICT governance for local municipalities in order to foster innovation and implementation of ICT projects. Within the roadmap guidance is given regarding of ICT implementations and the hope would be that such documents will guide the overall approach of local municipalities to establish ICT initiatives (Smith, 2012).
A recent review of the service delivery workflow of the City of Cape Town showed, that ICT systems implemented within the municipality to improve the internal workflow between managers in the office and response teams on the road can result in a measurable improvement. However, such systems are implemented as an internal management system for the municipality and do not provide access to the information by public stakeholders. As it is the case in Cape Town, these type of systems are often built as add-ons to existing ERP systems (such as SAP) which are established and form part of the operational management of a municipality. Such systems are in the majority found in well-resourced and urban municipalities (Rivett et al, 2011).

Another area that has in the recent past received substantial attention in the mGovernment sector is data generated through "crowd-sourcing". Crowd-sourcing refers in this context to collecting information through people, i.e. a "crowd". Whilst crowd-sourcing has been particularly relevant in recent political events such as the Arabian spring, the reliability of data created by a crowd is highly contentious in the context of governance. As stated by

Poblet (2011) "(i) the lack of sufficient evidence to assess whether crowdsourcing makes a difference as compared to the operational strategies already in place; (ii) the risk of information overload caused by unverified data; (iii) the reliability of these data, since they are vulnerable to potential manipulation and abuse" (Poblet, 2011) highlight some of the shortcomings and weaknesses of crowd-sourcing.

"Crowdsourcing data collection through mobile networks holds the promise to improve decision making in emergencies, crisis and conflict events, and also to foster public participation and citizens' awareness. But it also poses and additional challenge: the threats to citizens' privacy and security, especially when they report abuses or violations of human rights in conflictive areas or in authoritarian regimes" (Poblet, 2011).

Vijayakumar et al., cited in Poblet (2011), proposes the following criteria for mGovernance solutions:

- accessible to the masses, irrespective of their socio-cultural and educational background
- scalable to such an extent that the entire population benefits from them
- acceptable by and deployable across all the operators
- replicable and deployable with minimal changes, for similar requirements [Vijayakumar et al] (Poblet, 2011).

Additionally, Hellstrom recommends that there should be a "central body [to] facilitate and coordinate mGovernance activities and make them visible: citizen awareness campaigns of existing applications should be made (marketing is highly needed and lacking at the moment and there is no information regarding where to find the existing services)." (Hellstrom, 2011).

As highlight by the examples mentioned in the health sector, mGovernance is also hindered by unclear strategies on how to develop financially sustainable mGovernance systems. "Also, an innovative billing plan is needed for mGovernance services since cost and affordability constitutes a major challenge in East Africa. Most of the subscribers in East Africa are on a prepaid scheme where they top-up (load airtime, credit) when they need to make a phone call, beep or SMS. Most of the time there is no credit on the phone which means that if the system is designed in a way where the citizen are supposed to pay for the service, the completion rate will be low. The billing platform only works if there is money on the subscriber's phone but no money, no service." (Hellstrom, 2011)

A challenge for mGovernance is that in order to establish system, project size and scaling up are crucial and pilot projects are often short-lived.: "scale is important for impact reasons and for sustainability issues" (Hellstrom, 2011)

2.6 Mobile Applications in the Water and Sanitation Sector

mGovernance has been described as "the delivery of governance-related services via mobile communication devices, i.e., a tool and method that facilitates citizen to citizen, citizen to government and government to citizen interactions that can be leveraged to strengthen democracy and good governance" (Hellstrom, 2010 cited in Hutchings et al., 2012).

Mobile applications in the WASH sector are a sub-set of these mGovernance tools and can play an important role in providing much-needed means for consumers to interact with government and regulators.

“Many experts have argued that overcoming [the] varied challenges in the WASH sector requires a focus on governance, since good governance requires a wide range of institutions and non-state actors involved in different or overlapping aspects of water, sanitation, and hygiene to manage resources and demand better services and accountability.” (Allison, 2002; Plummer et al. 2007; UNDP Water Governance Facility 2009 cited in Hutchings et al. 2012).

“Mobile phones, a subset of ICTs, are particularly well-placed to serve the development needs of the poorest, most vulnerable populations, because they represent a widespread and relatively low-cost communication option for rapid information transfer and service facilitation, eliminating prevalent issues of distance or time.” (Hutchings et al., 2012) Despite indications of numerous pilot projects and evaluations dealing with various aspects of mobile phones in WASH service delivery projects, the area (like many others described in this report) lacks any substantial amount of published literature. Having said that, one particular extensive and well-researched report, “*mWASH: Mobile Phone Applications for the Water, Sanitation, and Hygiene Sector”* published by the Pacific Institute in 2012 stands out, and the reader is strongly urged to read it as a companion to this WRC report. The key findings of the Pacific Institute’s report are summarised below.

Relevance of ICTs

“Collecting, aggregating, and analyzing data from remote regions and making the data available in a transparent way can help identify where investments are most urgently needed and can improve the long-term project monitoring. It can also contribute to better water resources planning. Information and communications technologies (ICTs) have the potential to address these information gaps in the WASH sector by transforming the way data is generated, communicated, and shared. Mobile phones are already being used as tools for data collection and dissemination across multiple sectors, such as health, socio-economic development, agriculture, natural resource management, and disaster relief.” (Hellstrom, 2010; UNICEF, 2010 cited in Hutchings et al., 2012).

Designing and implementing mobile applications

The following elements were seen to be critical in the successful design of mobile phone solutions:

Considerations for User Participation and Experience	
Understand the socio-cultural context	While it is not always easy to anticipate challenges based in a specific socio-cultural context, documented successes and challenges of others can help future projects to prepare for issues such as: differences in mobile phone access and usage individually and as part of a household; rigid attitudes and expectations about government action; preferred mode of communication; and prohibitive fears and concerns.
Build the user base through well-planned outreach to achieve uptake	Outreach is important for user uptake of the system, both during project development and implementation.
Ensure the system is easy to use	The success of a system and level of user participation depended heavily on technical accessibility in the data collection step (which was the user’s first, and sometimes only, interface with the system), and relevant output formats in data dissemination and analytics.

Fulfill a key need – monetary incentives are not necessary	Compensation was not needed when the user received a direct benefit from submitting data, such as improvements to service provision.
Use of the Data	
Implement and promote user access to data	A key opportunity is missed when users do not have access to the same data as the agencies they are trying to hold accountable for making improvements.
Ensure government agency or service provider responds to reports	Low expectations of government services based on prior unresponsiveness created a lack of motivation for users to report issues at all. Service providers and government agencies can gain the trust of their customers and constituents through timely acknowledgement and response to reports, even when a solution is not immediately possible.
Use verification options to create high-quality data	Mobile phone applications have the potential to improve the quality and quantity of data that is collected in the long term. They can help to make manual data transfer more efficient, reduce manual data errors, and increase the frequency of monitoring due to relative cost effectiveness. Multiple manual and automated options exist to verify data.
Plans for Success and Sustainability	
Identify and measure indicators of short and long-term success; use this information to refine system design	Interestingly, most of the case study projects—information interventions to empower through the collection or dissemination of data—did not develop and track a variety of metrics of effectiveness that would help them to understand how different social, technical and program design factors might have impacted their success in the short and long term. Project performance and evaluation data has the potential to help understand and overcome short-term issues, but also to serve as factual proof of the need for and relevance of the system—powerful components when seeking funding.
Secure a future for the system through a plan for long-term sustainability	Implementers risk failing their beneficiaries when they can't keep a system running due to lack of funding. Some cases showed that mobile phone solutions can be sustained with strategies such as ensuring key user-stakeholders invest in maintaining the project (e.g., local governments) or leveraging technical partners to relieve some of the burden of developing, acquiring, and maintaining software or hardware.

(Hutchings et al., 2012)

Many of the points in the above table talk to points raised in the mHealth and mGovernance sections, indicating that the ICT and mobile development fields share a fairly well-contained set of challenges to implementations, irrespective of the context they are being used in.

Recommendations
Hutchings et al. (2012) conclude that the majority of mWASH projects surveyed (out of a total of 40) deal with access issues, failure, breakdown, and general unreliability in service delivery, i.e. issues that can be seen as more real-time and reactive. Hutchings believes that there is significant undiscovered value in leveraging mobile phones in long-term monitoring, planning, and management scenarios. As indicated before, any improvement in a system or process depends on the quality of information being received, and how it is processed and used. Additionally the work warns against focusing on short-term "wins" when sustained changes in water, sanitation, and hygiene are likely only to be seen over longer timespans.

"Globally, mobile phone solutions are proliferating rapidly in many regions, fuelled by desires to bring effective change quickly. Sustained success in these emerging projects will be dependent on effective program management, attention to the financial and technical sustainability of the system, and monitoring and adaptively managing for system effectiveness in the short and long term." (Hutchings et al., 2012)

Mobile billing in the water sector
Another area where ICTs are playing a major role in the water sector, is mobile payment. Rapid urbanisation and population growth is increasingly putting pressure on Water Service Providers (WSP) to expand their services, whilst maintaining an acceptable level of operational performance for existing delivery. If a WSP slips into a position of poor operational performance and low cost recovery (due to non-revenue water and under-collection on water bills), it becomes increasingly difficult to exit this state and recover (Foster et al., 2012)

Afrobarometer (2012) suggests that one in five urban households in Africa fails to pay for their water, whilst the World Bank claims that more than 50% of African utilities collect revenue from less than 50% of their customers, and unpaid water bills cost the African urban water sector almost USD 500 million a year. (Bannerjee and Morella, 2011 cited in Foster, 2012)

Non-payment for water services in South Africa was as high as 52% in 2010 (StatsSA 2010), a sharp jump up from 32% in 2008 – making it a worthwhile target for improving total revenue and avoiding falling into a position where services can not be maintained.

Foster et al. (2012) suggests that mobile payments, or mobile money, could be a solution to increasing revenue collection from consumers. Mobile money has been shown to be successful in East Africa, particularly Kenya, as it allows funds to be quickly, efficiently, and cost effectively accessed and transferred between parties that were previously "unbanked". "For WSPs, mobile water payments offer to help interrupt the cycle of poor financial and operational performance in two ways. First, if transaction costs incurred by customers when paying bills are reduced, revenue collection is likely to improve in terms of volume and timeliness. Second, if transaction costs for WSPs can be lowered (through reduction in labour, rental and cash security costs), operational efficiencies can be extracted. Arguably, WSPs can also offer more flexible payment arrangements with little additional administrative burden, meaning that serving the poor (and expanding the customer base) could become more commercially attractive." (Hope et al., 2011)

Mobile payments additionally reduce burden on consumers, by:

- eliminating travel costs to the local municipal office
- reducing the time investment required to pay your bill (which typically would take place during work hours)

and for WSPs, by:

- eliminating printing and postage costs for invoices (particularly in the case for invoices detailing free basic water usage)
- reducing payment processing time

In a 2012 study of four African countries (Kenya, Tanzania, Uganda, and Zambia) Foster et al. (2012) assessed the impact, adoption, and implications of mobile water payments. It was found that customer adoption rates of mobile payment option was modest (between 1 and 10%) due to limited awareness, high transaction fees, availability of existing alternative pay points, and delayed reconciliation of accounts over the billing system which sometimes resulted in service disconnections. One outlier reported approximately 80% of the community making use of mobile water payments – an analysis of this community found that the high adoption rate was decisively linked to time and cost savings compared to traditional payment methods. For consumers who declined to use the mobile system the primary reason was an uncertainty of how the system worked, with transaction security doubts and lack of paper-based receipts making up a minority of consumer concerns.

The benefits of such a system would be:

- increased revenue to WSPs through:
    - reduced labour needs
    - reduced processing times on payments
    - cost savings on printing and postage of invoices
    - potentially increased customer base (more flexibility in payments)
- increased cost recovery allows services to be sustained and expanded
- savings for consumers:
    - eliminates travel costs
    - reduces time spent away from job and family, particularly in rural settings
    - increased access to real-time information about water usage

However, on the other hand a number of barriers to implementation of such systems have to be expected:

- mobile money has yet to take off in South Africa, despite successes elsewhere (M-PESA Kenya vs. South Africa)
- a system of this kind would only be applicable to piped water consumers
- existing billing system and new mobile payment systems need to integrate which is often highly complex and expensive.

There are currently no documented systems for water billing in place in South Africa.

2.7 Smart metering and smart grids

Smart Water Metering (SWM) and Automated Meter Reading (AMR) systems enable water consumption to be electronically recorded and transmitted to a remote location without human intervention. Usage data is recorded at regular short time intervals (typically hourly),

and depending on the system can be accessed by the municipality or property owner for real-time feedback.

There are numerous implementations of smart meters, but basic premise is the same:

- a flow meter is retrofitted to the traditional water meter (if capable), or otherwise an entirely new meter with smart capabilities is installed
- the flow meter records consumption data at regular intervals and either:
    - logs it to a memory device for later retrieval by a meter reader, or
    - transmits it to a central database where consumers and water providers can access it

The benefits of SWM largely answer all the current shortcomings of traditional metering, but introduce a new set of problems, which are primarily centred around installation and cost issues. These costs are substantially more significant in the short-term than the savings from better water management and leak detection unless looked at over a long period (10-20 years).

“What you don’t measure you can’t manage. A smart water meter shows the water consumption in real time. It can generate alarms for excessive use. It identifies abnormalities as they occur so that a facility manager can take action to conserve precious and increasingly expensive water.” (Idris et al., 2006).

Blom et al. (2010) noted that “to ensure future water supply, each consumer should monitor their consumption and efficiently use water,” and De Beer (2010) states that “soon, water utilities may be subject to regulatory pressure to improve efficiencies and to implement [water demand management] programs. This would only be achievable on a consistent basis through effective metering, monitoring and control of the water distribution network, which in turn requires the implementation of a water “smart grid”, supported by [automated meter reading] technologies.”

Advantages offered by SWM/AMR systems:

- on-demand readings
- real-time leak detection
- no property access issues for meter readers
- reduced billing cycles
- rapid client dispute resolution due to access to better data
- vandalised or broken meters can be identified immediately
- increased awareness of water usage issues

(De Beer, 2010; Blom et al., 2010; Idris et al., 2006)

Barriers to implementation:

- installation cost
- finite battery-life of transmitter
- data communication costs (GSM or initial outlay for permanent wireless network)
- technical and mechanical upkeep (including vandalism)
- installation requires consumer awareness and acceptance
- potentially high mechanical failure rate and associated repair costs
- harsh operating conditions compared to other smart grids (cf. electrical grid)
    - located outside, away from buildings
    - lack of reliable power source

    - severe environment – wet and damp, extreme range of temperatures, potential of physical damage (i.e. not protected)

(De Beer, 2010; Blom et al., 2010; Idris and Hauber-Davidson, 2006)

The particular drawbacks of traditional metering that SWM answers are:

- slow data collection and dissemination
- few data points collected
- inability to detect sudden changes in consumption or leaks

On leak detection
With current meter set up water providers are unable to detect leaks within a private residence. These leaks can only be detected via a concerted effort by the property owner to isolate them. This is further compounded by the relatively infrequent billing cycle and inability to isolate and analyse any sudden changes in water consumption. SWM allows consumers to immediately detect any abnormal usage (compared to historical records) and thus enables rapid leak detection.

“At N2 Gateway it was discovered in the first week that 43% of the water entering the complex is going to waste. By taking daily readings the consumption patterns of water users revealed that 12 consumers use an average of 14000 litres a day compared to their neighbours 400 litres per day.” (De Beer, 2010)

Idris et al. (2006) list several case studies in which SWM directly contributed to leak detection, including:

- "after four weeks of smart meter monitoring, it was evident that there was a significant leak of 10 L/min which occurred constantly throughout day and night”
- “during the first week of a three week smart water metering period, a toilet block was found to have a base flow close to zero at night … during the second week of monitoring, the base flow overnight increased to 8 L/min .. [and] again in the third week of monitoring to 16 L/min”

Global status
Currently there are several trials running around the world, testing the efficacy of the claims made of smart water metering. Malta is aiming to be the first country in the world, “to build a nationwide smart grid and fully integrated electricity and water system” (John, 2009 cited in Blom et al., 2010). The state of Victoria in Australia plans to roll out 2.5 million devices across residential and business properties, whilst Sydney ran a two year pilot study to determine how SWM can change behaviour in consumers, and what cost savings a SWM enabled supply could introduce. The City of Cape Town ran its own two year study to test the feasibility of rolling out AMR devices in the city.

De Beer (2010) states that: “Very few of these technologies have been field-tested in a large scale out-doors application like this pilot project, and those that have been field-tested, experienced many problems, especially problems related to severe environmental conditions and communication challenges over large distances” and that this has led to a situation where there are very few proven SWM systems for water utilities to implement.

Findings
Blom et al. (2010) suggests that SWM systems can only show information and they “cannot force a person to take action in conserving water.” Furthermore it is noted that inciting

behaviour change in consumers (with regards to decreasing wasteful consumption) is a complex task and requires a well-thought out campaign of which SWM is only a part. "Behaviour change through SWM can only occur if information is presented to the consumer through a consumer interface." but it was found that this is needs to be part of a larger campaign of water consumption education and will not affect change by itself. 'Household water consumption can be reduced by up to 18% through using a combination of campaign strategies'." (Blom et al., 2010)

Idris et al. (2006) raise the point that, "the cost of a smart water meter is independent of the size of the meter it monitors … [which] makes it hard to justify its cost in domestic applications, especially with current water prices" but that the "situation is completely different for large water users." The assumption here is any change in bulk water users' consumption will have a far larger impact due to the proportional savings compared to a residential user. Commercial users are also possibly susceptible to larger leaks due to their infrastructure (large inlets, bigger properties).

De Beer (2010) found several significant barriers to implementation, including:

- **"**proper upkeep of meter and property data is sometimes overlooked and when field and office records do not agree it can cause long delays in matching data during the installation process."
- "AMR installations were also prone to some vandalism by consumers, some of whom expressed a great dislike in having their water meters 'monitored'."
- "The principal labour issue for the City of Cape Town, was to manage the concerns of meter readers, who were justifiably concerned that the AMR system, if implemented on a large scale, would cause major job losses for them."
- "… AMR for mass metering of water meters that are able to support "smart grid" capability, pose many technical challenges not encountered with electricity metering. These systems must be able to function independently from an external power source, must have an independent communication system, must be low-cost to install and operate and must have two- way communication capability that provides "on-demand" meter reading, detection and control functions."

Idris et al. (2006), De Beer (2010), and Blom et al. (2010) all raise the point of the high cost outlay required to implement such smart systems, and that a careful analysis must be done to ensure the cost-effectiveness of such a roll-out.

"In addition to technical challenges, water utility providers, unlike electricity utilities, are finding it hard to justify the installation of AMR/AMR systems from a direct financial benefit/cost perspective, mainly due to the fact that AMR is principally viewed purely as a replacement for manual meter reading, plus the fact that water is relatively cheap compared with electricity, plus the fact that losses, inefficiencies and non-collection of revenues can be passed on to consumers through tariff increases on a "cost-plus" basis". There is consequently little financial incentive to improve the overall efficiency of water utilities, through investments in AMR systems." (De Beer, 2010)
A slightly different take on the cost perspective arose in an Australian study:
" … Australian cities, most of which are experiencing severe water shortages and for which one would anticipate, there would be a clear-cut business case for implementing systems that would assist with WC/WDM. However, most Australian water utilities have opted to implement very costly desalination plants to augment water supply, instead of implementing "smart grid" technologies with which to support WC/WDM programs. Their reasoning is that the additional cost of desalinated water will be passed on to the consumer, whereas WDM will reduce water sales and revenues to the water utility! Consequently, Australian water

utilities have thus far implemented AMR systems purely for occupational health and safety (OHS) reasons and not for potential financial gain." (Blom et al., 2010)

Recommendations
Blom et al. (2010) suggests that further research and evaluation is much needed as there have not yet been any long-term evaluations done of smart water metering systems, but that "[their] findings show that a wide-scale implementation of SWM would have many informational benefits but few financial benefits."

The issue of labour force reduction was addressed by the City of Cape Town "through the improved re-deployment of meter readers to become meter inspectors, by using the AMR data as a tool to plan and execute inspections of identified problems in the water infrastructure and water meters." (De Beer, 2010)

Despite the above reservations the cost and practical implementation of large-scale smart systems, the literature strongly recommends the future use of SWM/AMR systems in theory:
"Full two-way automatic meter reading can provide significant operating advantages to the water utility. In the customer service area, AMR can reduce meter reading and billing costs; eliminate most estimated bills, cancel-and-rebills, or call-backs; and allow virtually instantaneous handling of final bills and high-bill investigations or inquiries. From the customer's perspective, AMR increases customer security. This AMR system supports the timely identification of tampering, theft of service, and improperly functioning meters. In addition, AMR can help a utility track down unaccounted-for water and can provide data for enhanced distribution system management. Finally, for meters in hard-to-read locations, AMR can reduce hazards to meter readers, traffic disruption, etc." (De Beer, 2010)
"It can provide more than just usage data for water consumption issues. It is a powerful tool to support an integrated water conservation management system to achieve sustained water savings. By actively monitoring the water consumption the asset manager can readily intervene as soon as an exception alarm is raised." (Idris et al., 2006)

2.8 Conclusions of the Literature Review

The literature review set out to unpack and understand the role that ICTs currently play in the water sector and other related fields, specifically in mHealth, e- and mGovernance, smart metering, and mobile payments. During this process several common themes linking the key barriers and enablers to project success were discovered, and an understanding of the real benefits that ICT systems can offer us were gained.

An abundance of literature was found in the ICT4D and mHealth fields, but significantly less for ICTs in the water sector, particularly in South Africa. Many papers, reports, and projects dealt with mobile payments, community participation, data collection methods, and water quality management, but few married ICT usage into it. We know that many IT systems exist in government by implication of our daily interactions with government agencies but there is extremely limited academic published work on them, which makes it incredibly difficult to find relevant and unbiased information to use in a study like this. Advertorials and websites are in comparison plentiful, detailing solutions that offer ground-breaking solutions to existing problems but finding objective writing on these proved fruitless, indicating one of the challenges of ICT – that there is little reflection and assessment of the actual value or contribution these systems offer.

There was no significant amount of work published on long-term ICT projects in developed countries within the public service area, and in developing countries the published work largely revolves around mobile solutions – taking advantage of their low-cost and relative ease of deployment in disadvantaged communities, as well as the buzzwordy nature of funding agencies.

Despite the general lack of reliable information, the lessons learnt and observations generated by the work found in the mHealth, mGovernance, and other sectors proved valuable and parallels can be drawn as to how similar interventions might play out in the water sector. One observation that stood out from a majority of work was that long-term evaluation of ICT and mobile projects is desperately needed, several papers mentioned this fact themselves and made it clear that this is a shortcoming in the work available at the moment and has become an impediment to improve existing systems. Votano et al. (2012) went as far as to say that improving the evidence base for mobile applications is singly one of the most challenging barriers to widespread adoption, and that only when a solution has been shown to achieve a tangible benefit at a reasonable cost is it likely to be adopted.

Related to this was the notion that a key shortcoming of ICT projects in the development sector as a whole have little to no indicators or metrics available to measure the success of implemented projects. As highlighted in the literature, aspects such as a common framework and a strategy to integrate a variety of platforms are challenges that hinder the success of many ICT solutions. Often implementations depend on the initiative of champions – in the context of South African governance this might refer to individual municipalities or departments – which are not sustainable or will only function within a pre-defined environment.

Findings from the health sector indicated that current pilot study methodologies fall short in the following areas:

- very small sample sizes give statistically insignificant results
- weak study design
- no long-term data evaluation
- few randomized controlled trials

In light of this it appears obvious that the impact of mobile applications and ICT systems must be assessed using evidence based methods and that developing such methods should form an integral part of any research agenda for ICT systems in the water sector.

It is suggested that before projects begin, a careful look at the following questions be conducted:

- does the research claim address an appropriate problem?
- Is there any existing literature or evidence supporting the claim?
- What analysis or research is needed to substantiate the claim?
- Is the proposed methodology correct?

Additionally it is important to ensure that research does not focus on whether projects work from a technical perspective, but rather if they offer real benefits to their intended audience and help contribute to solving existing problems.

The global development sector as well as the health sector review showed that whilst ICT applications and particularly mobile phone based solutions offer a response to the so-called digital divide, the successes of mobile implementations are limited and hard to prove. It is not contested that through the wide distribution of cellphones an opportunity has been created to use a well-known technology to acquire and distribute digital data, but the usefulness of such data and its translation into an improvement to existing problems is however highly contested. There was also emphasis placed on the very nature of rapidly changing technology used in projects causing applications to already be outdated by the time the project concludes because the previously “state of the art” technology as evolved or changed to something newer.

In the case of projects being successfully implemented, several common themes appeared amongst them, namely:

- program goals were clear and realistic and solid knowledge about the needs on the ground existed
- users were involved in planning and design, and were incentivised appropriately
- project focus was on benefits rather than on the technology
- buy-in from all stakeholders (particularly government)
- appropriate solutions (social, and technical)
- long-term monitoring and evaluation strategy present
- understanding the socio-cultural context
- ensure systems are easy to use
- fulfil a key need (no false incentivisation, e.g. money)

The Pacific Institute's mWASH report found the following shortcomings lead to poor implementation:

- lack of policy and guidelines
- lack of frameworks to work in
- stakeholder relevance incorrectly identified
- inadequate design methodology and evaluation

Work in the mGovernance field indicated that whilst governments are developing and implementing systems to better engage with citizens and to provide access to relevant data, it is unclear how successful such systems are and by whom they are used. Information might be available but not accessible to the user. Systems that support municipalities in fulfilling their tasks better have shown to be more successful than systems that engage with customers.

The majority of ICT applications in the public sectors are used for information gathering and sharing or co-ordinating of actions, but less for decision making or policy implementation. Successful systems still rely on low-tech solutions using SMS, voice or form-based data collection. Factors contributing to the success were realistic program goals with solid knowledge of the problem, an early engagement with users and a clear assessment if technology was actually the correct solution to the problem.

Barriers to implementation are costs, the capacity of the handsets, literacy levels as well as being able to deploy one solution to multiple settings. The conceptual proof of ICT systems through pilot projects has resulted in projects never reaching scale or not being designed from the beginning to adapt to multiple settings. The pilot project itself has become a self-fulfilling prophesy and speaks to the missing link of ICT policies and strategies with buy-in from government.

On the mWASH side, Hutchings (2012) believes that there is significant undiscovered value in leveraging mobile phones in long-term monitoring, planning, and management scenarios and that ICTs have the potential to address information gaps in the WASH sector by transforming the way data is generated, communicated, and shared. As indicated before, any improvement in a system or process depends on the quality of information being received, and how it is processed and used.

Mobile payments for water billing offer water service providers an opportunity to increase their total revenue by reducing costs associated with traditional billing and payment systems whilst also increasing the probability of consumers paying their bills by reducing the amount of time and energy required to do this. Of particular relevance to areas outside an urban

centre is the elimination of travel time (especially during normal working hours) and costs for consumers. Increased cost recovery for service providers enables them to better sustain and expand their services, whilst maintaining an acceptable level of delivery. Unfortunately such a system would only be applicable to piped water users, and would not help solve any issues related to increasing access to piped water.

Smart water metering is another area that suffers from a lack of formalised, long-term evaluations and studies. SWM or Automated Meter Reading fall into a unique position where the benefits, mode, and technical aspects of implementation are all well-known and understood yet it has failed to make any significant impact due to the high cost of implementation with currently little comparative reward for water service providers (due to the “cheap” price of water). Unlike smart metering of electricity, SWM requires robust and hardy devices to be installed in largely irregular locations often requiring significant man hours to complete. It is noted that SWM would only form part of a larger campaign of education and awareness for consumers, and themselves alone cannot elicit behaviour changes. The benefits of SWM were also illustrated to be largely based around information with little financial benefit at this point in time.

3 Stakeholder survey

In order to contextualise the findings of the literature within the South African water sector, a stakeholder analysis was done in order to establish if and how local experiences, expectations, best practises and current use of ICTs relates to the literature review findings.

Practitioners and experts were interviewed through semi-structured interviews, which were either done by email, telephone or face-to-face conversations. Using a laddering interview methodology participants were prompted for additional information on interesting/relevant discussion points. Personal interviews were held with 10 participants. Additionally, findings from the “But does it float?” workshop held in 2012 at the University of Cape Town were integrated into this report. This workshop consulted 30 experts in the ICT and water sector in order to understand and discuss some of the key challenges facing ICT development in South Africa.

Ethical approval for the interviews was granted by the Faculty of Engineering and the Built Environments Ethics Committee of UCT. 30% participants were from an academic Water Sector/ICT background, 20% from municipalities and 50% from a private/consultancy background.

The questionnaire was designed to assess the participants experience or expectation of ICTS in the context of information needs, technology needs, technology readiness, implementation readiness, and the current use of ICTs.

The analysis of the data assessed responses based on the following themes:

1. Benefits of ICT systems as experienced or perceived by the respondent
2. Negative aspects of ICT systems as experienced or perceived by the respondent
3. Barriers to ICT implementation
4. Readiness of organisations and government for ICT implementations
5. Value of ICT research

Based on the responses and the theme analysis, findings regarding the following objectives were formulated:

1. Challenges in the WASH sector in South Africa
2. Identification of current ICT practices in South Africa
3. Mapping of stakeholder expectations, experiences and needs
4. Identification of enablers and barriers to ICTs
5. Identification of research needs and water sector strategies for ICT

4 Findings and analysis

In this section we present the findings of the stakeholder survey. Additionally feedback from a 2012 workshop entitled “But does it float?” held at the University of Cape has been included. This workshop focused on much the same subject as this report, namely the role of ICTs and pilot projects in the water sector. An analysis is done within each chapter in order to create a comprehensive overview of all findings and to link the various aspects together.

4.1 ICTs in the Water Sector

Findings indicated that there has been a clear increase over the past five years of ICT systems being used in the water sector. The applications can broadly be categorised into three different areas:

- Customer Management
- Operational Management
- Financial and Control Management

In all three areas, ICT applications are used to collect information, streamline information flow, and to improve work processes. The systems used for operational management address aspects such as asset management, technical performance and implementation of regulatory requirements.

Customer management applications addresses shortcomings in public relationships, education and aspects of disaster management. They are also often used to improve the credibility of the water sector by sharing information in order to increase transparency (e.g. “My Water” SMS system). A major benefit of such publically targeted systems is the increased awareness of water issues and government body transparency.
Financial and control management applications are developed to improve and strengthen revenue collection, provide reporting mechanisms in order to manage resources, and to manage assets on the ground in a productive way. The majority of the systems highlighted as successful in this sector are integrated in existing structures usually within municipalities that have made financial commitments to maintaining the systems.

Key findings

- The mobile water sector has is rapidly growing and has shown a multitude of different projects being attempted in different countries with unclear success levels. Findings showed that experts in the field have fairly healthy doubts about the actual benefits offered by these mobile systems, and the long-term sustainability and the “wear-off” factor of new (sometimes unproven) technologies. The concern is that ICT systems may in the long-run prove to be a fancy term for projects with little impact connected to high cost – particularly in the case of mobile systems.

- Integration with existing systems is of great concern. Municipalities, stakeholders, and private organisations have invested substantial money to develop and maintain current systems. The concern is that a new system might result in data duplication and reconciliation issues, as well as increased costs due to having to retrofit or redo old systems wholesale.

- Survey participants highlighted that access to services for all and sustainable water resource management are key issues for the water sector in South Africa. Issues of affordability and sustainability versus maintenance of infrastructure and urban

development were also identified as important concerns. The rapid expansion and growth of developed areas has resulted in infrastructure failing to deliver and participants highlighted the limited data as one of the key issues to preventing accurate planning and response to these challenges on the ground.

- There is a perception that municipalities or at least people in decision-making roles in municipalities hesitate to make decisions on new or untested systems. This makes government agencies increasingly uncompetitive (in terms of staying up to date with technology) as the risk of failure is too high to justify an attempt.

- Barriers to solving challenges in the sector were identified as institutional challenges (poor management of different sectors within a municipality, and poor planning), educational, financial, political interference, budget delays, and social challenges of awareness and acceptance of technologies and processes.

- Working ICT systems cannot always be scaled since they are typically designed for a particular context during their initial stages. This is particularly true for systems that are developed with the users being co-designers to the system, as users are intrinsically linked to the context in which they currently find themselves.

- Many of the challenges in the water sector cannot be resolved with ICT systems alone. An improvement of information flow is of little use when it is not possible to act on the new information due to resource or budget constraints. The literature and survey findings confirmed that aspects such as institutional shortcomings, resource constraints, and other management issues cannot be solved solely through ICT systems even if the ICT system is the provider for information on the shortcomings.

4.2 Identification of current ICT practices in South Africa

As noted before, the relative youth of the ICT sector, lack of formal frameworks or regulatory bodies, and misidentification of systems (i.e. not classified as ICT) has led to a situation where it is hard to evaluate or even identify ICT systems in South Africa. This can be seen as largely an awareness and understanding shortcoming as it is apparent that government agencies use a variety of complex IT systems to run various aspects of service delivery yet these are not reported on, and there is little to no academic work on the subject.

The following findings emerged from the study, and support the claims above:

- Analysis shows that there is no common best practise or an understanding of best practise within the ICT sector.

- There is no body or organisation that is seen by stakeholders as performing a regulatory or advisory function.

- Some of the participants who are in the field were not at all aware of any other people or organisations in the sector doing any kind of ICT work.

- Initiatives are started within municipalities and often managed and implemented by consultants. These initiatives become all-in-one solutions for municipalities and leave little room for smaller, more agile projects to take root. Additionally these initiatives are kept in house and ill-reported.

Despite this, the SALGA (South African Local Government Association) initiative to develop a roadmap for ICT implementation in local municipalities provides hope and begins to

address some of the findings that were highlighted in the literature. This may be a substantial first step to showing commitment to support ICT innovations.

In the context of this report, the ICT community consists of a relatively small number of practitioners contained within a number of small disparate networks in the sector. Some of these are based in universities, whilst others are based within the corporate sector, but there is real potential to create a user-community or a community-of-practise within the sector that could provide a good platform to formalise some of the best-practices for ICT within the country.

4.3 Mapping of stakeholder expectations, experiences and needs

ICT systems are envisaged to improved information processes, leading to increased sustainability and efficiency for projects and users. Yet some survey participants spoke of reluctance towards new systems due to high costs, but at the same time mentioned that aspects such as data gathering (through mobile data collection) were considered to be cheap, quick solutions. This illustrates that there is currently little knowledge of the cost-benefit of ICT implementations, which can be ascribed to the non-existence of such analysis in the literature and the sector as a whole.

Stakeholders expressed the following views on ICT systems, the water sector in South Africa, and government involvement in projects:

- The monitoring of projects and interventions is made easy through remote data collection.

- Municipal feedback suggests that the South African government is perceived to be ready for implementation of new technologies, “as long as such implementations are not politicised”, but

- feedback from consultants/private individuals states that they do not believe the government is ready for implementations of new technology, as it becomes available.

- Trying to develop and make use of multiple separate systems within one municipality results in information and data chaos – work processes and data flow have to be planned and finalised before any ICT implementation starts.

- The experience exists that there are systems and tools available but that the implementation is lacking due to the perceived cost versus perceived benefit ratio. Participants felt that the “high initial costs are not contrasted to long-term savings.” The perceived cost of implementation and maintenance was raised as a key issue by all participants.

- Systems are expected to automate processes and to manage all aspects of the WASH sector, such as laboratory systems, asset management, engineering system, back-office admin and revenue protections. All sub-systems are expected to be integrated into one overall management system.

- It was felt that government departments may not see a reason to implement or even use a new system, as:

- Government has no incentive to constantly innovate (compared to the private sector); departments cannot afford to fail by implementing new and untested technology so would rather stay with a conservative approach in order to minimise risk. This is seen

to be one of the reasons why there is a faster turn-around and adoption of ICTs in the private sector compared to the public sector.

- There exists the possibility that there is a perception that ICT systems eliminate jobs through automation.

- Vandalism of new technology can de-rail projects (e.g. smart meters).

- Mobile phone applications are an example of a "pass-the-parcel" attitude to taking responsibility at government level, i.e. by decentralising further and further down the actual responsibility is handed down to a context that is less likely to be able to implement successfully.

- Tail-wagging-the-dog- scenario: a drawback of technology dependency is that whilst it is becoming an integral part of our lives, it cannot become the reason to develop new systems and structures (i.e. simply for the sake of having a new project).

- ICT systems can be a simple solution based on affordability and accessibility, but assistance in the implementation is needed and in the long run the financial sustainability depends on similar strategies that have to be developed to maintain the traditional IT systems. This is still a major challenge for the rural and under-resourced municipalities as can be seen from the limited amount of IT based management systems used in these environments.

4.4 Identification of enablers and barriers to ICT

Survey respondents were asked to describe what they felt were significant barriers to ICT adoption in the country, as well as things that might successfully enable projects to be rolled out. Evidence for claims was not asked for as it was felt that the perception of a barrier or enabler (whether it exists or not) is still critically relevant because it speaks to the buy-in aspect that was raised in the literature review. That is to say, without appropriate buy-in it is relatively easy for even a single person in a decision-making position to derail a project.

Barriers to successful ICT adoption

- Misuse of the technology – in this example it was thought that project participants might use the technology (mobile phones) for things other than project work (not aligned with the funders' aims and goals)

- Bureaucracy of procurement

- Failure to correctly understand project incentives

- Project coordinations or managers might see that more data results in more work and more responsibility in an already constrained environment

- Uncertainty about how much effort it will be to use the new system, e.g. how long does it take to actually enter the data?

- Projects becoming politicised and judged on merits other than the appropriate ones (technical and social success)

- Research and evaluation of projects or technologies not conducted in a rigorous manner – leads to doubts about the actual usefulness of systems. There is no proven method or framework to analyse projects for success/usefulness.

- The lack of long-term evaluations of projects also contributes to a feeling of uncertainty or ill-ease, coupled with projects not sharing results or findings.

- Financial concerns including the initial outlay for a project, as well as projects susceptible to being shutdown when money runs out

- The tendency to stick with what works and avoid risk by managers, and users resisting change because "this is not how I am used to doing it"

- Shortage of technical skills, or even technical literacy

- Infrastructure shortages – electrical and network connectivity

- Misunderstanding of project requirements or goals – communities can tell you what is wrong, but are not necessarily able to suggest a viable solution (partially due to not knowing what is possible)

Incentives and enablers to successful ICT adoption

- An increase in job satisfaction and status could be used as an incentive to encourage uptake of a new system, similarly the potential gain of technical skills is a valuable incentive

- Getting away from paper-based or traditional systems – "paper is a pain," said one participant

- A consistent record of information that can be used for accountability and transparency purposes is a significant draw card

- Leveraging the perception that IT systems enable better and more efficient collection and management of data

- Having a project champion that can engage at multiple levels of the organisation is a very significant factor in enabling project success. This is a double-edged sword though as a project could be seen to be successful due to its own merits when in fact the champion was carrying it the entire time

4.5 Identification of research needs and water sector strategies for ICT

As part of the survey, participants were asked to identify research needs they felt should be focused on in the future in order to best prepare the country for successful implementation of information systems.

Many of these tie into needs raised by various authors in the literature review.

It was suggested that there is a need for a set of "best practices" – something that can be consulted before starting a new project, to inform decisions and help decide the appropriateness of the proposed solution. Accompanying this is the need for solid and

dependable advice on how to implement and develop systems in such a way that they will be sustainable and able to withstand a variety of setbacks.

One responder felt that research is often too generic and not entirely applicable to the private or public sectors (ivory tower syndrome). Another felt similarly that there is no direct connection between academia, industry, and the government, and without this link the three parties are unable to effectively communicate their needs and experiences to each other. This raises the issue of how to create a research stream that can remain academically rigorous but still be accessible to practitioners on the ground.

5 Conclusion

ICTs adapt to rapidly changing information needs, which enables and provides better foresight, planning, and immediate action. As such, ICTs present an opportunity to obtain information in real time for time-critical decision-making. This is important in the water sector as availability of water resources comes under pressure from: economic growth, climate changes and extreme weather events, and rising populations. Major areas in the water sector where ICTs are currently being used, or could effectively be used are: mapping of resources, weather forecasting, asset management, risk assessment, early warning systems, water demand management, and irrigation management.

The analysis of past and present ICT projects in the water sector has shown that ICT development and implementation is certainly complex and its success and failure are dependent on three dimensions which were highlighted in the reviewed literature:

1. Social Design – this comprises the social component of an ICT design. Aspects such as the social context of the implementation, organisational structures, stakeholders and the way in which information is shared are key concerns in this dimension.

2. Technical Design – the system appropriateness and technical correctness for the problem at hand

3. Program design – the support structure for scalability and sustainability of the project

The point was raised that we need to understand data and why it is being collected, and to also know the limitations of it:

- out of date data is no good
- what is this data telling us? What is it **not** telling us?
- how good is the information being fed into the system?

Related to this is the clear warning to avoid implementing an ICT solution just for the sake of having an ICT solution. Care must be taken to distance the technical solution from the actual problem at hand – ICT is a means to an end, but not the end itself. It is increasingly useless to launch projects to test the available technology without making a conscious and concerted effort to focus on the problem area itself (we know by now that anything is technically possible, given enough planning, time, and money).

Current ICT use around the world
The literature showed us that whilst there have been and continue to be numerous investigations into using ICTs, mobile applications, and other related technologies around the world, there has been little done to formally analyse them. Lessons learnt here are that projects need to be continuously aware of their long- and short-term goals and to constantly evaluate themselves in terms of these goals.

Academically speaking it is difficult to find objective reports on the success of projects, which leads to a situation of uncertainty and possible distrust of pilot projects. In fact, several countries have begun to place moratoriums on pilot ICT projects in their health sectors (including Kenya and South Africa).

Despite the shortcomings, some projects have found success and show that there is a real benefit to ICT systems when they are implemented appropriately and effectively.

ICT use in the water and sanitation sector
There is a clear experience that ICT can assist in management functions of the WASH sector and the literature is optimistic about the value of ICTs in terms of development and incorporation thereof into the various development sectors, but conclusive proof of such assertions, however, remains elusive.

Survey participants indicated that the majority feel that there is an untapped benefit to incorporating ICT systems into the sector, but few had any good recommendations as to how, merely stating that they felt the government was unprepared for such implementations. The very act of trying to classify ICT projects as "ICT projects" might be doing the field a disservice, as it draws a distinction between pre-existing and long-running IT systems and new projects making use of mobile phones (for instance). This may lead to a situation where certain technologies are seen as more relevant to a situation (due to ease of funding, adoption, etc.) when in fact they are just a new aspect of an existing technology. This links in to the warning to avoid implementing something merely because it is new or currently popular.

A relevant barrier to successful implementation of information systems in the sector is that whilst there may be a far and away clear benefit offered by better information collection and management, this benefit could well not translate to a financial benefit. In other words there are plenty of opportunities available for improvement in the sector, but they would not recoup costs over any short to medium timespan (particularly in the water sector). Conversely, this does speak to the important of agile and cost-effective solutions offered by the proliferation of mobile phones globally.

Barriers and enablers
An entire host of barriers and enablers (real and perceived) was raised in the literature review and during the stakeholder survey.

Key findings regarding enablers mirrored in the survey and the review were the following:

- program goals were clear and realistic and solid knowledge about the needs on the ground existed
- buy-in from all stakeholders (particularly government)
- appropriate solutions (social, and technical)
- understanding the socio-cultural context

The literature raised additional points regarding successful implementation of projects:

- long-term monitoring and evaluation strategy must be present
- users are involved in planning and design
- project focus was on benefits rather than on the technology

Barriers identified by both areas included:

- lack of policy, guidelines, or frameworks to work in
- failure to correctly understand project incentives
- stakeholder relevance incorrectly identified
- **inadequate design methodology and evaluation**

On top of these primary barriers, survey participants indicated a wide range of perceived problems around "people" issues, including: lack of skills, no incentive to change, bureaucracies of getting projects off the ground, uncertainty, and so on.

Recommendations for future projects and research

- *Development of a method or framework for analysing ICT projects* – the lack of long-term evaluations and impact assessments of ICT projects was raised again and again by different sources. There is a clear need for an objective method to be developed with which new and existing projects can be analysed and compared to one another. This report and the SALGA report take steps towards this goal, but more work is required.

- *An in-depth investigative study to map the current IT practices within government* – this would entail visiting government offices around the country to engage in interviews and observations to learn exactly which and how IT/ICT is being leveraged. The current lack of literature and understanding of what systems are in place makes it difficult for an outsider to gain an overall understanding of how information is being used inside government agencies.

- *Fostering a community around ICT projects* – it was shown that there is seen to be a fair disconnect between academia, industry, and government in terms of knowledge sharing. By developing links between the three actors and encouraging an environment of sharing, it would be hoped that industry and government could help academic institutions direct new research towards valuable and pragmatic goals, whilst these institutions could provide unbiased analysis and important feedback on best practices for projects.

Additionally, despite the uncertainty concerning the way forward, it is recommended that new projects and initiatives be judged on their merits and allowed to explore new areas, as long as the barriers and enablers and successes and failures illustrated in this report are taken into account. We cannot hope for an instantaneous change where suddenly every project is successful, but by taking the lessons and striving to share knowledge and experiences we can affect an evolutionary change in this nascent field.

A final point is that success or non-failure is not a binary option – there is an entire spectrum with a range of performance that is “acceptable”.

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Addendum A – Literature Categorisation

Category	Region	Year	Author/ organization	Title	Summary	Relevant Findings	Application of recommendations	ICT Evaluation
transmitting water quality data	Developing countries – Vietnam, Cambodia, Mozambique	2012	Ball et al.	Mobile Data Tools for Improving Information Flow in WASH: Lessons from Three Field Pilots	Although the application improved the efficiency of information flows in all three settings, it did not increase the amount or quality of data that was transmitted in areas with previously established data collection procedures.	- describe pre-existing information flow of the system - mobile data tools can improve the consistency, speed and efficiency with which decentralized agents report monitoring data - Common challenges relate to network connectivity, phone and application settings and phone management - A tool is only as strong as the monitoring program it supports	The limited information technology support services within local institutions might favor external service providers to ensure the sustainability of mobile applications, but we noted reluctance to develop formal service relationships among our partners.	TECH – Android app pilot study – first evaluation/ project description - implemented in 3 countries -evaluation based on interviews with managers and end users - No ICT4D "design methodology/ theory"
transmitting water quality data	Developing countries – South Africa, Vietnam, Cambodia, Mozambique	2012	Champanis & Rivett	Reporting Water Quality – A Case Study of a Mobile Phone Application for Collecting Data in Developing Countries	the design of a set of mobile applications and their role in water quality management in rural and under-resourced areas in developing countries… tools were developed to allow data relating to water quality to be collected remotely using low-cost mobile devices	In all three cases it was a key learning that the support of middle-management is key. The ability to change forms "on the go" when receiving feedback proved to be a key feature to ensure ongoing user engagement.	a solid understanding of the local context is vital to a successful deployment. Of equal importance is the ability to adapt an ICT-based solution to compliment systems already in place instead of replacing them outright	TECH – Android app Pilot study – first evaluation -comparison of implementation challenges in different locations - No ICT4D "design methodology/ theory"
Reporting water quality data, WQ education	Developing country – South Africa	2012	Brown et al.	WATER Alert!: Using Mobile Phones to Improve Community Perspective on Drinking Water Quality in South Africa	Design a symbol-based prototype mobile phone application to alert, advise and report water quality information to consumers and allow for citizen involvement in water management.	- the WATER Alert! application would be an enhancement over the existing paper-based water quality report. - It suggests that such an application could help to improve consumers understanding of water quality in their area and correct misperceptions. - users want to be able to communicate with WSPs after alert notification	-used abstracted images and few colours - A key area for emphasis is in designing such an application for a diverse user group (in terms of literacy levels and area of residence (rural vs. urban, low-income).	TECH – App Pilot study – conducted 12 semi structured interviews for potential users - 5 participants for evaluation through quiz - No ICT4D "design methodology/ theory"
water quality test and data collection	Developing country – Haiti	2010	Holstius et al.	Wireless Monitoring of a Distributed Environmental Health Intervention in Haiti	a prototype system, currently in pilot testing by a Haiti-based NGO, that supports increased transparency and scalability for data assimilation efforts in the context of a distributed water sanitation project.	Impediments: low technology literacy, scarce technological resources, unreliable connectivity, remote household locations > have forced paper-based data collection which is found to be largely inaccurate and time-consuming	app enables on-site collection and remote transmission of electronic questionnaires	TECH – Java-based App, NFC tags -being pilot tested -no evaluation - No ICT4D "design methodology/ theory"
water quality test and data collection	Developing country – Haiti	2012	Kaye	Using NFC Phones to Track Water Purification in Haiti	Programmed 40 NFC phones to track chlorine usage in 2000 households.	User experiences - Concern about battery life, power button and no electricity at home - Sociotechnical difficulties - Sourcing local language pack > usability issue	- Insufficient management structures and processes were in place to respond to the needs and concerns of CHWs - Change to barcode instead of NFC tags - Develop app for supervisors	TECH – Java-based App, NFC tags and Frontline SMS -pilot test - 40 phones = 2000 households - 2 focus groups of CHW - No ICT4D "design methodology/ theory"
Water consumption monitoring and data reporting	Developed – California, USA	2010	Lanzarone and Zanzi	Monitoring Gas and Water Consumption through ICTs for improved user awareness	-provide end-users with direct feedback over gas and water consumption, along with self-assessment parameters related to their utilization behaviour - Hourly data on gas and water	- digital reading device attached to traditional (analogical) water and gas meters - the information system not only presents both the consumer and the provider with data, but allows		TECH – Java-based service platform - 300 households - No real evaluation

					consumption are collected, transmitted and analysed -A Web portal allows the end-users to look at their consumption and to identify ways to save costs and improve efficiency in gas and water utilization	interaction - use emoticons to reinforce consumption data > found favourable change in consumption		
Rural water usage patterns;	Developing – rural community Lusaka, Zambia	2012	Thomson et al.	GSM-enabled remote monitoring of rural handpumps: a proof-of-concept study	Waterpoint Data Transmitter (WDT) automatically monitors the number of strokes made in operating a handpump, and then transmits this information over the GSM network – provides volumetric output estimates… real-time monitoring of rural handpump functionality is possible	WDT 3 essential elements: IC-based accelerometer, microprocessor, GSM modem - If the apparent volume of water starts to deviate significantly from previously observed patterns > indicates and issue with the borehole casing or affecting pump performance 4 CHALLENGES - tested one type of pump - leakage will confound volume calc algorithm -concern battery life and power consumption - environmental durability and user acceptability	-studies have found that users are generally able to repair minor faults but struggle with major breakdowns and preventative measures -a handpump with a low failure rate and low-cost spare parts is of little relevance if specialist training and equipment is required to repair them. -risk of vandalism and theft if long-term user acceptability is not ensured	TECH – accelerometer, SMS via GSM modem - Trial> no long term monitoring - Live tests over 4 days on 3 pumps
Mobile water payments	Developing – urban Africa: Kenya, Tanzania, Uganda and Zambia	2012	Foster et al.	Mobile water payments in urban Africa: Adoption, implications, and opportunities	- Survey data indicates that **time savings** –universally viewed(80 mins/month) and cost savings – 2/3rds(transaction costs incurred by customers & WSPs) are major drivers of customer adoption - Several barriers to further adoption: customer trust, lack of a physical receipt, lack of awareness, and transaction levies by mobile network operators	- Full-time work status emerged as a statistically significant predictor of mobile payment usage - Those using mobile payments are now 10% more likely to pay by the bill payment deadline than their counterparts paying at the bank	- This revenue collection mechanism can help provide the circuit-breaker that many African utilities seek to escape the vicious cycle of low cost recovery and poor operational performance	- No programme evaluation> connected to Hope (2011)
Mobile water payments	Developing – East Africa	2012	Foster et al.	Impacts and implications of mobile water payments in East Africa	Results suggest that if broader behavioural and operational constraints can be overcome, partnerships between mobile network operators and water service providers could lead to more sustainable water service access for inclusive, developmental outcomes. - predictions (employed) and reasons (TIME and cost saving) for adoption	- Kenya (MPESA): launched in 2007, 15 mill users - Since 2009, at least 22 WSPs across 7 African countries have introduced a payment option allowing customers to settle bills using mobile money - Mobile payment option considered complimentary to existing physical pay points	- Because of a range of operational and behavioural constraints, major utilities have yet to sway more than 1 in 10 customers to switch to the mobile payment option. - Including convenience of alternative pay points and delayed reconciliation of billing systems	TECH – MPESA, -comparative assessment across countries> semi-structured interviews with managers from 8 WSPs, 3 water service regulators and 6 MNOs - include survey of 272 households in Kiamumbi (>80% customers with MPESA)
Mobile water payments	Developing – Urban Africa	2011	Hope et al.	Mobile Water Payment Innovations in Urban Africa	Discussion paper corresponding to article above			
Water point mapping and data collection	Developing	2011	Kleemeier et al.	Mobile Phones and water point mapping	Applications for water point mapping: FLOW (field-level operations watch) and EpiSurveyor – data collection needs	Practical experience in Liberia – limited battery life and unreliable access to electricity> external chargers with AA-batteries - No mobile phone or internet connection> download data at HQ	PoiMapper and ODK (Open Data Kit) – alternatives to FLOW	TECH – FLOW=smart phone app EpiSurveyor=SMS capable - Basic intro into mobile water mapping applications
Social media	Developing – South Africa	2011	Butgereit	Dam that Social Networking: Connecting South Africa's Major Dams to Social Media	Four major dams are connected to Twitter and Facebook giving residents access to information about water levels – the project was to investigate which mechanism was easiest to replicate and maintain	- communication valuable during periods of flooding and drought		G2C communication - No real evaluation on impact to users

Smart metering	Developing country context	2012	Hope	Water Security and Mobile Technologies	""Smart metering consists of measurement, communication and data management components using a meter enhanced with radio frequency or GPRS functionality to transmit consumption data as well as control water flows"	- "Accurate, timely and reliable data can drive accountability and transparency in the global water sector to improve operational and financial performance." - "However, the most water insecure globally are rural residents counting for four of every five people without safe water."	"'smart handpumps' installed with a low-cost, mobile transmitter device can automatically sends real-time information on pump use and performance to trigger maintenance alerts"	- Introduction paper to smart water systems - No intervention – no evaluation
Climate change adaptation	Developing country context	2012	Ospina et al.	The ICTs, climate change adaption and water project value chain: A conceptual tool for Practitioners	- Develop a conceptual model [project design, operation and evaluation] that contributes to the implementation of ICT-enabled adaption projects in the water sector	- "Building adaptive capacity for the management of water resources is among the most urgent areas for action in the climate change agenda of developing countries." ICTs potential for implementation - Water supply (precipitation) and demand - Water availability (surface and GW levels, WQ, monitor distribution systems) - Water management (WRM) - Water governance (enable access to relevant info)	Within vulnerable developing contexts characterised by asset scarcity and by the presence of inequality, marginalisation, weak institutions and centralised governance structures – among other development challenges – the timely identification of enablers and constraints to the implementation of ICT applications in the water adaptation field could also be crucial.	- Discussion paper - Use principles from the ICT4D value chain – 4key domains: readiness, availability, uptake and impact – (Heeks, 2010) and sustainable livelihoods approach
Water Governance	Developing – Tanzania	2010	Jimenez & Perez-Foguet	Challenges for Water Governance in rural water supply: lessons learned from Tanzania	- Finally, the establishment of reliable and inclusive information routines for sectors is the key ingredient for many of these changes to be possible, as well as to anticipate future challenges. Objective, reliable and detailed information about water access is essential. - Tools based on GIS, like the Water Point Mapping, have great potential. But above all, the will of having reliable monitoring systems in the water sector should become a real priority for international donors and governments.	– use water point mapping: challenges with updating ('basic' annual update) and effective use of information - Weaknesses in rural water sector: low quality and sustainability of service, lack of pro-poor targeting, and inadequate information systems - Plans based on real needs to ensure poor and small communities are not overlooked.	- Recommend demand-response approach (DRA) at community level - Local level equitable targets should be monitored from central government - National plans should include periodic evaluations of indicators related to equity and functionality rates - Develop transparent mechanisms - Role of local governments has to be strengthened	Discussion paper on challenges in rural water sector in Tanzania and possible remedies/ interventions from governance and policy perspective
public participation, governance, water resource management	Developed – Southern France	2003	Guimaraes Pereira et al.	ICT tools to support public participation in water resources governance & planning: experiences from the design and testing of a multi-media platform	-reviews motivations for stakeholder participation - highlighting methodological and technical problems with design and deployment of suitable ICT platforms -TIDDD: Tools to Inform Debates, Dialogues & Deliberations	- ALEPH system (Corral Quintana et al., 2002a)>takes into account thresholds of suitability, or may compare scenarios using multi-criteria evaluation, through Novel Approach to Imprecise Assessment and Decision Environments method (Munda, 1994) NAIADE > ranking of the alternative actions based on decision criteria and ranking of acceptability by stakeholders - "Because multi-media tools allow different languages to be expressed and different visualisation formats to be used, they are powerful means to overcome cognitive barriers and tense relationships."	- Developed different possible future scenarios of river basin and tested on 3 different groups of evaluators - Tool was found to be 'potentially dangerous' offer possibility to manipulate information > "the tool should only help stakeholders to ask the right questions" - "The authors of this paper, argue that exclusion is rather due to context or inadequate problem framing rather than to tools and techniques designed to support a dialogue (see Lemon et al. in this issue)."	- experimental test of multi-media based ICT platform for use in stakeholder debates - 70 semi-structured interviews were conducted with reps from various categories of users
Smart water		2010	Mauree	ICT as an enabler for Smart Water Management	Overview of how ICTs can be a strategic enabler for smart water management policies and surveys upcoming standards that will act as a catalyst for successful implementation of smart water management initiatives	Major areas for ICT in water management - mapping of water resources and weather forecasting (remote sensing satellite systems & GIS> predict water levels in Yellow River Basin in China, environmental mapping & identifying arsenic presence in West Bengal)	- standardising data: smart meters, GIS, and water data transfer format standard [Water ML 2.0]	Discussion paper of potential ICTs use in the water sector, including a variety of case studies around the world where ICTs systems are implemented in the water sector

						- asset management for the water distribution network (smart meters-USA) - early warning systems and meeting water demand for cities of the future (smart levees for the UrbanFlood project in Netherlands) - just-in-time irrigation and landscaping		
Smart water		2011	Hope	Smart Water Systems	The aim of the project was to examine the generic case for smart water systems (SWS). This work has been undertaken via two work streams over the period October 2010 to March 2011. First, a global desk-based review of smart metering and mobile banking systems has been undertaken to determine the applicability and feasibility of SWS to a developing country context. Second, proof- of-concept workshops with key stakeholders have been convened in Lusaka, Nairobi and London to critically examine and debate the case for SWS.	- Smart meters: automated meter reading (AMR) – automated reading collection, advanced metering infrastructure (AMI) – 2way communication with meter. Shift from AMR to AMI and 'smart grid' solutions - Upfront cost stands as a barrier to smart water meter undertakings; payback periods 3 to 15 years		Discussion papers of opportunities for smart metering and mobile payments in water sector – desktop review [with examples of implementation cases] and proof-of-concept workshop
Water Security		2012	Hope et al.	Harnessing Mobile Communications Innovations for Water Security	The confluence of rapid mobile network expansion, mobile phone ownership, mobile water payments and smart metering technologies offer new policy pathways to water security to accelerate progress on sustainable, safe water access, particularly for those in the greatest need and those most difficult to reach. We chart emerging mobile water innovations in Africa and policy implications in the region and beyond.	- Mobile banking innovations have rapidly increased financial access amongst low income groups with innovative applications being introduced into the water sector (McKay & Pickens, 2010) - Smart water metering has expanded in industrialised countries driven by water resources conservation benefits and operational efficiency gains (Hope et al., 2011)		Discussion paper – mobile payments and smart metering -workshop in Kenya and Zambia: display differences in implementation of mobile payments
Monitoring	Rural	2012	Thomson et al.	Is silence golden? Of mobiles, monitoring, and rural water supplies	Reliable and cost-effective monitoring of rural water supply infrastructure has long been hampered by the geographical curse of dispersed and low-income populations, and weak institutional performance. Recent advances in monitoring technology combined with mobile network expansion into rural areas has created an opportunity to bypass these seemingly intractable challenges. Mobile-enhanced technologies have the potential to produce data that is orders of magnitude richer, faster, and cheaper than that provided by traditional monitoring methods, which require costly field visits. **However, more data does not equate to better data**; information generated by crowd-sourced and automated systems each has its respective limitations.	- understanding the risks and limitations of monitoring methods for rural water supply is essential to make appropriate policy and investment choices - monitoring approaches differ in design and purpose> differing objectives - crowdsourcing options: difficult to mobilize end-users to report problems to local authorities. Barriers include: socio-demographics such as literacy and tech 'savvy' and entrenched political interests. - While high-quality analysis and presentation of data is invaluable, it can only be genuinely helpful if we understand what the underlying data represent and their limitations. The **quality** of the raw source data must be considered, in terms of both **accuracy and timeliness.** - The communities least likely to be able to maintain their water systems without outside support in the first place may well be the least likely to effectively use a new type of reporting	- measuring certain performance characteristics, preferably continuously, also opens up the possibility of predictive maintenance - With near real time performance data integrated into the management of a system, a 'monitoring and evaluation leading to lessons learnt' paradigm gives way to a 'surveillance-response' paradigm.	- discussion paper on challenges with monitoring rural water systems – includes case studies from developing countries to make relevant points

						system.		
Mobile technology, fault reporting	Uganda	2012		Mobile phone technology to improve functionality of rural water sources	- M4W: being piloted in7 districts – water users can send a SMS to report a fault at a water source; follow up can be monitored and fed to Water Atlas Update Project (WATSUP) database with real-time info on status of water sources	- Project aims: improving efficiency in reporting faults; triggering action for response to non-functional sources; and improving efficiency in updating district and national information systems - Preliminary evaluation of challenges wrt mobile phone use – network, lost data; HPMs – literacy, transport challenges; inconsistencies with m4w and WATSUP info and verification	- Require communication strategy to make water users aware of system	- Introductory report on M4W initiative in Uganda - SMS based information exchange system; HPMs with Java-enabled handsets - Roll-out of system started in Jan 2012
Emergency messaging	Mozambique	2013	Jackson	Text messages help fight cholera in Mozambique	Text messages to inform people to collect bottle of chlorine for water purification			- News article - SMS technology
Smart water	Australia	2012	St John	The Smart Grid for water gets bigger	Smart metering deployment in Australia			- News article: background to need for technology & relevant cases
Smart water	Kenya	2013	AllAfrica.com	Mobile technology from the UK gives villagers access to clean water	Smart hand pumps- consists of low-cost data transmitters which monitors movement of the handle and sends periodic text messages to WS managers			- News article - Pilot project in Kenya
mWASH		2012	Hutchings et al.	mWASH: mobile phone applications for the water, sanitation, and hygiene sector	This paper seeks to identify best practices and help inform future mWASH implementation for current and potential implementers of mobile phone solutions in the WASH sector. - In developing mWASH apps, aspects to be considered: social context and info needs (social design); appropriateness of tech platform (technical design); effective support and sustainability of app (program design)	Projects reviewed related to WASH: - FLOW (worldwide): mapping software for data collection for monitoring the functionality of water access points - Human Sensor Web (Tanzania): SMS gateway app collect user reports and automated sensor data through water and power monitors - Maji Matone (Tanzania): accepts and manually processes unstructured SMS messages about rural water point issues – relevant SMS also forwarded to local media - NextDrop (India): utilizes Kookoo – program that allows web app to interface with IVR system from utility employees in the field; generates public water timing information. Residents are notified of piped water availability via SMS - WQ Reporter OTHER PROJECTS -NFC RFID safe water tracking (Haiti): allow CHW to track water treatment - mWater (Senegal): app for management of small water schemes - smart water systems (Zambia, Kenya): smart water metering and mobile banking - M-Maji (Kenya): mobile phone-based water information system for water buyers/providers - MajiSMS (Kenya): customers can check account balance & meter readings by sending SMS to utility -UrSMS (India): collect info on water supply/quality or sanitation issues via SMS	Elements critical to design: User Participation and Experience - Understand socio-cultural context - Build user base through outreach - Ensure system is easy to use - Fulfil a key need>monetary compensation not needed Use of Data - Allow & promote user access to data - Ensure responsiveness from provider - Verification to create high-quality data Success and Sustainability - Identify and measure indicators of short and long-term success>use to refine system design - Plan for long-term sustainability	Conducted global survey, reviewed 10 projects- discuss what is available and determine best practices

Addendum B: Mobile Applications and Developers in South Africa

The table below gives an overview of the most recent mobile applications and developers in South Africa. (InfoDev, 2012)

Table 14. Various key applications and platforms by category

Category	Application	Description
	Drug Advice Support	A cooperative counselling drug advisory service through instant messaging, supported by Mxit and JamiiX.
	JamiiX	Allows subscribers to engage in more than one conversation at a time, giving counselors the opportunity to provide support to different people at the same time.
Health	HI4LIFE	A mobile service to allow South African women and their partners access to relevant up-to-date, health information on HIV, pregnancy and baby health.
	Eastern Cape Department of health Shared Call Centre	Provides a central point where all queries are received, processed and managed to provide value-added service and bridge the gap between health services and the communities that use the service.
	SIMpill	A medication adherence system that assists patients/carers in making sure that medication is taken as prescribed. It can detect non-compliance in real time.
	Cell-Life Communicate Services	Addresses health-related logistical challenges such as the provision and distribution of anti-retroviral treatments, continuous patient monitoring and evaluation, and collection and communication of relevant data.
	CommCare	Tracks activity and provides electronic job support during visits. Makes use of visual and audio clips to better communicate health messages.
	EMIT	Allows facilitators to capture field data on mobile devices and submit via GPRS to a central database. OneVoice uses it to capture data on their HIV and AIDS prevention program.
	Wisepill	Provides ways to help users take medicine on time. It is a portable medication dispenser with a GSM communication chip. The dispenser sends a message to a central management system whenever medication is taken.
	Babyinfo	Pregnancy advice service.
	MTN CareConnect	Healthcare nurses' advisory line.
	Dispense.iDart	To assist antiretroviral pharmacies in dispensing antiretroviral treatment. Currently used by 350,000 individuals and 300 clinics.
	Young Africa Live	A combination of regularly updated dynamic stories and live chats and a series of permanent content pieces. Facts on HIV and AIDS; daily news & celebrity stories.
	Bozza	Platform ranging from social issues such as HIV and sexual health to entertainment.

Table 14. Various key applications and platforms by category		
Category	Application	Description
Employment /Job	Ummeli (originally conceived as "LinkedIn for the BoP")	Gateway for young people to enter the mainstream economy through a network of connections to community jobs. Allows communities to share and set goals and to initiate their own projects.
	Mobenzi	A software service designed to create work in impoverished communities. Mobenzi pays individuals to perform simple tasks via SMS on their phones.
Environmental	WaterReporter	Allows for results of field tests to be sent through mobile phones for analysis.
	Open Data Kit (runs on Android mobile operating system)	A data collection system (CyberTracker) in SA has used it to allow non-literate animal trackers to communicate their environmental observations.
Education /Learning	Mobile Learning for Mathematics	Provides learners and teachers with access to interactive mathematics learning materials, using a mobile delivery platform combined with a social media application for peer-to-peer support.
	M4Lit ("Yoza")	Used to support reading and writing by youth (hosted on the Mxit platform and on a mobisite). Provides a platform for publication of local content in local languages.
	Dr Math	Provides tutors to help with mathematics homework. Uses the Mxit platform.
	Voices of Africa Mobile Reporting	Enables users to make video reports and publish them on the training website for feedback.
	QuizMax	Easy, fun way to do exercises and to prepare students for exams.
Agricultural	Manobi	A mobile data services operator. Provides added-value corporate services that help small scale farmers play a more active role in the product value chain.
Financial /Transactional	Wizzit	Low-cost transactional bank account aimed at mobile phone customers who are unbanked or underbanked. Accessible by mobile phone and debit card.
	MTN MobileMoney	Offers MobileMoney transactional accounts for banking purposes.
	MPESA	Allows users to send and receive money. Can also buy Vodacom credit.
	Standard Bank Community Banking	A mobile banking account that allows clients to carry out affordable banking transactions in their communities.
Social	SocialTxt	A mobile messaging platform that uses the available advertising space on "please call me" messages to communicate selected information to a specific target audience.
	Mxit	Free instant messaging that runs on GPRS/3G mobile phones and PCs. Allows for one-on-one text, multimedia messages and general chat rooms.
Enhancing Communication for NGOs	FrontlineSMS	Turns a laptop or mobile phone into a central communications hub. Enables users to stay in touch through SMS. Enables instantaneous two-way communication on a large scale (ideal for grassroots NGOs). Downside is that it requires a PC.
	Mobilisr	An open-source enterprise-class mobile messaging platform for NGOs (for broadcasting and two-way communication).
Social Issues Application: Violence/Drug Addiction	Fahamu Umnyango Project	Promotes social justice issues in Africa. Uses SMS to report on acts of violence against women and on land rights.
	South African Depression and Anxiety Group (SADAG)	Suicide Crisis Line and Substance Abuse Line. A helpline that allows individuals to send queries or problems via SMS, which are entered into a computer database, and receive counseling.