INFLUENCE OF PREPAID SMART WATER METERING ON PERFORMANCE OF COMMUNITY WATER PROJECTS IN MARSABIT COUNTY, KENYA

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ABSTRACT

Water in Marsabit County is a gem that is treasured. Despite billions of shillings invested in the water sector, access to safe water does only improve slowly. Over the past several years, the Department of Water, Environment and Natural Resources of the County Government of Marsabit, through Private- Public Partnership (PPP) collaboration, has invested into improving water sector service delivery through the use of scalable and replicable business models which entail the use of prepaid meters popularly known as Water ATMs and the use of sensors for monitoring different variable at communal water points. This study therefore sought to investigate the influence of prepaid smart water metering on performance of water projects in Marsabit County, Kenya. The study looked into the influence of meter reliability, meter efficiency, billing accuracy and meter flexibility on performance of water projects in Marsabit County. The theories used include the expectancy disconfirmation theory, the value-percept disparity theory and cognitive dissonance theory. A descriptive research design was used. The research targeted the project managers and the Marsabit County Water Department staff members. A sample size of 215 respondents were obtained through stratified sampling technique. Self-administered questionnaires were used to collect primary data. Quantitative data was analysed using descriptive statistics like percentages, means, standard deviations and frequencies. The qualitative data collected from the open-ended questions was analysed using content analysis. Inferential data analysis was done using multiple regression analysis. The relationships between the independent and dependent variables were established using multiple regression analysis. The information was displayed by use of tables. The study found that there was an improvement in access to water for the residents in both formal and informal settlements as prepaid smart water meter is equitably distributed. The study also found that accurate measurements were taken and recorded correctly. However, the study found that loading the credit via M-pesa was instantly updated in the meter. The research also found that more water is now consumed. The research concluded that meter efficiency had the greatest influence on the performance of water projects in Marsabit County, Kenya, followed by meter reliability, then billing accuracy while meter flexibility had the least influence to the performance of water projects in Marsabit County, Kenya. This study recommends that national and county governments increase investment in prepaid smart water metering infrastructure and establish clear regulatory frameworks to ensure equitable access and protect consumers. Water service providers should improve public awareness through education campaigns and expand vending infrastructure and technical support to enhance user experience and trust. Future research should adopt longitudinal and qualitative approaches to better understand the long-term impacts and consumer experiences associated with prepaid metering systems.

Keywords: prepaid smart water metering, performance of water projects, meter reliability, meter efficiency, billing accuracy, meter flexibility.

INTRODUCTION

Water is the essence to life as all human activities depend on it. According to Reniko and Kolawole (2020), the main human water needs include: drinking water for survival; water for hygiene; water for sanitation services and household needs, for example, preparing food. The post-2015 eight Millennium Development Goals (MDGs) and the newly adopted 17 Sustainable Development Goals (SDGs) aim at integrating social inclusion, economic development and environmental sustainability. The SDG 6.1 aims to achieve the realization of the human right to water through universal and equitable access to available, safe and affordable drinking water for all, by the year 2030 (World Bank, 2015). The water crisis has been attributed to among other things: population growth, industrialization, urbanization, increasing water consumption due to changes in lifestyle, climate change and variability, increasing water pollution, inefficiencies in agriculture and poor water governance. It is the result of myriad environmental, political, economic, and social forces (WHO-UNICEF, 2014; ADF, 2015). This is particularly critical for Africa which still accounts for 40 percent of the population without access to safe drinking water.

Africa faces a situation of economic water scarcity, and current institutional, financial and human capacities for managing water are also lacking (Suresh, Muthukumar & Chandapillai, 2017). It is for this reason that global financial institutions such as the World Bank and International Monetary Fund (IMF) proposed measures such installing prepaid water meters and water privatization in order to improve the economic efficiency in the management of water resources (Check, Abdiel & Mbwille, 2018). Water meters are used to measure the volume of water consumed by residential households and industries that are supplied with water via public or private water supply systems. Prepaid water metering, is based on meters that charge for water based on consumption and requires consumers to pay before using the service, as a form of water resource management innovation (Kashid, Gaikwad, Deshmukh & Marchande, 2019).

Prepaid Water Meters (PPWMs) have been introduced in Bolivia, Colombia, Palestine and Turkey, among other countries and in more than 20 countries in Africa (Heymans, Eales & Franceys, 2014). Advocates of PPWMs see it as a way to improve customer relations, revenue, and access to services (Mohamed, Munier, William, Nagar & Ibrahim, 2018). Despite their advantages, the implementation of PPWMs has raised a number of questions. The South African Constitution, for an example, recognizes access to water as a human right and therefore any form of restriction on water access violates the right to water (Wang, Shao, Van Steenbergen & Zhang, 2017). Implications of PPWMs on residents have not been adequately considered as protests against water privatization usually breakout, for example in Bolivia and South Africa. These protests were mainly linked to the lack of participatory approach of water users at all levels of water development and management as per the second Dublin Principle.

In Namibia, PPWMs have been installed in about half of the country's towns, these include, Katima Mulilo, Keetmashoop, Otjiwarongo, Rehoboth, Swakopmund, Tsumeb and Windhoek, with the city of Windhoek being the pioneer in 1998. PPWMs were found to be installed in low-income and informal settlements (Saes, 2012). PPWMs restrict access to water, especially in a case where one has not paid for water. This not only disadvantages the poor, but it also infringes on the human right to water. Therefore, the question is how do we integrate water as an economic good and as a human right in the management of water resources? This uses the concept of the human right to water. This is defined as the right of everyone "to sufficient, safe, acceptable, physically accessible and affordable water for personal and domestic uses" by the United Nations Committee on Economic, Social and Cultural Rights (UNCESCR) – General Comment 15 (Saeed, 2017).

The Kenyan water sector has for a long time been characterized by inefficiencies, lack of investments, poor management and confusing array of legal and institutional frameworks. In addition, the exponential growth of Kenya's urban centers has put increasing pressure on utilities to extend services to new areas. To address these challenges and as part of a global trend, the Government of Kenya introduced far reaching reforms in the water sector to restructure and improve sector performance (Sadiku, Omotoso & Musa, 2019). In the study country, investments in water supply needed to rise more rapidly to expand services to a growing urban population if the country was to achieve its National Water Services Strategy target for access to safe water of 80% in urban areas and 75% in rural areas by 2025 (Moraa, Otieno & Salim, 2012). The introduction of prepaid metering by the company was prompted by the fact that the prepaid system had various challenges which included inefficient monitoring of consumption, wrong meter reading, ineffective revenue collection and inefficient energy use (Kinuthia, 2019). Water utilities in Marsabit County are typically mandated to serve everyone in their catchment area. These communities are often characterized by poor-quality housing, insecure tenure and high population densities; by subsistence living and low incomes; and by low levels of access to basic services. As such, the environment can pose unique technical and social challenges to utilities in expanding services; these challenges increase the need for innovative, context specific approaches, to ensure all residents have access to a safe, reliable and affordable water supply.

Statement of the Problem

Water in Marsabit County is a gem that is treasured. One would cover many miles to literally spot a water point. Despite billions of shillings invested in the water sector, access to safe water does only improve slowly. This is because almost 40% of the investments in water supply fail within 3-5 years creating an access gap. Over the past several years, the Department of Water, Environment and Natural Resources of the County Government of Marsabit, through Private-Public Partnership (PPP) collaboration, has invested into improving water sector service delivery through the use of scalable and replicable business models which entail the use of prepaid meters popularly known as Water ATMs and the use of sensors for monitoring different variable at communal water points. The stakeholders adopted prepaid metering to improve on efficiency, the quality of service offered and also empower customers to control the cost of water. The installation of prepaid water ATMs in kiosks in Marsabit County has become a

tremendous success. Through the deployment of this technology and innovation, water sector service delivery is expected to undergo major transformation especially with revenue collection that has broken the cartels and mismanagement within community water points in various parts of the County (Kaimenyi & Wanyonyi, 2019). The prepaid meters project ensures that water projects are sustainable and continue to serve communities by improving integrity in the management and governance of the water facility. However, the projects have been riddled with poor management and lack of transparency (Donge, 2013).

Even with the adoption of this technology, the performance of several water projects is still inconsistent (Hagarsu, 2020). The potential of many of the meters is being compromised by unreliable performance, which is inconvenient and frustrating for customers and onerous and costly for the water utilities. Most utilities and customers complained about prepaid water meters breaking down, and it would appear that the necessarily skills and spares are not always readily available to deal with faults. In addition, the meters that are initially inexpensive to purchase have proven costly in some cases when they have failed early and cannot be repaired locally.

Despite the installation of prepaid meters at Shauri Yako by Pastoralist Community Initiative and Development Assistance (PACIDA), the waiting time are still as long as 7 hours. Further, when prepaid water meters and sensors at Dakabaricha Community Water Point in Saku Sub-County has failed severally making the residents to go home without water. In addition, a good proportion of the people still prefer obtaining water from rain water, rivers, boreholes and other sources (Concern Worldwide, 2019) even with the introduction of prepaid metering because they find the water from the metered system expensive, a high incidence of malfunctioning meters, inaccurate meter readings, and frequent outages that forced water users to seek the services of the expensive water vendors.

Further, even with the installation of the community prepaid water metering, there are many service provision challenges in areas such as Dirib Gombo and Odda boreholes where there is low water coverage, high non-revenue water and lengthy time to fetch water (Concern Worldwide, 2019). Some of other complaints were that pre-paid meters do not give the consumers a breakdown of their consumption, breeding suspicion that it is expensive. This study therefore sought to establish the influence of water metering on performance of water projects in Marsabit County, Kenya.

Objectives of the Study

The purpose of this study was to investigate the influence of prepaid smart water metering on performance of water projects in Marsabit County, Kenya.

Theoretical Review

This analysis was based on several theories that showed how the prepaid smart water metering in water projects is applied. The theories to be used include the expectancy disconfirmation theory, the value-percept disparity theory, and cognitive dissonance theory.

Expectancy Disconfirmation Theory

Oliver (1977) developed the Theory of Expectancy Disconfirmation (EDT). The theory states that consumers pay for goods and services with pre-purchase prospect against the expected performance. The expectation level is used as a standard against which the product or service is judged. That is, once the product or service has been consumed, the results are compared alongside expectations. Expectancy disconfirmation theory came up as a way to clarify making of decisions by consumers, Oliver, (1997); Oliver (1980) the theory too has been established and made functional in public management. The expectancy disconfirmation theory has proved as leading theory of explaining fulfillment of the consumers in the public sector (Van Ryzin, 2013). The model points that fulfillment on the side of consumers largely depend on implied previous performance anticipated and the result of the targets set on government use of a good or service. If for example, the perceived presentations of a service positively surpass earlier prospects, the outcome in positive disconfirmation, leading to consumers that are more content. Hence, different anticipations of the presentation of a community service will take part of a vital task in explaining fulfillments differences in consumers.

Liao and Cheung (2002) in their theoretical study recognize expectancy as an essential attribute in the apparent value of prepaid water meters. This expectancy absolutely influences consumers‟ eagerness to utilize prepaid metering. Elkhani and Bakri (2012) agree that expectancy has a major impact on customers‟ adoption of prepaid metering in Hong Kong. The theory of Expectancy disconfirmation explains the relationship between pre-purchase expectation disconfirmation and customer satisfaction. The theory suggests that by evaluating actual performance of a product or service, the consumer forms their judgments. The theory is in line with the prepaid meters‟ system which is either advantageous to both the Kenya Power as well as the consumers of water or for disadvantage when comparing between the post and prepaid system. They both had an expectation of prepaid meters‟ performance and later on the intensity of perceived worth that is persuaded by expectations when using or having an experience with the prepaid meters. This implies assessing the outcome of putting the prepaid billing system in place, (Weber, 1997). The theory of helps in measuring the customers‟ satisfaction from perceived quality of services offered through adoption of pre-paid metering system by the power company. The power provider will be better placed in identifying the areas to improve on in order to supply cost effective power, which is dependable, accessible and of the best quality power in order to exceed customers’ expectation and make their lives betters at homes and in businesses, Quality Policy.

The Value-Percept Disparity Theory

This theory was originally formulated by Locke (2007); it asserts that customer satisfaction/dissatisfaction is an emotional response triggered by a cognitive-evaluative process in which the perceptions of or beliefs about an object, action, or condition are compared to one's values, needs, wants and desires. The smaller the disparity between percepts of the object, action, or condition, and one's values the more favorable the evaluation and the greater the generation of positive effect associated with goal attainment, i.e., satisfaction. Conversely, the greater the value-percept disparity, the less favorable the evaluation, the less the generation of

positive affect, and the greater the generation of negative effect associated with goal frustration (Hauser, Tellis & Griffin, 2006).

Since it is the attainment of values which consumers seek i.e. the reliability and accessibility of pre-paid metering system of water, these actions are simply tested against the extent to which they meet the customer's values. The products may provide more of an attribute or outcome than what is desired, this has no impact on satisfaction unless this aspect causes a blockage in the attainment of another value (Westbrook & Reilly, 1983).

Locke (1967) originally formulated this theory. Locke (2007) revisits the theory and confirms that customer's fulfillment or discontentment is an emotional response. The argument being whether a product or service satisfaction is based on what consumers' value most. This is brought about by likening the evaluative process in which the perceptions of or beliefs about a condition, deed or object are compared to one's desires, wants, needs and values. Water projects seek recognition of values that is; the reliability and flexibility of prepaid metering system of water, and therefore, these events are simply tested against the extent to which the customer's values are met rather than confirmation of their expectations. According to Westbrook and Reilly (1983); an understanding of consumer satisfaction and dissatisfaction has been of much interest recently. There is need to put great emphasis or attention to the specification of the construct. The product or service could have more of a characteristic or result than the preferred and this has no force on satisfaction unless this aspect causes an obstacle in the realization of another value. The lesser the difference among percepts of the object, action, or condition, and one's values the more favorable the evaluation and the greater the generation of affirmative outcome linked with goal attainment, that is; contentment as Locke (2007), argues. On the other hand, the larger the value-percept disparity, the less favorable the assessment, the less the generation of affirmative outcome, and the larger the generation of negative effect related with objective is appointment (Hauser, Tellis & Griffin, 2006).

The significance of this theory to the study is its values to attainment. This is appreciated on evaluation of the numerous challenges facing water projects while using prepaid smart water metering. In pursuit of overcoming these challenges, the water projects have embraced on a suitable technology and innovation in order to improve the water network and customer service. The researcher has emphasized on billing accuracy, which is perceived to be more reliable, and flexible, adding value to the water provider in terms of increased performance of water projects with minimal costs.

Cognitive Dissonance Theory

Cognitive dissonance is an uncomfortable feeling caused by holding two contradictory ideas simultaneously. The theory of cognitive dissonance proposes that people have a motivational drive to reduce dissonance by changing their attitudes, beliefs, and behaviours, or by justifying or rationalizing them. The phenomenon of cognitive dissonance, originally stated by Festinger in 1957, has been quickly adopted by consumer behaviour research. Described as a psychologically uncomfortable state that arises from the existence of contradictory (dissonant, non-fitting) relations among cognitive elements (Festinger, 1957) cognitive dissonance

revealed high exploratory power in explaining the state of discomfort buyers are often in after they made a purchase.

Performance of water projects through the use of prepaid metering system is also grounded on the cognitive dissonance theory. The projects had the perception that the prepaid metering system would be very reliable and cost effective. As postulated by the theory, customers' expectations were very high in the effectiveness of the prepaid metering system especially because they thought it would be cheaper than prior metering system. Most consumers especially those living in rented house where meter sharing is common have been complaining that since they began using the prepaid meter, they spend more than usual. They feel that the prepaid meter run fast and they spend twice as much as what they used to spend on the prepaid meter. Many consumers believe that this cash and carry system has made life a bit difficult since they always have to budget for it in daily lives unlike the prepaid where they could settle in parts.

Festinger (1957) originally stated the phenomenon of cognitive dissonance theory. The consumer behavior study describes it as an uncomfortable sentiment caused by holding opposing thoughts at the same time. Brehm and Cohen (1962) in their study explain that cognitive dissonance discovered examining influence in explaining the state of discomfort consumers experience after a purchase. The suggestion given in cognitive dissonance theory is for consumers to change their approach and way of thinking, and action behaviors, or by justifying or rationalizing them and in this way they will have a driving power to reduce discord. ADF (2015) points out that many complaints in regard to prepaid meters are from tenant consumers particularly the ones sharing a common meter. They argue that they spend more than usual and they feel that consumption while using the prepaid meter is twice as much as what they used to consume on the prepaid meter. Consumers on monthly payroll too feel overwhelmed because unlike in prepaid where they could settle bill in parts or at month end, they now need to carry cash and budget for power on daily basis. Mathenge (2015) did a research on the influence prepaid water meters‟ implementation on the level of consumer fulfillment and the findings were that there were problems of payments and she recommended more pay points. There is also lack of understanding regarding the prepaid billing system and recommended for more information to be shared to customers as well as trainings of the customer service staff to enlighten them with knowledge and fully equip them with skills to deal with the dissonance experienced by the customers in the new technology of prepaid meters.

Cognitive Dissonance Theory according to Festinger (1957) is a broadly recognized construct in behavior research but has been criticized in that application in the current market research projects has been scarce. He explains that dissonance is a merely a transitory phenomenon and second is problems with measures and data collection administration affects the empirical address of the theory. Performance of water projects is dependent on innovations such as the prepaid metering system. The perception of the prepaid metering system was that it would be very cost effective, reliable and flexible when the decision to install was made. In relation to the theory, water projects management's expectations of prepaid metering system adoption

were very high in that it was help reduce unpaid bills and increase revenue. This theory is significant to the study in that we are comparing two systems simultaneously. Water projects should ensure a very reliable and cost effective billing system because the perception was that prepaid system would give maximum satisfaction as compared to the prepaid system. Water projects should justify this phenomenon by providing quality services to the client and in return more sales and revenue as well.

RESEARCH METHODOLOGY

Research Design

A plan, blueprint, or guide for data collecting and interpretation is referred to as research design. It is clear from the objectives that the study was both quantitative and qualitative. In this study, a descriptive research design was used. Researchers can utilize both quantitative and qualitative data in descriptive research to obtain information and features about the population or phenomenon being examined (Creswell & Poth, 2016). Data collection for descriptive survey research has several advantages because it allows for a diverse strategy that includes interviews, observations, questionnaires, and participant interaction (Patten & Newhart, 2017).

Target Population

A population is a group that the researcher wishes to generalize, while a sample is the group that is chosen to participate in the study. It's a subset of the whole population (Kumar, 2019). The research targeted the project managers and the Marsabit County Water Department staff members as shown on Table 1.

Table 1: Target Population

	Population	Percentage
Water Department staff	158	62.7
Project managers	94	37.3
Total	**252**	**100.0**

Sample Size and Sampling Procedure

Sampling is the choosing of a number of participants who provided the needed data which was used to draw conclusions about the study. The sample is a representation of a larger group. The sample makes up a subset of the target population that is used as a representation of the whole population (Kumar, 2019). The sample size was determined using Morgan and Krejcie (1970) model, and the study used a sample size of 215 respondents. According to Krejcie Model:

$$n = \frac{X^2 NP(1-P)}{d^2(N-1) + X^2 P(1-P)}$$

Where: n = Desired sample size
N = Target population **(252)**
P = Population proportion **(0.5)**
d = Degree of accuracy expressed as a proportion **(0.05)**
X^2 = 3.841 at 95% confidence level

Therefore $\mathbf{n} = \frac{3.841 \times 252 \times 0.5(0.5)}{0.05^2 (252) + 3.841 \times 0.5 \times 0.5}$

$\mathbf{n} = 215$

Sampling Procedures

Stratified sampling methods was used for the selection of the study respondents. This is a sampling technique that is not biased and it involves grouping of heterogeneous group of the population into homogenous subsets and then choosing the sample from the individual allowing for representativeness. The technique sought to get a desired representation from the different sub-groups in the study population. Using this technique, the sampling is done such that the existing sub-groups are less or more represented in the chosen sample (Marshall & Rossman, 2015). For each of the strata, simple random sampling was used. To get the sample size per stratum, the following formula was used. Table 2 shows the sampling frame.

$$N_s = \frac{P_S \times S}{N}$$

Where: N=Study population

N_s=Sample from each stratum

S=Total sample size

P_s=Population in each stratum.

Table 2: Sampling Frame

Category	Management staff	Sampling Ratio	Sample size
Water Department staff	158	0.855	135
Project managers	94	0.855	80
Total	**252**		**215**

Research Instruments

Self-administered questionnaires were used to collect primary data. The survey includes both open-ended and closed-ended questions. The open-ended questions allow the respondent to answer the questions with a measure of detail and understanding with fewer constraints and the closed ended questions allow the respondent to choose from a set of limited possibilities. According to Krosnick (2018), open ended or unstructured questions allow for more in-depth responses from respondents, whereas closed or structured questions are easier to assess. The questionnaire was utilized to aid easier analysis because it is in an easily useable format, is quick to administer, and is a less expensive research method.

Pilot Testing

Pilot testing is testing of the research questions to a different population that has similar traits as the population under study (Gillham, 2011). The pilot study was done to ascertain the research tool reliability and validity. The pilot survey used 22 questionnaires which will be a 10% representation of the sample size. After a day, the participants were asked to give responses to similar questions although this time there was no prior notification. This helped pinpoint any changes in the responses given using both times.

Validity of Research Instruments

Validity, as per Kumar (2019), is the accuracy and significance of inferences drawn from study findings. One of the main goals of the pilot study was to determine the validity of the questionnaire. To determine the validity of the questionnaires, the researcher utilized both face and content validity. Test scores are used to infer the content validity of a vast domain of items

that are comparable to those on the test. The representativeness of the sample population is an issue for content validity. According to Yin (2017), the test items' knowledge and abilities should be indicative of the greater area of knowledge and abilities. Content validity was verified through expert opinion from supervisors and practitioners in the industry. This assisted in improving validity of the collected data. It as well ensured the appropriate modification and revision of instruments of research thus augmenting validity. The questionnaire was subjected to expert analysis and judgments from at least two external experts who extensively examined the research instrument's representativeness at face value for face validity. The experts critically examined each question against study objectives and how they were answered by the potential respondents and necessary adjustments were made. Instruments developed for other similar studies were also used for comparison purposes. The questionnaire demonstrated face validity, according to the reviewers, and the questions were assessed as a good translation of all the study constructs.

Reliability of Research Instruments

Reliability is a measure of the consistence of results or scores obtained. A pilot test was done with the key informants before full administration of the questionnaires. Cronbach's Alpha Coefficient was used to estimate reliability of the selected research instrument. The Alpha (α) is used to measure internal consistency by helping arrive at a determination if single item measures the same construct give uniform results. Cronbach's Alpha was established for every research objective in order to help evaluate the possibility that for the objectives under review, the same output was yielded if the research were to be conducted later on. The commonly accepted Cronbach Alpha value for reliability is 0.7 (Zikmund, Babin, Carr & Griffin, 2012).

Data Collection Procedures

A letter of introduction from the researcher's university of study was presented to the respondents to gain permission to ask questions from the participants. Data was collected through administration of questionnaires cases for clarity. The questionnaires were given to the respondents through the drop and pick method and Google surveys so as to obtain well thorough answers from the respondents. An appointment was booked by the researcher with the respondents' firms two days before dropping the questionnaires. The researcher administered the research instruments to the respondents.

Data Analysis Techniques

The questionnaires as received were reviewed to ensure consistency and thereafter code the useful ones. Quantitative data was analysed using descriptive statistics like percentages, means, standard deviations and frequencies. The qualitative data collected from the open-ended questions was analysed using content analysis. Inferential data analysis was done using multiple regression analysis. The relationship between the independent and dependent variables was established using multiple regression analysis. The multiple regression model in this study assumed the following equation because there are four independent variables;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$$

Where: -Y= performance of water projects in Marsabit County

β_0=constant

$\beta_1, \beta_2, \beta_3$ and β_4 = regression coefficients
X_1= meter reliability
X_2= meter efficiency
X_3= billing accuracy
X_4= meter flexibility
ε=Error Term

RESULTS AND DISCUSSION

The purpose of the study was to establish influence of prepaid smart water metering on performance of community water projects in Marsabit County, Kenya. The following are findings for each of the objectives of the study.

Meter Reliability and Performance of Water Projects

The study aimed to establish the influence of meter reliability on performance of water projects in Marsabit County. The study found that there was an improvement in access to water for the residents in both formal and informal settlements as prepaid smart water meter is equitably distributed, they were involved in sensitizing the consumers on the advantages of using the prepaid smart water meters, they believed that customers are most often satisfied with the quick response from water customer support any time they encounter challenges and prepaid smart water meter aimed at facilitating affordability and reduction in utility costs as well as being among the innovative solution.

Meter Efficiency and Performance of Water Projects

The study sought to establish the influence of meter efficiency on the performance of water Projects in Marsabit County. The research established that water was restored once the token is loaded, credit tokens were available in many vending points, the token loading information was readily availability, tokens were available in reasonable quantity and the staff responded competently to customer complaints. However, the study found that loading the credit via M-pesa was instantly updated in the meter.

Billing Accuracy and Performance of Water Projects

The study aimed to establish the influence of billing accuracy on performance of water projects in Marsabit County. The study found that accurate measurements were taken and recorded correctly, there was transparent readings and billings system, getting a payment statement was easy, and paying to wrong accounts was minimal with the meters.

Meter Flexibility and Performance of Water Projects

Moreover, the study sought to establish the respondents' level of agreement with statements on meter flexibility influencing performance of water Projects in Marsabit County. The study found that the tokens were easily accessible whenever they are needed, prepaid meters overcome limited infrastructural development required to dispatch and receive credit slip (bills), and prepaid meter system to help tackle difficulties arising from irregular income. The research also found that more water is now consumed.

Regression Analysis

Multiple regression analysis was carried out to determine the influence of meter reliability, meter efficiency, billing accuracy and meter flexibility on performance of water projects in Marsabit County, Kenya. The findings were presented in Table 3, 4 and 5.

Table 3: Model Summary

Model	R	R Square	Adj. R Square	Std. Error of the Estimate
1	0.867	0.751	0.745	1.350

a. Predictors: (Constant), Meter flexibility, Billing accuracy, Meter reliability, Meter efficiency

The outcome of Table 3 found that the adjusted R-Square value is 0.745, which indicates that the independent variables (meter reliability, meter efficiency, billing accuracy and meter flexibility) explain 74.5% of the variation in the dependent variable (performance of water projects in Marsabit County, Kenya).

Table 4: Analysis of Variance

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	884.022	4	221.006	119.092	1.23E-46
Residual	293.209	158	1.856		
Total	**1177.231**	**162**			

a. Dependent Variable: Performance of water projects

b. Predictors: (Constant), Meter flexibility, Billing accuracy, Meter reliability, Meter efficiency

The results are shown in Table 4 which found that the model had predictive value and thus it was significant. This was because its p-value was less than 5%, p=1.23E-46 and F-calculated (119.092) was significantly larger than the critical F value (2.4289).

Model coefficients provide unstandardized and standardized coefficients to explain the direction of the regression model and to establish the level of significance of the study variables. The results are captured in Table 5.

Table 5: Regression Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	21.502	6.880		3.125	0.002
Meter reliability	0.689	0.314	0.674	2.194	0.030
Meter efficiency	0.711	0.213	0.682	3.338	0.001
Billing accuracy	0.633	0.095	0.533	6.663	0.000
Meter flexibility	0.618	0.230	0.512	2.687	0.008

a. Dependent Variable: Performance of water projects

As per the SPSS generated Table above, the equation ($\mathbf{Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon}$) becomes:

$$Y= 21.502+ 0.689X_1+ 0.711X_2+ 0.633\ X_3 + 0.618X_4$$

The findings showed that if all factors (meter reliability, meter efficiency, billing accuracy and meter flexibility) were held constant at zero, performance of water projects in Marsabit County, Kenya will be 21.502. The findings also show that a unit increase in the scores of meter reliability would lead to a 0.689 increase in the scores of performance of water projects in Marsabit County, Kenya. This variable was significant since 0.030<0.05.

Further, the findings shows that a unit increases in the scores of meter efficiency would lead to a 0.711 increase in the scores of performance of water projects in Marsabit County, Kenya. This variable was significant since 0.001<0.05. The study found that a unit increase in the scores of billing accuracy would lead to a 0.633 increase in the scores of performance of water projects in Marsabit County, Kenya. This variable was significant since 0.000<0.05. The findings also reveal that a unit increase in the scores of meter flexibility would lead to a 0.618 increase in the scores of performance of water projects in Marsabit County, Kenya. This variable was significant since 0.008<0.05.

As per the findings, at 95% confidence level, all the variables were significant as the p-value was less than 0.05. The study infer that meter efficiency had the greatest influence on the performance of water projects in Marsabit County, Kenya, followed by meter reliability, then billing accuracy while meter flexibility had the least influence to the performance of water projects in Marsabit County, Kenya.

Conclusions

The study concluded that meter reliability is a foundational pillar in enhancing consumer satisfaction and trust in prepaid metering systems. Reliable meters not only ensure the physical delivery of water but also foster a perception of fairness and dependability in service provision. The ability of the prepaid smart water meters to function consistently and equitably across various settlement types contributed significantly to the credibility of the water utility providers. Moreover, reliability was found to have a ripple effect on consumer behavior—where consistent performance reduced service complaints, encouraged timely payments, and reinforced long-term engagement with the metering system. The study thus positions meter reliability not just as a technical function, but as a strategic enabler of sustainable water service delivery in resource-scarce environments.

The study concluded that meter efficiency serves as a critical driver of operational responsiveness and user autonomy. By automating the connection between payment and water access, prepaid meters eliminated bureaucratic delays and enabled instant service restoration. This technological empowerment redefined the consumer's role from a passive recipient to an active manager of their water usage. Importantly, meter efficiency was also associated with broader institutional benefits—such as reduced administrative overheads, streamlined customer service, and improved responsiveness to system errors. The convergence of user convenience and system performance illustrates that efficient metering is not only a user-

centric innovation but also an operational imperative for water service providers seeking to scale delivery in marginal areas.

The study concluded that billing accuracy is pivotal in building financial transparency and accountability in community water projects. By providing clear, itemized, and real-time billing data, prepaid meters addressed longstanding concerns around arbitrary or estimated charges. Accurate billing demystified water consumption, empowered users to monitor their usage, and reduced the likelihood of disputes over payments. The consistency of billing outcomes also had a reinforcing effect on payment behavior, encouraging users to take ownership of their water consumption and plan accordingly. Importantly, billing accuracy contributed to increased revenue reliability for service providers, enhancing their ability to invest in network expansion, maintenance, and service improvement.

The study concluded that meter flexibility plays a crucial role in aligning water service delivery with the socio-economic realities of communities in Marsabit County. The ability to purchase tokens in varied amounts and at one's convenience allowed low-income and informally employed households to maintain access to water without the constraints of rigid billing cycles. Flexibility extended beyond payment options to include access channels, such as mobile platforms and diverse vending points, thereby democratizing water access across income groups. This adaptability not only improved user satisfaction but also strengthened system resilience by accommodating fluctuations in household income and water needs.

Contributions to the Body of Knowledge

This study contributes significantly to the expanding field of water governance and utility management by providing empirical evidence on the influence of prepaid smart water metering on the performance of community water projects. By focusing on Marsabit County—a semi-arid and underserved region of Kenya—this research offers a contextualized understanding of how prepaid smart metering systems function in low-resource, geographically remote areas. This adds to the existing body of literature that has predominantly concentrated on urban or economically advanced regions.

The study further enriches scholarly discourse by offering a locally grounded analysis of how technological innovation in water management directly affects performance indicators such as accessibility, operational efficiency, billing accuracy, and user payment flexibility. These insights reveal that the adoption of prepaid smart metering is not just a technical upgrade but a holistic intervention that transforms user engagement, resource planning, and utility accountability.

In addition, the research enhances theoretical understanding by linking empirical findings to well-established consumer behavior models, including the expectancy disconfirmation theory, value-percept disparity theory, and cognitive dissonance theory. These frameworks proved relevant in interpreting consumer satisfaction, perception shifts, and behavioral responses in relation to prepaid water services. This integration of theory and practice affirms the

applicability of these models in public sector utility services, particularly in the context of water provision.

Moreover, the study makes a valuable contribution by highlighting practical user-centered challenges and proposing implementable improvements. It exposes service delivery bottlenecks such as limited vending points, complexity in tariff structures, and technical support delays, which are often underrepresented in existing literature. By doing so, the study addresses a critical research gap and offers a platform for designing more inclusive, efficient, and adaptive prepaid metering systems tailored to the needs of vulnerable populations in resource-constrained settings.

Recommendations

Based on the findings of this study, several recommendations are made to improve the implementation and outcomes of prepaid smart water metering in Marsabit County and other similar contexts. From a policy perspective, there is a compelling need for national and county governments to scale up the investment in prepaid metering infrastructure. By expanding this system to other counties, equitable access to reliable water services can be promoted, particularly in regions with underserved or marginalized populations. Additionally, county governments should develop and enforce regulatory frameworks that guide the operation of prepaid metering systems. These regulations should protect consumers from potential exploitation, such as overbilling, service denial, or misinformation, and should also hold service providers accountable for performance and transparency.

From a practical implementation standpoint, water service providers are encouraged to enhance public education campaigns to raise awareness and understanding of how the prepaid smart water metering system works. Many of the observed user challenges stem from limited knowledge or misconceptions about system functionalities, token purchasing, and tariff structures. Effective consumer education can bridge this gap, fostering greater trust and smoother adoption of the technology. Furthermore, there is a need to expand the infrastructure for token vending. Increasing the number of mobile-based platforms, agent networks, and vending points will enhance convenience and reduce access disparities, especially in remote or rural areas. Equally important is the establishment of robust technical support systems to address meter errors, token loading failures, and general complaints promptly. Responsive customer service is crucial to sustaining user confidence and ensuring uninterrupted access to water.

Methodologically, future research should consider adopting longitudinal designs to evaluate the long-term effects of prepaid smart metering on water project performance. Such studies would capture trends, adaptations, and systemic improvements that emerge over time, offering a more comprehensive understanding of the technology's impact. Moreover, incorporating qualitative methods, such as focus group discussions or in-depth interviews, can provide rich insights into the lived experiences of consumers. These narratives would complement quantitative data by revealing underlying attitudes, coping strategies, and user feedback that are not easily captured through structured surveys.

REFERENCES

ADF (African Development Fund) (2015). *Rural Water Supply and Sanitation Program in Ethiopia: Appraisal Report*. Infrastructure Department North, East and South Onin.

Brehm, J. W., & Cohen, A. R. (1962). Explorations in cognitive dissonance.

Check, K., Abdiel, I., & Mbwille, E. (2018). *Study of Solar-powered Prepaid Water Systems in Tanzania* (No. 125581, pp. 1-18). The World Bank.

Concern Worldwide. (2019). Concern Sierra Leone—Safe and Dignified Burials Programme. *Annual Country Programme Progress Report. Dublin, Ireland: Concern Worldwide [cited 2019 May 5]. Available from URL: https://ec. europa. eu/health/sites/health/files/ngo_award/doc/summary_ report_concernworldwide_en. pdf*.

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Donge, J. K. (2013). Reforming justice: a journey to fairness in Asia, by Livingstone Armytage: Cambridge, Cambridge University Press, 2012, xvi+ 365 pp., GBP 60, ISBN 978-1-107-01382-7.

Elkhani, N., & Bakri, A. (2012). Review on "expectancy disconfirmation theory"(EDT) Model in B2C E-Commerce. *Journal of information systems research and innovation*, *2*(12), 95-102.

Festinger, L. (1957). *A theory of cognitive dissonance* (Vol. 2). Stanford university press.

Gillham, B. (2011). *Developing a questionnaire*. London: A&C Black.

Hagarsu, A. A. (2020). Investigating Major Drivers of Performance in Community Water Projects: A Case of Water Projects in Saku Sub County, Marsabit County, Kenya. *European Journal of Business and Management Research*, *5*(5).

Hauser, J., Tellis, G. J., & Griffin, A. (2006). Research on innovation: A review and agenda for marketing science. *Marketing science*, *25*(6), 687-717.

Heymans, C., Eales, K., & Franceys, R. (2014). *The Limits and Possibilities of Prepaid Water in Urban Africa*. Upper Hill, Nairobi: World Bank.

Kashid, P. V., Gaikwad, N., Deshmukh, P., & Marchande, P. (2019). Smart Water Monitoring System for Real-Time Water Quality and Usage Monitoring.

Kinuthia, E. M. (2019). *A Wireless M-Bus based smart water meter model: a case of Nairobi City Water & Sewerage Company* (Doctoral dissertation, Strathmore University).

Krejcie, R. V. & Morgan, D. W. (1970). *Determining Sample Size for Research Activities. Educational & Psychological Measurement*,18 (30), 607-610.

Kumar, R. (2019). *Research methodology: A step-by-step guide for beginners*. Sage Publications Limited.

Locke, E. A. (1967). Motivational effects of knowledge of results: Knowledge or goal setting?. *Journal of Applied Psychology*, *51*(4p1), 324.

Locke, E. A. (2007). The case for inductive theory building. *Journal of Management*, *33*(6), 867-890.

Mathenge, P. (2015). *Influence of prepaid electricity meters adoption on the level of customer satisfaction: a case of Thika Sub County, Kenya* (Doctoral dissertation, University of Nairobi).

Mohamed, K. A., Munier, M. G., William, P. P., Nagar, S. A., & Ibrahim, A. M. (2018). Enhanced Smart Water Meter Efficiency Based on Mounting Position Selection and Extended Battery Life Time. In *2018 International Conference on Computer, Control, Electrical, and Electronics Engineering (ICCCEEE)* (pp. 1-6). IEEE.

Moraa, H., Otieno, A., & Salim, A. (2012). *Technology in Solving Society's water problems in Kenya, iHub Research, June 2012*. Retrieved 12/12/2012 from http://research. ihub. co. ke/uploads/2012/july/1343006935_819_277.

Oliver, R. L. (1977). Effect of expectation and disconfirmation on postexposure product evaluations: An alternative interpretation. *Journal of applied psychology*, *62*(4), 480.

Oliver, R. L. (1980). A cognitive model of the antecedents and consequences of satisfaction decisions. *Journal of marketing research*, *17*(4), 460-469.

Patten, M. L., & Newhart, M. (2017). Understanding research methods: An overview of the essentials.

Reniko, G., & Kolawole, O. D. (2020). 'They don't read metres, they only bring bills': Issues surrounding the installation of prepaid water metres in Karoi town, Zimbabwe. *South African Geographical Journal*, *102*(3), 356-371.

Sadiku, M. N., Omotoso, A. A., & Musa, S. M. (2019). Smart Water Metering.

Saeed, M. O. A. (2017). *Prepaid Smart Water Meter University of Khartoum* (Doctoral dissertation, University of Khartoum).

Suresh, M., Muthukumar, U., & Chandapillai, J. (2017). A novel smart water-meter based on IoT and smartphone app for city distribution management. In *2017 IEEE region 10 symposium (TENSYMP)* (pp. 1-5). IEEE.

Van Ryzin, G. G. (2013). An experimental test of the expectancy-disconfirmation theory of citizen satisfaction. *Journal of Policy Analysis and Management*, *32*(3), 597-614.

Wang, X., Shao, J., Van Steenbergen, F., & Zhang, Q. (2017). Implementing the prepaid smart meter system for irrigated groundwater production in northern China: Status and problems. *Water*, *9*(6), 379.

Weber, K. (1997). The assessment of tourist satisfaction using the expectancy disconfirmation theory: a study of the German travel market in Australia. *Pacific Tourism Review*, *1*(1), 35-45.

Westbrook, R. A., & Reilly, M. D. (1983). Value-percept disparity: an alternative to the disconfirmation of expectations theory of consumer satisfaction. *ACR North American Advances*.

WHO-UNICEF. (2014). *Joint Monitoring Programme for Water and Sanitation.* http://www.wssinfo.org/en/238_wat_latino.html.

World Bank (2015). *Strengthening infrastructure for social development: a submission to the World Summit for Social Development Five Year Review*. Washington DC: The World Bank.

Yin, R. K. (2017). *Case study research and applications: Design and methods*. London: Sage publications.

Zikmund, W., Babin, B., Carr, J. & Griffin, M. (2012). *Business Research Methods*. New Jersey: Cengage Learning.