Role of Information Communication Technologies in Water Management Systems

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ABSTRACT

Kenya has low levels of water access whereas the demand for water services continues to rise largely as a result of the increasing population. In Nairobi, only 50 per cent of the population has direct access to piped water. The rest obtains water from kiosks, vendors and illegal connections. Of the existing customers, about 40 per cent receive water on the 24-hour basis. The low access levels have increased pressure to manage the country's water resources more efficiently and ensure that water services are availed equitably among the diverse uses. The purpose of this study was to establish the role ICTs can play in managing the water resources and services efficiently. The study adopted descriptive census design. The response rate for the target population was 83% which is statistically significant to analyze the data. Data collected was analyzed using both descriptive and inferential statistics. The study established that Billing System, Meter Reading System, Financial Management system, Procurement system and the Dam Monitoring System were the main ICT applications used in water management. Further the study established that limited staff skills, limited resources (finance), lack of customized applications, lack of detailed top level management support and appreciation of the role of ICT by other departments were main challenges facing the implementation of ICT applications in the company. The study identified; quality management, water supply chain monitoring, mapping of water supply stations using GIS and customer management to be the priority functions in water management where ICT applications are required most.

Keywords: GIS, SCADA, water resource management, mobile applications, water sensors, smart pipes, smart meters

1. INTRODUCTION

Kenya, which is considered as a water scarce country below 64,710 cubic meter of water per capita compared to the international benchmark of 1,000 cubic metres per capita, faces serious challenges with regard to protection of water resources, water supply and sanitation services. Despite the resources that have been provided so far, existing water sources and facilities have continued to deteriorate whereas the demand for water services continues to rise largely as a result of the increasing population. The pressure to manage the country's water resources more efficiently and ensure that water services are availed equitably among the diverse uses is bound to increase as the country gears itself towards meeting the Vision 2030 goals.

ICTs have a potential to contribute towards improvements in water resource management techniques; strengthen the voice of the most vulnerable within water governance processes; create greater accountability; provide access to locally relevant information needed to reduce risk and vulnerability; and improve networking and knowledge sharing to disseminate good practices and foster multi-stakeholder partnerships, among others [2].

Research has shown that ICTs have the potential to improve water use efficiency as evidenced by [3]. However, it is impossible to realise the full potential of ICTs in improving water use efficiency due the current fundamental problem with the design and prioritisation of the existing ICT Infrastructure and applications. If this design problem is rectified, it is believed that ICT can play an immeasurable role in mitigating, adapting to and monitoring climate change. The objectives of this study are;

- Establish ICT applications used in management of water resources
- Establish the functions of the ICT applications that are used to improve water use efficiency
- Evaluate the platforms that host the ICT applications used to improve water use efficiency.
- Identify the challenges faced in the implementation of ICT in the management of water resources

2. LITERATURE REVIEW

2.1 Climate change and variability status

According to the United Nations Framework Convention on Climate Change [16], many areas in Africa have climates that are among the most variable in the world on seasonal and decadal time scales.

Reports indicate that one third of African people already live in drought-prone areas and many more are exposed to drought each year [42] [9]. Across Kenya, the effects of climate change are wreaking havoc” [4]. The prolonged droughts of the past decade have threatened food security and societal stability, especially in vulnerable
pastoral areas [6]. Water is a critical element in ensuring livelihoods, since more than 40% of Africans live in arid, semi-arid and dry sub-humid areas and about 60% live in rural areas and depend on farming for their livelihoods [42]. In terms of dryness, Africa is second only to Australia.

2.2 ICT and water use efficiency
Water is a critical natural resource today. Projections made by the 2030 Water Resources Group show that world demand for water will exceed accessible supplies significantly, threatening to impede global economic growth and result in large-scale food insecurity. Water efficiency is reduction of water wastage by measuring the amount of water required for a particular purpose and the amount of water used or delivered. ICT has emerged as a strong way to understand water security challenges. They are increasingly being adopted as key decision support mechanisms for adapting to water use effects in the developing world. The proper use of ICT applied to water use efficiency allows gathering data to know in real time about supply, demand and use of water among its users.

2.3 ICTs and climate change
In particular the mobile phones are continuing to shape development in ways that were not anticipated a few years ago, including in the water sector [1] [6]. Examples include the Android application of Field Level Operations Watch (FLOW) for data gathering, analysis and reporting. However, crucial barriers prevail in Africa constraining the wider deployment of ICT-based climate change-related solutions to climate change resource problems. The barriers vary from country to country and even within countries (e.g. between urban and rural areas and also between different ecosystems) [2].

3. METHODOLOGY

3.1 Research design for this study
This study was conducted through a descriptive census design. The census design was more appropriate as it enabled the researcher to collect data from broader category for comparison purposes. The study settled for this research design in order to better understand the intricate issues involved in the water sector in relation to ICT. This design was considered to be appropriate for this study because they saved time, expenses and the information provided was expected to be of high quality and valid.

3.2 Sources of data
The descriptive census design was necessary due to the relative small size of the population, it provided an overall picture of the ICT application that are being implemented by the water service providers in Athi Water services board area of operation. The number of water service providers operating within the Athi Water services board area was small and as such sampling is not necessary. AWSB has appointed twelve (12) WSPs within its area of jurisdiction which covers Nairobi, Thika and Kiambu.

3.3 Data collection instruments and procedure
Primary data was collected through structured questionnaires, for secondary data, annual reports and magazines were reviewed. Questionnaires were incorporate both open-ended and closed-ended questions to gather the study’s data. The questionnaire was first pre-tested on appropriateness, structure and relevance to the study. As recommended by [1], the questionnaire was conveniently used because it was cheaper and quicker to administer, it was above researcher’s effect and variability, and was highly convenient for the respondents as they could fill them during free times or when workloads are manageable. The instruments will incorporate Likert scales to measure perception, attitude, values and behavior. The questionnaires will be self-administered to minimize the measurement error.

3.4 Data analysis and presentation
The survey used questionnaires that were issued out to different staff of the organizations who had been identified as key data sources. Quantitative data was reviewed to eliminate huge inconsistencies, summarized and coded for easy classification in order to facilitate tabulation and interpretation descriptive statistics that was used in describing the sample data in such a way as to portray the typical respondent and to reveal the general response pattern. The data generated was analyzed using computer aided software such as Statistical Package for Social Sciences (SPSS) which offers extensive data handling capability and numerous statistical analysis routines that can analyze small to very large data statistics.

4. Findings and results

4.1 ICT applications used in water management
[2] indicated that the rationale for considering ICT tools, platforms and protocols is to facilitate the collection, storage, analysis, distribution and utilization of data via interaction and feedback among various water actors. The respondents were asked to indicate ICT applications that are used in water management applied in their organization. On whether SMS notifications were used as ICT applications in water management, the respondents agreed with a mean of 3.6234 and a standard deviation of 1.1468 that SMS notification was used in water management. The finding agrees with [1] who pointed out that mobile phones are continuing to shape development in ways that were not anticipated a few years ago, including in the water sector. On whether Internet based water bill access, the respondents agreed with a mean of 3.5368 and a standard deviation of 0.97581 that Internet based water bill access was used in water management. The finding concurs with [10] who indicated that the application of ICT solves climate-induced water management challenges in prediction, mitigation,
monitoring, and now increasingly, adaptation and national or institutional strategy formulation. In addition, the respondents pointed out that Billing System, Meter Reading System (MRS), Financial Management system, Procurement system, Customer complaints Management system (MajiVoice) and Dam Monitoring System were the ICT applications used in water resources management. The finding coincides with [7] which provided an overview of how ICTs can be a strategic enabler for smart water resources management policies and surveys upcoming standards that will act as a catalyst for successful implementation of smart water management initiatives.

4.2 Functions of the ICT applications

The study sought to establish the functions of the ICT applications. From the responses, the respondents agreed with a mean of 3.74758 and a standard deviation of 1.04879 that the ICT applications were used in customer information management. The findings agree with [12] who reported that emerging experiences from vulnerable communities pointed to the increasing use of community radio, mobile phones, the internet and other ICTs in climate change responses. The respondents further agreed with a mean of 3.86013 and a standard deviation of 0.89256 that ICT applications were used in water billing processes. The finding further concurs with [13] who reported that ICT applications also provided directory and authentication services, virtualization services, and infrastructure management and monitoring services.

In addition, the respondents also agreed with a mean of 3.53561 and a standard deviation of 0.73892 that ICT applications were used in communicating with customers. The respondents were agreed to a moderate extent with a mean of 3.48236 and a standard deviation of 1.16125 that ICT applications were used in water quality management. The finding was impartial to [10] who stated that ICT applications can be used solve climate-induced water management challenges in prediction, mitigation, monitoring, and now increasingly, adaptation and national or institutional strategy formulation. The respondents further highlighted that Laboratory Information Management system (LIMS) for water quality was underway.

4.3 Platforms that host the applications

The respondents were asked to indicate the platforms that hosted the ICT applications. From the responses, the study established that the respondents agreed with a mean of 3.92487 and a standard deviation of 1.26854 that web based platforms hosted the ICT applications. The respondents further agreed with a mean of 3.74965 and a standard deviation of 1.1487 that mobile phone based platform hosted the ICT applications. The respondents further indicated that basic client/server connection was also a platform that hosted ICT applications.

The respondents were further asked to indicate to what extent the applications were actively used by the current customers’ service. From the responses on the extent the applications were actively used by the current customer service, 80% of the respondents indicated always used while 20% indicated the applications were mostly used by the current customers’ service. In addition the respondents were also asked to indicate the percentage of the customers who actively used the applications rolled out by the company. From the responses, the study established that 70% of the respondents indicated that 51-75% of the customers actively used the applications rolled out by the company, 20% said that 76-100%, 10% of the respondents highlighted that 25-50% of the customers actively used the applications rolled out by the company while none of the respondents 0% indicated 0-25%. The respondents commented further that the rolling-out of e-billing and mobile payment as well as mobile customer complaint management platforms had seen an upsurge in the utilization.

4.4 Challenges faced during implementation of ICT applications

The study sought to establish the challenges the respondents faced in implementing ICT application for the company. From the responses, the respondents agreed with a mean of 3.68247 and a standard deviation of 0.11586 that limited staff skills was a challenge they faced during implementation of ICT applications. The respondents indicated limited resources (finance) with a mean of 3.84369 and a standard deviation of 0.84295 as a challenged during implementation of ICT applications. The respondents also agreed with a mean of 3.77254 and a standard deviation of 1.02487 that lack of customized applications was a challenge they faced during implementation of ICT applications. The respondents were further asked to indicate of the ICT applications previously mentioned, which ones had improved water-use efficiency the most at the local level. The finding showed that communication customers (MajiVoice), billing applications and water quality management had improved water-use efficiency the most at the local level. The respondents commented further that in the water sector there was total reliance on the customers in terms of revenue and hence continuity of the organization. Systems that made it easier for the customer to get to the organization and sort out their issues provided instant improvement in water-use. Proper billing was efficient as well as assuring quality of the water raises the consumption rates.

In addition, the respondents were asked to suggest on what should be done differently in order for ICT applications to be effectively deployed at the community level in water management. The respondents said that there should be development of more mobile based applications because with the fast growth of mobile technology, more easy-to-use mobile applications for water management would easily reach the vast majority of the community.
From the responses, all the respondents agreed that ICT plays a greater role in water use efficiency. For the 30 respondents who answered the question 90% agreed with the notion that ICT plays a greater role in water use efficiency while 10% disagreed that ICT plays a role in water use efficiency.

4.5 General Information on ICT in water resources management and climate change adaptation

The respondents were asked to indicate to what extent they agreed with the following statements of ICT in water resources management and climate change adaptation. The finding indicated that 80% of the respondents strongly disagreed that ICT does not play an important role in the water sector, 20% disagreed while none 0% agreed, strongly agreed or were neutral that ICT does not play an important role in the water sector. This means that majority of the respondents strongly admitted that ICT does play an important role in the water sector. None of the respondents 0% strongly disagreed or disagreed that climate change effects had critically influenced the organization’s ICT policy, 20% were not sure while 70% agreed and 10% strongly agreed that climate change effects had critically influenced the organization’s ICT policy. This means that majority of the respondents agreed that that climate change effects had critically influenced the organization’s ICT policy.

The finding coincides with [7] that showed that there is an increasing role of ICTs in climate change-related water systems management. The report indicated that ICT 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. The finding further agrees with [8] who specifically pointed out that ICTs should be innovatively incorporated in mitigation, monitoring, adaptation and strategy of water management systems.

On whether ICT applications played an important role in shaping the water sector towards responding to climate change, none of the respondents 0% strongly disagreed or disagreed whereas 10% was not sure, 50% agreed while 40% strongly agreed that ICT applications played an important role in shaping the water sector towards responding to climate change. This indicates that majority of the respondents agreed that that ICT applications played an important role in shaping the water sector towards responding to climate change. The finding concur with [17] who reported that ICT development had impacted the continent in the form of modernised infrastructures like broadband fibre optic cables and data centres, added value services and IT innovations. With these developments, prices are falling while demand for equipment, expenditure on ICTs and local content are burgeoning. ICT expenditure was expected to grow by 10% across Africa in 2011, reaching a total of USD 25 billion.

Majority of the respondents disagreed that it had been easy to integrate the use of ICT in its strategy to improve water use efficiency, 20% of the respondents strongly disagreed that it had been easy to integrate the use of ICT in its strategy to combat the effects of climate change whereas 70% disagreed, 10% agreed while none of the respondents 0% strongly agreed or were not sure if it had been easy to integrate the use of ICT in its strategy to combat the effects of climate change. From the responses on whether it had been easy for our customers to integrate the use of ICT in its strategy to combat the effects of climate change adapt to the increased use of ICT in our operations, 10% strongly disagreed while 80% disagreed. 10% of the respondents agreed while none of the respondents 0% strongly agreed or were neutral that it had been easy for our customers to integrate the use of ICT in its strategy to combat the effects of climate change adapt to the increased use of ICT in our operations. The finding concur with [15] who showed that FP7 WISDOM project which aims to achieve a step change in water savings via the integration of innovative Information and Communication Technologies (ICT) frameworks to optimize water distribution networks and to enable change in consumer behaviour through innovative demand management and adaptive pricing schemes. However, there is a growing need to foster knowledge sharing and collaboration.

5. CONCLUSION

5.1 ICT applications used in water management

The study concluded that SMS notifications and Internet based water bill access were used in water management. These tools allow water users and system managers to understand current water systems conditions and make informed forecasts. The study concluded that Billing System, Meter Reading System (MRS), Customer complaints Management system (MajiVoice), Financial Management system, Procurement system and Dam Monitoring System were the ICT applications used in water resources management.

5.2 Functions of the ICT applications

The study further concluded that ICT applications were used in customer information management, water billing processes, communicating with customers, water quality management and soon on Laboratory Information Management system (LIMS) for water quality.

5.3 Platforms that host the applications

In addition, the study concluded that web based platforms and mobile phone based platform hosted the ICT applications. It was further concluded that basic client/server connection was also a platform that hosted ICT applications. The study also concluded that the applications were actively used by the current customer service; 51-75% of the customers actively used the applications rolled out by the company and rolling-out of e-billing and mobile payment as
well as mobile customer complaint management platforms had seen an upsurge in the utilization.

5.4 Challenges faced during implementation of ICT applications

The study concluded that limited staff skills, limited resources (finance), lack of customized applications, lack of detailed top level management support and appreciation of the role of ICT by other departments were challenges facing the implementation of ICT applications in the company. It was concluded further that communication customers (MajiVoice), billing applications and water quality management had improved water-use efficiency the most at the local level. The study also concluded that the water sector totally relied on the customers in terms of revenue and hence continuity of the organization and that the systems made it easier for the customer to get to the organization and sort out their issues provided instant improvement in water-use.

5.5 Information on ICT in water resources management and climate change adaptation

The study concluded that ICT plays an important role in the water sector; climate change effects had critically influenced the organization’s ICT policy and ICT applications play an important role in shaping the water sector towards responding to climate change. The study further concluded that it had not been easy to integrate the use of ICT in its strategy to combat the effects of climate change and also it had not been easy for customers to integrate the use of ICT in its strategy to combat the effects of climate change adaptation to the increased use of ICT in our operations. They study finally concluded that most of the companies had plans to scale up the use of ICT in its operations in the near future.

5.6 ICT applications used in water management

The study recommends that the organization should increase the use of community radio, mobile phones, the internet and other ICTs in water management responses since they help communities and nations sustain resources management.

5.7 ICT applications used in water resources management

The study also recommends that more mobile based applications be initiated because with the fast growth of mobile technology, more easy-to-use mobile applications for water management would easily reach the vast majority of the community.

5.8 Functions of the ICT applications

The study also recommends that Laboratory Information Management system (LIMS) for water quality be completed faster to ensure provision of clean and healthy water. Other key ICT applications that need to be prioritised in order to have improved water use efficiency include.

5.9 Customer management

Application of ICT in the management of customers can go a long way in improving the general service delivery and customer satisfaction in the water sector. Automation of processes such as customer records, billing, and tracking of user complaints go a long way in improving service provision efficiency. ICT applications developed to facilitate these processes and by extension improving the efficiency in management and use of water resources.

5.10 Quality management

Water is a basic need, and as a necessity, its quality must be assured to the end user. Diseases (water borne diseases) easily spread through water. Management of the quality of the water supplied to clients is therefore very vital. The use of Laboratory Information Systems (LIS), and other ICT systems in the monitoring and management of water quality should be enhanced. Water processing and supply stations should embrace the use of the LISs to keep records of the laboratory processes that check for the quality of the water supplied to clients.

5.11 Water supply chain monitoring

The most common water supply chain used is pressurized water pipes. Excess pressure can lead into the bursting of these pipes (majority are made of plastic). Lower pressure in the pipes may also result into water not reaching the clients. Leakages can also occur in the delivery process. ICT applications can be used to monitor this supply chain and give timely feedback to the stations for respective corrective action measures to be taken, in the process improving efficiency.

5.12 Mapping of water supply stations using GIS

Geographical Information Systems are increasingly being used in monitoring and management of resource allocation. The water sector can also apply GIS technology to map out the water resources available and get a visual representation of the distribution of these resources, and based on this information, decisions can then be made on how best resources can be distributed to serve the population better, hence improving water use efficiency.

5.13 Platforms that host the applications

The study further concluded that more key platforms should be exploited by the organization to ensure proper functioning of ICTs in water resources management and climate change adaptation.
5.14 Challenges faced during implementation of ICT applications

The study recommends that the top management and other departments in the organization should support the ICT department in implementation of ICT applications. The study also recommends that at the requirements analysis stage, the system should be explored to establish if it has the ability to improve water use efficiency. It recommends also that the design level should be checked for the ability to integrate with the other existing systems.

5.15 Recommendation for further studies

The study recommends that a similar study be carried out in other regional water authorities in the country to establish the role of ICT in water resources management and water use efficiency. It recommends also that a similar study be carried out in other organizations in the East African region and beyond to determine role of ICT in water resources management and water use efficiency. The study further recommends that a study should be carried out to establish the extent the organization has adopted ICTs in water resources management and climate change adaptation.

REFERENCES