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Effectiveness of the maintenance practices of service providers on the functionality of rural water supply facilities in Turkana County

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Effectiveness of the Maintenance Practices of Service Providers on the Functionality of Rural Water Supply Facilities in Turkana county

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DECLARATION

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made in the thesis itself.

James Origa Otieno

June 2019

Approval

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ABSTRACT

The purpose of this study was to assess the effects of post-construction infrastructure maintenance practices of rural water service providers in Turkana county on the functionality of the facilities. Data on prevalent maintenance practises and attendant revenue mobilisation and management practises was collected from ten sampled sites within Turkana county through quantitative household questionnaires. Focused group discussions with the service providers and key informant interviews with county government officials and other water sector partners was also carried out to validate the quantitative data. The data was analysed using descriptive statistics and instrumental variables regression analysis. The study findings showed endogeneity in the independent variables with the time taken to repair broken down water facilities emerging as the main predictor of functionality. The regression results indicate that a rural water system in Turkana is likely to be functional if it takes less time to repair compared to the base category of less than 24 hours. Affordability of water by the households emerged as another key factor that determines functionality since it influences sufficiency of revenues needed to respond to a break down. The results demonstrate a cyclic relationship in which affordability increases functionality as more households are able to and willing to contribute towards repair costs, hence making funds available for repairs and increasing prompt response to break downs. In turn, functionality increases household's willingness to pay since the system is well maintained thus available when needed.

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LIST OF ABBREVIATIONS

WHO	World Health Organisation
UN	United Nations
UNICEF	United Nations International Children's Fund
GDP	Gross Domestic Product
MDG	Millennium Development Goals
SDG	Sustainable Development Goals
WMC	Water Management Committee
WSP	Water Service Provider
WASREB	Water Services Regulatory Board
NGO	Non-Governmental Organisation
O & M	Operations and Maintenance

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SPECIAL DEDICATION

With deep sorrow in my heart, I dedicate this thesis to my MPPM 2016 cohort classmate, the late Isaack Mutuma Kaaria. A great friend to us all and loving husband to Loise. You left us too soon, just before graduation. It would have been so lovely for us to graduate together from Strathmore University and continue doing what you loved most-serving the nation faithfully and with integrity. I will miss having the conversations with you on how we can better the public leadership in our beloved country, having been imparted with the skills and strategy of public policy making. The nation has lost a great servant leader.

Till we meet again brother, rest in peace.

Chapter 1 : INTRODUCTION

1.1 Introduction

Despite the United Nations (UN) member countries declaring access to safe water and sanitation a basic human right (UN, 2010), recent reports by the World Health Organization (WHO) & The United Nations Children's Fund (UNICEF), 2017) indicate that 159 million people,58% of them living in sub-Saharan Africa, still rely on unsafe water sources putting them at high risk of premature mortality and preventable morbidity. The Global Risks report also indicates the global water crisis where millions of people are without access to improved water sources as the number one threat facing the planet in the coming decades (World Economic Forum, 2015). To achieve water security especially for the millions unserved in sub-Saharan Africa, an increased investment in new water infrastructure to expand coverage as well as institutional strengthening for sustainable services delivery are key. This emphasizes the critical importance of the country being able to sustainably manage existing water resources as well as ensuring sustainable and reliable water services delivery to contain water looses in an already resource constraint context.

Water supply projects are designed to achieve three outcomes. First is an ultimate outcome of continuous functionality of installed facilities. Second is sustainable management of infrastructure services including sustainable revenue streams to recover costs of operations and maintenance, maximised efficiency and professionalism in service delivery and management of risks facing source over-abstraction. Lastly is affordability and equitable access particularly for those having less ability to pay within the community. The practises adopted by the service providers mandated to operate and maintain the installed systems is thus critical for successful attainment of these three outcomes. This study sought to assess the effects of infrastructure maintenance practises adopted by the rural water service providers responsible for operating the rural water schemes in Turkana county on their long-term functionality as the ultimate outcome.

This thesis is organised into 6 chapters. Chapter 1 presents a contextual background of the proposed study detailing the rationale, objectives, limitations and significance of the study. In chapter 2, a review of literature on sustainability of rural water services and

management of water services delivery, particularly on maintenance of water infrastructure and financing the maintenance needs. A conceptual framework is developed at the end of chapter 2 to guide the study research design and development of data collection instruments. Chapter 3 details the research design and methods applied including the approach chosen for sample selection, data collection. Chapter 4 presents the findings of the study from the field data. Chapter 5 presents a discussion of the study findings as related to the literature on maintenance practices in water services delivery, revenue management practices as well as rural water sustainability and functionality as discussed in chapter two. Chapter 6 presents the study conclusions, significance of this study's findings to policy makers as well as highlights the limitation of the study and make suggestions for further research.

1.2 Background to the study

In response to public infrastructure funding gaps, increasing stresses on water sources exacerbated by climate change effects, distributional inequalities in access to safe water services and the worrying high infrastructure failure rates (Castro & Heller, 2012), three trends characterise the current global water sector. First is increasing focus on strengthening and professionalizing service delivery institutions (Fogelberg, 2013; Lockwood & Smits, 2011; Rural Water Supply Network, 2010; Moriarty, Smits, Butterworth, & Franceys, 2013; Schouten & Moriarty, 2013; Hepworth, 2016; Hope, Foster, Money, & Rouse, 2012; Laban, 2007); second is a move towards adaptive ecosystem management to manage competing demands for multiple water uses (Boelee, Chiramba, & Khaka, 2011; Honkonen, 2017; Martínez, 2014; Varady, Zuniga-Teran, Garfin, Martín, & Vicuña, 2016) and thirdly is increased efforts to leverage the constrained public funds with private sector financing and expertise. (Castro, 2018; Fonseca & Pories, 2017; James, Trémolet, & Ikeda, 2016; Müller, 2016).

For more than three decades after gaining independence in 1963 until 1999, the government of Kenya operated without a substantive strategy and policy for the water sector. While the 2002 and 2016 water sector reforms in Kenya has led to great advances in improving professional management of urban water services, success in the

management of rural water services remains characterised by poor management practises and low sustainability of installed infrastructure. The Kenya water sector regulator, the Water Services Regulatory Board's (WASREB) interventions to develop regulatory tools to ensure sustainable management of rural water services (WASREB, 2018) are yet to yield the expected results for residents of remote rural contexts, especially the dry northern Kenya counties.

The rural water services delivery chain involves organising the production and supply of services to end users. These services include facility maintenance to keep the infrastructure in good working condition as well as attendant collection and management of revenues to cover the cost of facility maintenance. Ultimate functionality of the facilities is a sum-total of both services. The service providers responsible for the management of these facilities are expected to have sufficient capacity to maintain certain level of professional service delivery that adds public value to the water users. At the service level, the managing entity, whether it's a large water utility or a small community-based operator, is expected to carry out daily regular maintenance such as simple cleaning of facilities; prepare and follow an effective preventive maintenance regime involving acquiring of spare parts, scheduled replacement of parts; promptly responding to facility breakdown within the shortest time possible; Administrative tasks such as keeping of records and monitoring key trends to enable accountability to regulatory authorities; financial management such as collection of rates, deployment of collected rates to efficiently meet the cost of operating and maintaining the system as well as having a responsive customer engagement interface and processing of emerging complaints.

WASREB requires every water service provider to organise a maintenance system that ensures the assets are in operating conditions that enables continuity of services. The subject of inquiry in this study was to examine to what extent service providers in rural settings with small point water sources such as Turkana are organising such effective maintenance regimes.

1.3 Problem definition

The Government of Kenya's goal is to achieve 100% water access by the year 2030 to all citizens. To this end, the government invests about Ksh.40 billion annually in developing new water supply infrastructure country-wide ranging from large capacity dams, pipelines and boreholes (WASREB, 2018). Turkana county has been a priority county for increased infrastructural investment owing to the low water access coverage of only 39% compared to a national average of 55% (Mwangi, 2013; Turkana county Government, 2016). A public expenditure review by the government of Kenya indicates that the Turkana county government has in the last 3 years, 2015/16 to 2017/18, cumulatively invested about Ksh.347 million in developing new water infrastructure (Government of Kenya, 2018). Despite these efforts to increase investments in new infrastructure, a study by Oxfam mapping existing water supply schemes in Turkana county observed that 33% of these water sources were non-functional and not delivering services as designed (Oxfam,2017). This is happening despite the existence of water management committees responsible for collecting water use revenues and using these funds for maintenance operations to ensure these water points are operating at full potential. Similar findings on rural water supply scheme functionality status have been reported by Kwena & Moronge (2015), Lockwood & Smits (2011), Sutton (2004), Government of Kenya (2009) and the United Republic of Tanzania (2016) who observed that between 30-45% of rural water supply systems in Africa will be non-functional within 3-5 years after construction. This outcome raises concerns over the effectiveness of the management systems put in place to ensure sustainability of installed infrastructure. Unless facility functionality is addressed and significantly improved, the 100% universal access rate envisioned will most likely not be achieved.

Studies by Leclert, Nzioki, & Feuerstein (2016); Walters & Javernick-Will (2015); Skinner (2009) and Rural Water Supply Network (2010) all suggest that the critical underlying causes of this high non-functionality rates of rural water facilities are weakness in revenue management, ineffective maintenance activities and weak social accountability structures lacking in transparency, responsiveness and accountability of water service providers. Even the government of Kenya, in the draft 2018 national water

policy statement, recognizes that operators of rural water supply systems operate with a weak governance framework, low technical capacity, insufficient revenues, and application of inappropriate technology (Ministry of Water,2018). These challenges, the ministry recognizes, affect the effectiveness of their service delivery and ultimate functionality of water facilities.

This study sought to assess the maintenance practises of the rural water management committees responsible for operating the water points in Turkana county and the effects these practises have on water schemes functionality. The findings will form an evidence basis for proposing appropriate policy interventions in operating rural water schemes such that high functionality is achieved.

1.4 Research Objectives

The **general objective** of this study was to assess the effects of infrastructure maintenance practises of water service providers responsible for operating the rural water schemes in Turkana county on their functionality.

The specific objectives were to:

1. To examine the maintenance practices of water service providers managing rural water schemes within Turkana county.
2. To investigate how the service providers managing rural water schemes in Turkana county raise and manage revenues needed to facilitate the maintenance needs.
3. To establish how the maintenance practices and attendant revenue management practises of the water service providers affect the functionality of the water schemes.

1.5 Research Questions

The study research questions were as follows;

1. What are the specific types of infrastructure maintenance activities practiced by rural water service providers in Turkana county?

2. What are the specific ways rural water service providers in Turkana county raise and manage revenues needed to facilitate the maintenance of the water schemes?
3. How do the maintenance and revenue management practises of the rural water service providers in Turkana county affect the functionality of the water schemes?

1.6 Scope and limitations of the study

The study focused on maintenance practises of the water service providers and the attendant revenue management and their effectiveness in ensuring functionality of the schemes. The study is limited to management of water service delivery and its effects on long-term operational functionality and does not extend to effects of climate and governance of water services.

1.7 Significance of the study

The outcome of this study, targeted for dissemination to national and county government political leaders and senior level bureaucrats as well as non-governmental agencies supporting rural water services delivery, is envisioned to provide critical evidence needed to trigger changes in how rural water services provision are organised and financed. Policymakers will find the outcomes of this study useful in guiding policy proposals aimed at re-designing the institutional architecture for rural water services delivery as well as ensuring equitable access to water for all. The findings will also support Non-governmental agencies and water users/citizen action groups in refining the specific role they need to play in ensuring that rural water services are sustainably maintained.

Chapter 2 : LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of literature on management of water services delivery, operations and maintenance practises, financing of maintenance needs as well as rural water sustainability and functionality. Based on the extensive literature review, a conceptual framework was then developed at the end of the literature review to guide the design of the data collection instruments applied in operationalizing the study variables and answering the research questions.

2.2 Theoretical Review

2.2.1 Life-Cycle Service-delivery theory

Lockwood & Smits (2011) defines rural water supply service delivery as "*an approach to the provision of rural water supply services, which emphasises the entire life-cycle of a service, consisting of both the hardware and software required to sustain a certain level of service*". This definition diverges from the traditional narrow infrastructure development approach, as it draws attention to the full life-cycle of an infrastructure service which emphasizes post-construction technical support, planning for longer-term facilities maintenance and expansions. Lockwood, Smit, Schouten, & Moriarty (2010) further expounded that a rural water supply service delivery model is: "*the how to of applying the service delivery approach and describes the policy, legal, institutional, financial, governance and normative frameworks that determine what services will be provided to the consumers and how this will be done*".

Service delivery models may include different management arrangements such as self-supply referring to water supplies developed largely or wholly through user own-investment usually at household level (Mekonta, Butterworth, & Holtslag, 2015); Community-based management model-a model in which the communities collectively manage, maintain and operate their own supply systems through selection of a voluntary

water management committee by community water users (SNV, 2010); Private operator supply model where private sector actor is contracted to operate and manage the service delivery and is remunerated based on pre-determined performance indicators; Utility management model where a public utility is primarily responsible for the management of the services and lastly Municipal management model where a municipal water department is in charge of the operation and maintenance of the systems (World Bank Group, 2017; RWSN Executive Steering Committee, 2010). Lockwood et al., (2010) asserts that it is "*difficult or indeed impossible to conceptualise one 'generic' model, which can be applied universally*".

Lockwood (2014) presented that at the service provider level, the key activities to be carried out by the entities managing the water supply services involve day-to-day system operations such as regular maintenance, cleaning, provision of spare parts, regular replacement of consumable parts of the equipment; Administrative tasks involving keeping records; Financial management involving the practices of revenue collection, calculation of income & expenditures, maintenance of bank accounts as well as consumer interface involving management of complains and feedback from water users.

The examination of the maintenance practises and attendant revenue mobilisation and management practises in Turkana county was guided by the emerging theory advancing a service delivery and life-cycle thinking paradigm as described above. The study examined the extent to which the service providers in Turkana have adopted the defined maintenance and revenue management practises as specified in the service delivery approach theory.

2.3 Empirical review

2.3.1 Sustainability and functionality of rural water supply schemes

Hope, Pérez-Foguet, Katomero, & Georgiadou (2008) warns that the rush to meet the sustainable development goals (SDGs) of universal access by 2030 through increasing infrastructure coverage and accelerated development of new water supply schemes stands

the risk of diverting attention from a focus on beneficiaries' involvement, building institutional capacity and ensuring sufficient operations and maintenance systems which are crucial for sustaining services. Sustainability requires that to keep a water system functioning over the long-term, the dynamic and systemic interactions between technical, social, financial, institutional, and environmental factors that can lead to premature water system failure must be concurrently addressed as a precursor for infrastructure development (Walters & Javernick-Will, 2015).

The topic of sustainability of rural water supply services has been extensively studied empirically. Several authors have endeavoured to explain the multiple dimensions of sustainability such as social, environmental, financial and technical dimensions. Travis & Sara (1997) and Ostrom (2000) analysis concluded that what matters most for the social sustainability of rural water points involves working with and having the community members agree on infrastructure options, ascertain the community's preferences for service levels, and clarify the community's responsibilities and preferences for financing, operations and maintenance structures. Peter & Nkambule (2012); Enéas da Silva, et al., (2013); Jones, et al.,(2013), Jones, Anya, Stacey, & Weir, (2012), Amjad et al., (2015) conclusions from both literature review and empirical analysis emphasize technical sustainability-defined as the availability of equipment and technically skilled people for operating the system, financial sustainability-defined as the capacity to generate sufficient revenues as well as environmental sustainability defined as capacity of the water source to continuously provide water without drying up as critical factors affecting functionality of rural water points.

Chowns (2014), from extensive quantitative and qualitative analysis of the community management model of 679 rural water points in Malawi concluded that the model has benefited more donors "*as a means of offloading responsibility for public service provision*" but has failed in sustaining the benefits from installed capital infrastructure for communities. She describes two broad dimensions of sustainability. Environmental sustainability as the ability of the natural ecosystem and resources to provide services without compromising the future availability of those resources and economic sustainability as implying outcomes will continue after capital inputs cease, or that new

resources are found to replace the initial inputs. From her conclusions, the sustainability failure has been largely economic contributed to by the combined effects of weak accountability in financial management as well as low technical capacity of rural service operators to maintain the schemes in good condition. In her recommendations, she reinforces Lockwood and Smits (2011) that by taking a service delivery approach rather than a project approach to rural water supply, the focus essentially shifts away from delivering stand-alone outputs measured as completed water points to delivering outcomes measured as continued access to clean water. Montgomery, Bartram, & Elimelech (2009) on the other hand, concluded that the three most critical sustainability factors are effective community demand, sufficiency of local financing and cost recovery, and existence of a dynamic operation and maintenance regime. They observed that it is the interaction of these factors that ultimately affects how well an installed water scheme functions over time.

Walters' (2015) study used a detailed Delphi survey and cross impact questionnaire study to investigate the interaction of factors influencing functionality of rural water systems by modelling the factors as a system. His results concluded that the factors, including ability of the government to provide post-construction maintenance expertise and resources, existence of a water system management entity that collects and deploys water rates for maintenance, availability of spare parts and ability of the water source to sustain abstraction among others, interacted as a complex system. In his conclusions, he emphasized the lynchpin of sustainable management of rural water schemes as operationalising a system that '*aptly considers all these complexities*".

2.3.2 Functionality as an indicator of sustainability

Lockwood & Le Gouais (2014) and the World Bank (2017) in using functionality as a proxy indicator of sustainability, both argue against the definition of functionality as a one-off binary check on a water facility to determine whether the system is working or not working at a single point in time. Similar sentiments are expressed by Leclert (2012); Tincani et al. (2015); Carter and Ross (2016) who argue that functionality should be tracked over time to give a picture of sustainability of the water facility. Bonsor,

MacDonald, Casey, Carter, & Wilson (2018) decry the lack of a single accepted definition of constitutes a functioning water point.

In an experimental research in Ghana, they introduced a tiered approach for defining functionality of water points fitted with hand-pumps. They thus defined a functional water facility as one that is physically working and producing water at the time of the survey visit, provides the minimum design yield and has less than 30 days of downtime within the last 12 months. Adank et al., (2013) used a stroke and leakage test to determine the functionality of water points. They set that handpump water points are functional if they pass both tests while those that pass only one of the two tests are classified as partially functional. Those that pass neither tests are classified as broken-down systems. The stroke test involved "*taking a maximum of 40 strokes, administered within one minute, to fill the bucket for Afridev and India Mark II and 30 strokes for Nira AF-85 hand pumps*" while the leakage test involved "*resuming pumping after five minutes rest following the stroke test. If water flows from the hand pump within five strokes, the pump has passed the leakage test*". While this definition seems promising and practical, its disadvantage is that its only limited to handpump water sources. It leaves out many more water sources common in the rural areas such a diesel generator pumping sets. Langdown (2018), in a qualitative evaluation of water points in northern Kenya, provides a more transient definition of functionality based on the downtime and number of days the water point has been operating in the preceding fourteen days. He concluded that a water point should be considered functional if it didn't break down for more than 24 hours not more than three times during the preceding two-week period, otherwise it should be considered non-functional.

In this study, Langdown's definition of functionality was applied given its strength in providing a reliability-based transient picture rather than a static picture of functionality as well as its applicability to any type of water source.

2.3.3 Maintenance and repair practices in rural water supply delivery

Harvey & Reed (2007) asserted that irrespective of the management model applied-be it community management or utility management, the key tasks of the service provider is

essentially to set and collect water tariffs and use these to maintain and repair the water supply facilities and where enabling expand the facilities. The Ghana community water boards managing rural water points used financial and operational indicators to assess the sustainability of rural water points (International Water and Sanitation Centre (IRC), 2012). From a financial indicators position, they defined a sustainable water point as one whose annual income exceeds annual expenditure, the service providers maintain proper revenue records, operate a bank account, sets water tariffs based on projected costs of operations and maintenance and carries out an audit at least once a year. Based on operational indicators, a sustainable water point was defined as one that has spare parts and mechanics in less than 24 hours, corrective maintenance practises in response to a facility breakdown is completed in less than 24 hours and at least one periodic maintenance or system overhaul is completed in a year.

Simukonda, Farmani, & Butler (2018) in emphasizing the importance of proper maintenance, assert that the performance of water supply infrastructure depends on the maintenance regime adopted. They concluded that the main causes of having a weak maintenance regime are insufficient funds due to poor revenue collection, poor data management and a lack of sufficient technical and managerial skills among service providers. Behailu, Hukka, & Katko (2016) in a detailed analysis of the causes of failures of rural water schemes in Ethiopia, concluded that lack of timely maintenance, failure of rehabilitation, lack of spare part supplies, and inadequate cost recovery are the key causes apart from environmental causes such as droughts. Boulenouar & Schweitzer (2015) study asserted that well planned, resourced and effectively implemented maintenance regimes for rural water points helps avoid catastrophic lump sum expenditures needed to replace failed components and associated premature failure and frequent breakdowns.

2.3.4 Financing and revenue mobilization for maintenance

While Bohm, Essenburg, & Fox (1993) concluded that rural water supply systems are not sustainable unless grants are available to finance most of the initial construction costs, Kaliba, Norman, & Chang (2003) asserts that water systems will only be sustainable in

the long-term if water users are willing to pay user charges sufficient to cover the costs of delivering the services. This section considers past research and theoretical literature on revenue generation required for water infrastructure capital development, maintenance and factors related to consumers' payments for water services.

Central to the successful delivery of rural water services is revenue mobilization and management specially to cover for the continuous operations and maintenance of the facilities. Chowns (2014) demonstrated, from a study of 679 water points in Malawi, that the ability and willingness to pay for recurrent operations and maintenance costs in rural water supply is the most significant factor in ensuring sustainability. Adank et al., (2013) studied the status of water supply in three rural districts in Ghana and found out that inability to raise funds for continuous Operation and maintenance was considered the major reason for unreliability in services. This lack of funds, they observed, impeded the ability of the service providers to maintain water facilities as money realized is inadequate to buy spare parts, properly train and provide competitive salaries to attract high caliber technical personnel. Carter, Harvey, & Casey (2010) demonstrated that in most cases, the revenues collected from water use fees were often much lower and inadequate to meet these recurrent costs. As such, communities are often left to solicit for financial support from external agencies including NGOs or local government offices (Davis et al. 2008). Several factors have been put forth as affecting water users' willingness and ability to make payments and thus sustainable resource mobilization practices of water service provider's managing those water points. Key among these is service delivery levels.

A study by Koehler, Thomson, & Hope (2015) observed that payments made by water users in rural areas is contingent on level of services provided. They observed that the higher the quality of services and reliability of water supply, the higher the revenues mobilized from the water users. Similarly, Shah & Mills (2018) highlighted the vicious cycle relating rural water facilities failure and the water users' willingness to pay. They posited that even the poorest water users are often willing to pay for quality reliable water services but are unwilling to pay for unsatisfactory services. As a result, when service

level drops due to lack of proper maintenance and responsiveness of the service providers, the water users become less willing to pay which further constraints operations and maintenance activities. They concluded that in most cases, it's not insufficient revenues that leads to failure of rural water points but rather it is mismanagement of collected revenues.

According to Adank & Tuffuor, (2013), the components of sustainable water tariffs for rural water service providers should be able to cover water production costs, routine maintenance and repair works, tariff collection expenses and some extent of spare parts replacement costs This is emphasized by Simukonda et. Al, (2018) who decried the fact that very few water service providers charge tariffs that cover the full costs of supplying water and in developing countries, tariffs are too low even to meet the basic operation and maintenance costs

2.4 Literature review summary and research gaps

From the foregoing review, research and practice of rural water services delivery points out that functionality of rural water points is an outcome of complex systemic interactions between political-economic, technical, financial and environmental factors. While the social norms, political values and economic incentives have an indirect influence on infrastructure functionality since these appear to determine whether the community water users pay for water and how much they pay for it. On the other hand, the practices around management of collected revenues from water use, which includes transparency, determines the effectives of the repair and maintenance activities carried out by the water service providers mandated to manage the water supply scheme giving these a more direct influence on infrastructure functionality. Conversely, reliability of water supply, in the sense of fewer breakdowns interrupting supply, is an outcome of the effectives of the maintenance practices affected which according to the literature review, largely influences water users' willingness to pay and make revenues available for repairs and maintenance.

In terms of the gaps this study seeks to contribute to, much of the literature reviewed indicates substantial work has been done in assessing critical success factors affecting

sustainability of rural water points. There're limited studies focusing into detail the specific maintenance and repair activities as well as revenue generation and management practices to ensure funds for maintenance. This study fills in this research gap by focusing on the specific revenue management and maintenance practices adopted by different management models including community management since these have a direct influence over infrastructure functionality in comparison to social norms and political economy factors which have an indirect effect on infrastructure functionality.

2.5 Conceptual framework and definition of study variables

Drawing from the literature, sustainability of rural water schemes is a multi-faced complex interaction of different system elements ranging from social factors, financial, environmental and technical drivers. Functionality is used in this study as a proxy indicator of sustainability. The dependent variable for this study is thus functionality created by assigning 1 to a water source found functional at the time of the study and had not break down for more than 24 hours not more than three times during the preceding two-week period, otherwise it is assigned 0 (non-functional water source). It emerges from the reviewed literature that fundamental to sustaining infrastructure functionality longer is the capacity and effectiveness of carrying out operations and maintenance (O&M) of the facilities. Availability of revenues, how the collected revenues are managed, water user's perceptions of affordability and willingness to pay are factors that facilitate the maintenance practices. For this study, practices on infrastructure maintenance and repairs was observed as the key independent variable. Generation of revenues needed to facilitate the maintenance activities was also observed but only as a factor facilitating the maintenance activities. This relationship is depicted in the conceptual framework shown in figure 3. Based on this conceptual framework, data collections tools were prepared and applied to collect primary data from the sampled rural water supply schemes in Turkana county.

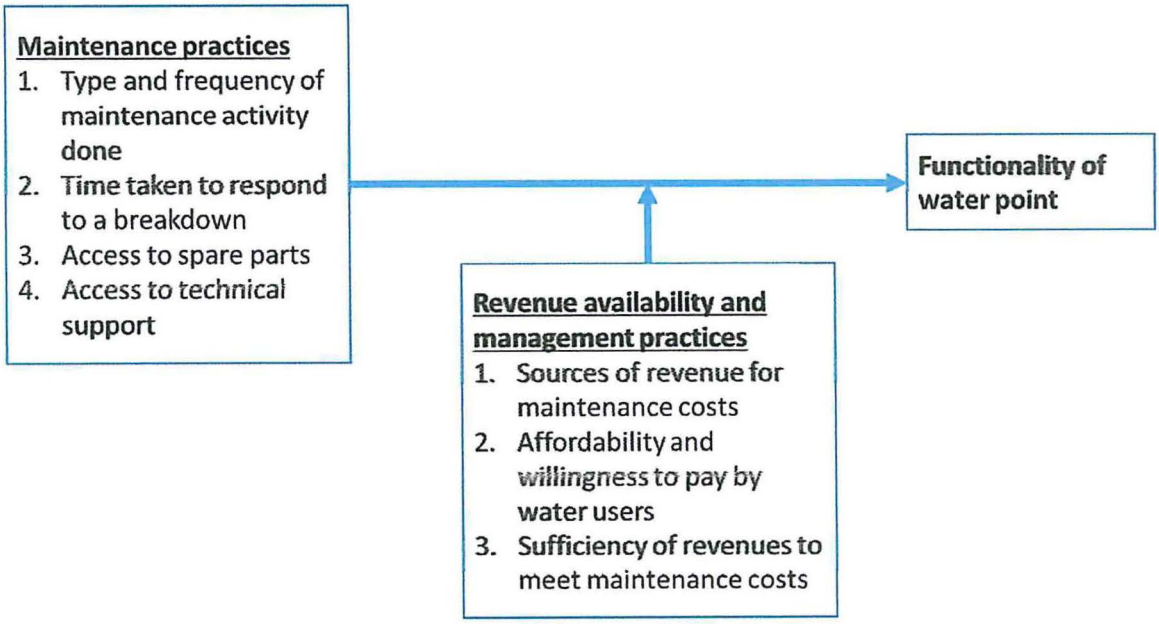

Figure 2-1 Study conceptual framework

Chapter 3 : RESEARCH METHODOLOGY

3.1 The research design and rationale

Quantitative research approaches were primarily used to collect data from water users (household) respondents in this thesis. Focused group discussions with water management committee members as well as key informant interviews with county government and non-governmental agencies was then applied as a follow up to validate and interpreted the quantitative data. Quantitative approach was deemed most appropriate because the type of data on the study variables consisted of largely numerically quantifiable data. Applying the qualitative focused group discussions and key informant interviews allowed the researcher to make interpretations from the quantified statistical results and interpret the data from a knowledge, attitudes and practices perception.

3.2 Sampling

Turkana county with a population of 1,427,797 was the study population. Turkana was purposively selected based on its low levels of access to safe water services (39% of Turkana residents have access to safe water against a national average of 55%) and high non-functionality rates (33% of installed infrastructure are non-functional). Turkana county located in the Arid Semi-Arid Lands (ASALS) of Kenya is also categorized as the poorest county in Kenya with roughly 90% of the residents living below poverty level (Mwangi, 2013).

3.2.1 Sampling frame and procedure

The sampling frame was a list of 41 villages distributed county-wide with water facilities installed in the last 5 years by the county government of Turkana and other Non-Governmental Organisations operational in the county. A simple two-stage cluster sampling procedure was used to select the study respondents. The primary sampling unit, the clusters, were the 41 villages. From this sampling frame, given that the villages have differing population sizes, probability proportion to size sampling was applied so that the larger clusters were given a greater probability of selection. For the follow up key

informant interviews and focused group discussions, purposively selected respondents given their role in rural water services delivery were relied upon.

3.2.2 Sample size

Since the population was finite, the sample size, the number of participants in the study (Frey, 2018), were selected at 95% confidence level such that the margin of error (desired absolute precision) was 5% using the Cochran formulae applying a finite population correction factor as shown in equation 1 (Cochran, 1977; Berenson, Levine, & Szabat, 2015; Lavrakas, 2011). The sample size was computed as Ten (10) sample sites with a total of 201 respondents from the 41 clusters using probability proportional to size sampling calculations. Table 3-1 summarises the sampling procedure used during the study. Table 3-2 summarises the 10 sampled sites at the time when the study proposal wa submitted. Due to unforeseen security challenges in accessing some of the sampled sites during field work, a few of the sampling sites had to be changed. The final sampled sites visited during the study are show in Table 3-3.

$$n_{srs} = \frac{N\hat{p}_{srs}\hat{q}_{srs}}{\frac{d^2}{1.96^2}(N-1) + \hat{p}_{srs}\hat{q}_{srs}}$$

where

n_{srs} = sample size

N = population size

$\hat{p}_{srs}$ = the estimated proportion

$\hat{q}_{srs} = 1 - \hat{p}_{srs}$

d = desired absolute precision

Equation 1: Sample size calculation formulae

Table 3-1 Summary of the sampling procedure

	Quantitative data (Administer Household survey questionnaires)	**Size**
Study population	Turkana county	1,427,797
Sampling frame	41 villages where water systems were installed in the last 5 years	140,450
Primary sampling unit	Sampling units were selected from the sampling frame of 41 villages (clusters) using probability proportional to size (PPS), taking the population of each village as the reference value.	10 villages with total population 104,108
Secondary Sampling units	Within each selected sampling unit (village), random walk methodology was used to select the respondent households.	
Respondents	An adult member of the household willing to take part in the survey will be interviewed by a research assistant.	219

Table 3-2:The 10 Initially selected primary sampling units and sizes

	Village Name/Sample site for data collection	**Type of water point**	**population size**	**sample size**
1	Kakuma – Karbokorit	solar/diesel hybrid pump	17,000	33
2	Kataboi	Solar powered pump	6,703	13
3	Lodwar town (Kanamkemer, Nakwamekwi)	solar/electricity hybrid pump	21,756	42

4	Loperot	Solar powered pump	8,726	17
5	Lokichogio	solar powered/diesel/electricity system	33,700	65
6	Meyan	Solar powered system	1,800	3
7	Naotin	Solar powered system	500	1
8	Kaikor	Hand Pump/Solar powered system	8,700	17
9	Kakelea	Hand Pump	4,028	8
10	Nabulkok	Hand Pump	600	2
				201

Table 3-3: The 10 finally selected primary sampling units during field work

	Village Name/Sample site for data collection	Type of water point	population size	sample size
1	Kaaleng/Kaikor	Hand pump	8,700	24
2	Kakelae	Hand pump	4028	8
3	Kakuma/Kabokorit	Solar/diesel hybrid system	17000	33
4	Kalokol	Solar powered	470	6
5	Kanamkemer- Lodwar town	Solar/electric hybrid	11756	24
6	Kataboi	Solar powered	6703	13
7	Lokichar	Hand pump	1227	13
8	Lokichoggio	Electric/diesel hybrid	33700	53
9	Loperot	Solar powered	8726	17
10	Nakwamekwi-Lodwar town	Solar/electric	11878	27
				218

3.3 Data collection tools

Household questionnaires was used as the primary data collection tool to collect data from the 219 study respondents. Focused group discussions and key informant interviews were used at a second stage to validate the collected quantitative data from households.

3.4 Data analysis

Given that the data was largely quantitative, various statistical methods including descriptive statistics, frequency counts and regression analysis were applied to analyse the data and process it into useful information for answering the research questions

3.5 Research Quality – validity, reliability and objectivity of the research.

The data collection tools were piloted before the study to ensure that the respondents all understand the question in the same way, so as to ensure both reliability and validity. The pilot was done with 27 household respondents in Nakwamekwi community. Piloting allowed for adjustment in areas where weaknesses of the tools were noted. A key issue that emerged during the pilot was the difficulty the enumerators faced in translating some of the more technical questions into the local Turkana language. The tools were revised to make it easier for the enumerators. The study additionally triangulated the information provided by households with those provided by water management committee members, county government and NGO officials to enhance research quality.

3.6 Ethical considerations during the study

This study applied the following ethical research guidelines to mitigate against any form of harm possible to those involved in the study;

1. Consent was given voluntarily, and the participants were informed that consent could be withdrawn at any time during the study.
2. The respondents were not required to give their name on any of the questionnaires and strict confidentiality of respondent's identity was maintained.
3. Respondents were informed of the duration of the questionnaire to allow then to plan their schedules accordingly.

Chapter 4 : PRESENTATION OF RESEARCH FINDINGS

4.1 Data Collection

Data collection was carried out between December 10th and 21st 2018 at the 10 sampled rural water systems within Turkana county each with different characteristics. Some had solar pumping systems, some diesel generator pumping systems, some hybrid solar-diesel pumping systems and some with handpumps.

Quantitative questionnaires were administered at household level to 218 respondents (water users), both men and women sampled from the 10 communities. The respondents were distributed proportionately across the 10 water systems sampled using probability proportional to size sampling process. Follow up Focused Group Discussions and key Informant Interviews were conducted with water management committees members for each system (averagely 5 committee members per system), 6 county government officials and 4 NGO staff to triangulate and validate the largely quantitative data from water users. Ethical clearance for the study was obtained from Strathmore University Institutional Ethics Review Committee protocol ID SU-IERC0278/18 on the 4th of December 2018.

4.2 Response rate

The study had 10 study sites sampled within the county. Questionnaires were successfully administered to 218 household respondents through face-to face interviews. The response rate recorded was 100%. Figure 4-1 shows the gender of the respondents.

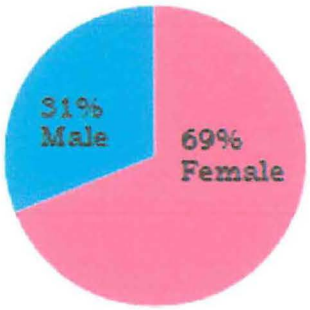

Figure 4-1 Gender distribution of the study respondents

4.3 Objective 1 results: Maintenance practices of water service providers

The first research question sought to establish the specific types of infrastructure maintenance activities practiced by rural water service providers in Turkana county. This required a descriptive presentation of the current practices with regard to typologies of repairs and maintenance, response to emerging repair needs and access to spare parts for rural water systems in Turkana county.

4.3.1 Typologies and frequency of maintenance activities

The routine and periodic operations and maintenance and repair activities carried out by the managers of the water points is critical for their sustained operations. A key focus of this study was to understand from the service providers and the water users, the different types of repair and maintenance activities including their frequency and whose responsible. While some requiring less expertise like general cleaning of water point areas are done more regularly, there are more technical activities requiring external intervention which comes far between as shown in table 4-1

Change of oil filters and fuel filters for water systems using a generator pumping set was observed as the only preventive maintenance activity carried out by the service providers. Otherwise majority of the maintenance activity are done only when the need arises like when a pipeline is broken. For the water systems having solar pumping system, only 10% reported cleaning the solar panels at least once per week. Only 2% of the respondents indicated cleaning the livestock watering troughs. 100% indicates that the service providers mentioned carrying out the said maintenance activity with the corresponding frequency

Table 4-1 Typologies and frequencies of maintenance activities by service providers in Turkana

Type of maintenance activity	Frequency done (Done at least)					
	Daily	weekly	monthly	Every 3 months	>3 months	Variable, when need arises
Changing of oil filter						
Changing of fuel filter						
Cleaning of solar panels						
Cleaning pump area						
Repairing broken pipes						
Repairing leaking tanks						
Replacing taps at water kiosks						
Cleaning of livestock watering troughs						
Repair of broken-down hand-pump system (e.g. replacing seals)						
Repair of faulty solar pumping system (e.g. replacement of burnt out control panel)						
Repair of non-functioning water pump inside the borehole						
Repair of broken kiosks and watering troughs						
Repairing of pump/replacement of pump parts						

4.3.2 Time taken to repair broken down water facilities

Frequent breaking of pipes and water taps at the water kiosks were listed as the leading cause of water system failures at 57.82% by the respondents as Figure 4-2 shows. Drying up of wells or significant reduction of yield from the water sources leading to insufficient supply of water for both livestock and people came as a third cause of breakdown after pump failures.

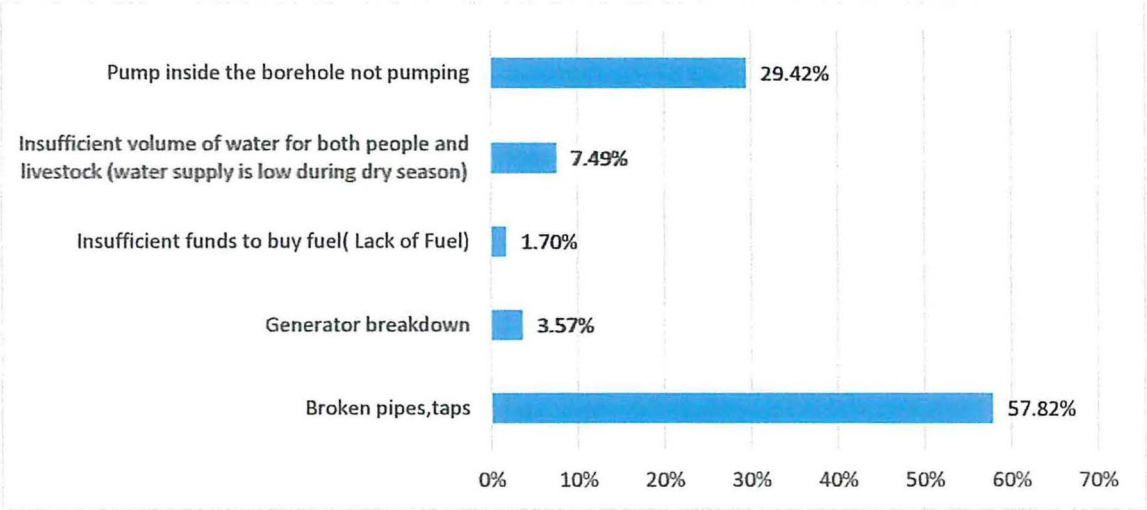

Figure 4-2: Causes of water facilities breakdown in Turkana

The water users and water management committee members were asked how long it takes to respond to a facility breakdown when it occurs. While the time it takes to respond was varied across the water points with the majority taking two weeks or more and none completed within a day, the most common response was that the time to repair a broken system depends on the availability of funds. 69% of the water users are of the view that it takes as much time to restore functionality as it takes to make the funds available. This is an interesting response since it was observed that it could be a day or 3 months in some cases. These results are shown in figure 4-3. This trend points towards a lack of a pool of easily available cash flow to respond to repair needs.

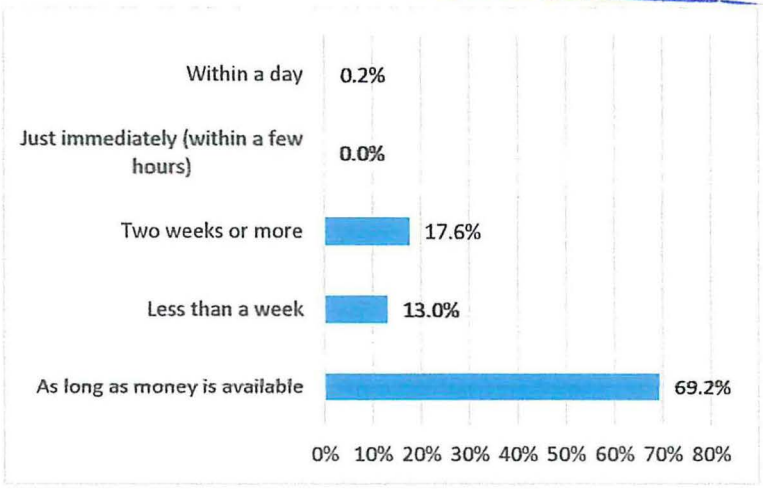

Figure 4-3: Time taken to respond to water facility breakdowns in Turkana

While 100% of the committees reported receiving at least five days training on basic operations and maintenance of the water systems mostly from Non-Governmental Organizations (NGOs) and local sub-county water officer who installed the systems, maintenance practices were found to be carried out erratically and response to break downs varied from 3 days to more than three months depending on the nature of work needed and availability of funds. In one community, it took one and half months to acquire and replace a broken seal on a handpump while in another solar powered system, it took 3 months to replace a pump controller that broke down. When asked whether the water facility has enough human resource capacity for maintenance activities, 100% of the responded indicated not. This is because they still have to rely on the sub-county water offices or NGOs sending repair technicians. If both these channels delay, the community collectively contributes and pays a private technician from the nearest urban center i.e. Lodwar town, Kakuma or Lokichogio to come and do the repair. In some cases where the community has a solar powered system, the respondents indicated reaching out to the NGO who installed the system who then facilitates an electrician from Nairobi to repair- like the case of the broken pump controller system at Kaaleng'.

A follow up question on responding to repairs was related to perceptions on who should be carrying out the response to breakdowns. Figure 4-4 indicates that about 50% of the respondents believe that it's the duty of the water service providers, water management committees in this case, to ensure there's enough funds and expertise to carry out the

required repairs. About 22% are of the opinion the county government should do it while about 15% interestingly believe it's the water users' responsibility to do the repairs. This is an interesting finding since the water committees do not have sufficient technical skills to carry out the repairs hence they rely on NGOs and county government support.

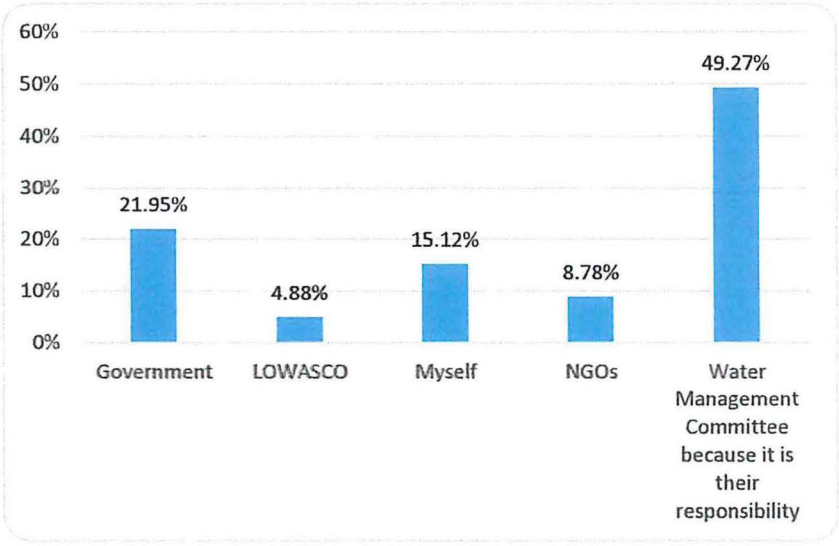

Figure 4-4: Perceptions on who should carry out water facilities repair in Turkana

4.3.3 Access to spare parts

None of the service providers reported keeping a set of spare parts within their stock. They all purchase from the nearest source when the need arises. The service providers were asked how difficult it was for them to access the spare parts needed for operations and maintenance. The majority, 76.4%, as shown in figure 4-5, felt they have difficulties in access ing spare parts while none felt any ease in accessing spare parts. While some spare parts such as plumbing fittings were available in local hardware stores in local town Centres such as Lokichar, Kakuma and Lokichogio, the more advance spare such as pump parts and electrical components could only be sourced from Lodwar, Kitale and Eldoret where service providers such as Davis & Shirtliff have workshops.

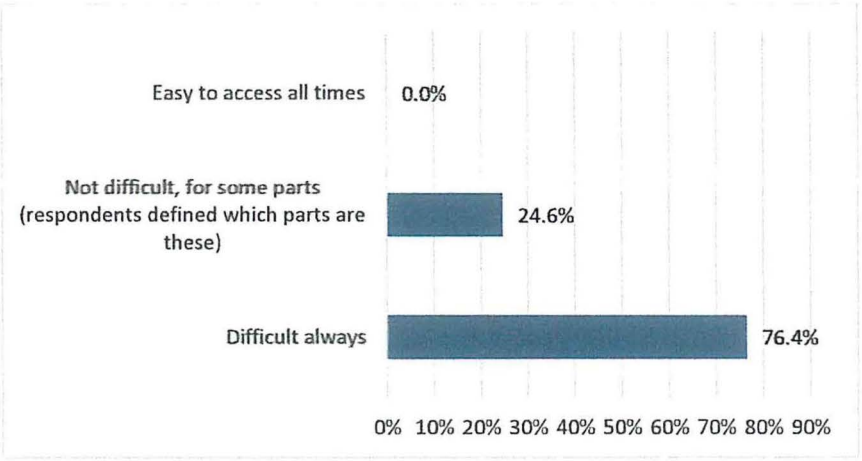

Figure 4-5: Ease of access to spare parts in Turkana

Figure 4-6 shows the responses received when respondents were probed further how they obtain spare parts needed for maintenance and repairs. The major providers of spare parts for the service providers at 53.2%, are NGOs who support the development of community water supplies. It's worth noting that the NGOs provided spare parts support for both water points they developed as well as for water points developed by the government. These findings suggest that distance is a key barrier to accessing spare parts on time and thus quick response to break downs. The furthest study site, Lokichogio is about 214km from Lodwar while Kitale to Lodwar is about 300km.

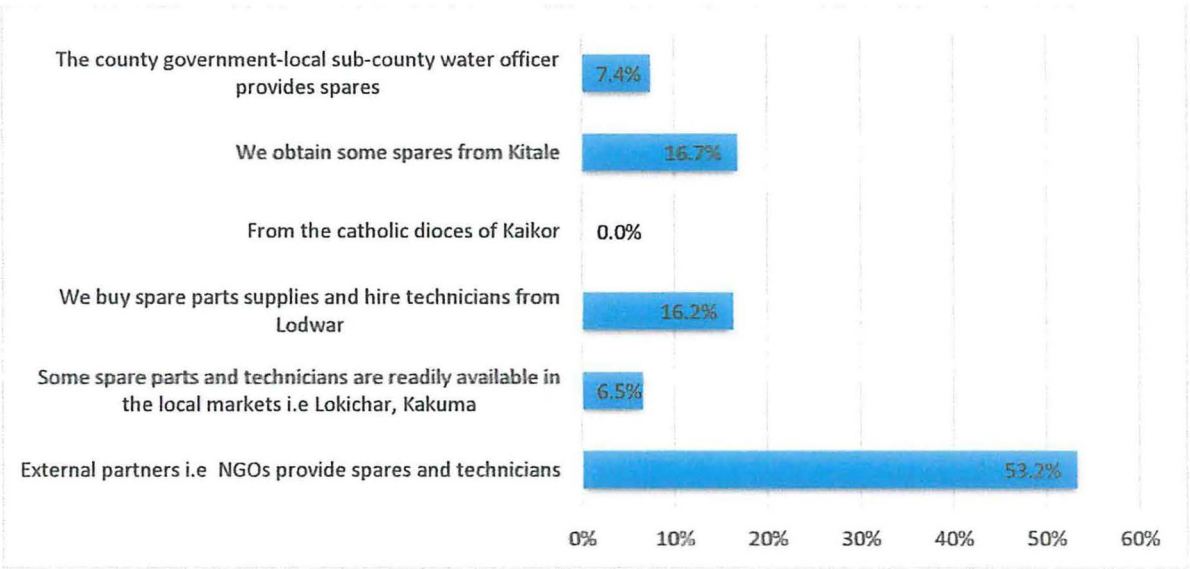

Figure 4-6: How service providers in Turkana obtain spare parts

4.3.4 Availability and access to post-construction technical support and monitoring

The data shows that the two key external partners to the communities in Turkana in managing their water systems are the county government and NGOs with a specific mention of the Catholic Diocese of Lodwar water program. Majority of the service providers indicated they have received some kind of post construction support-supply of spare parts, support in responding to a breakdown mostly from the NGO, Catholic diocese of Lodwar and periodically from the county government of Turkana. The Catholic diocese of Lodwar water program received a constant mention as a key source of post-construction technical support at all the sampled sites. The NGOs were observed as the only source of any structured technical training and capacity building to members of the water committees for operations and maintenance of the water systems. This is shown in figure 4-7.

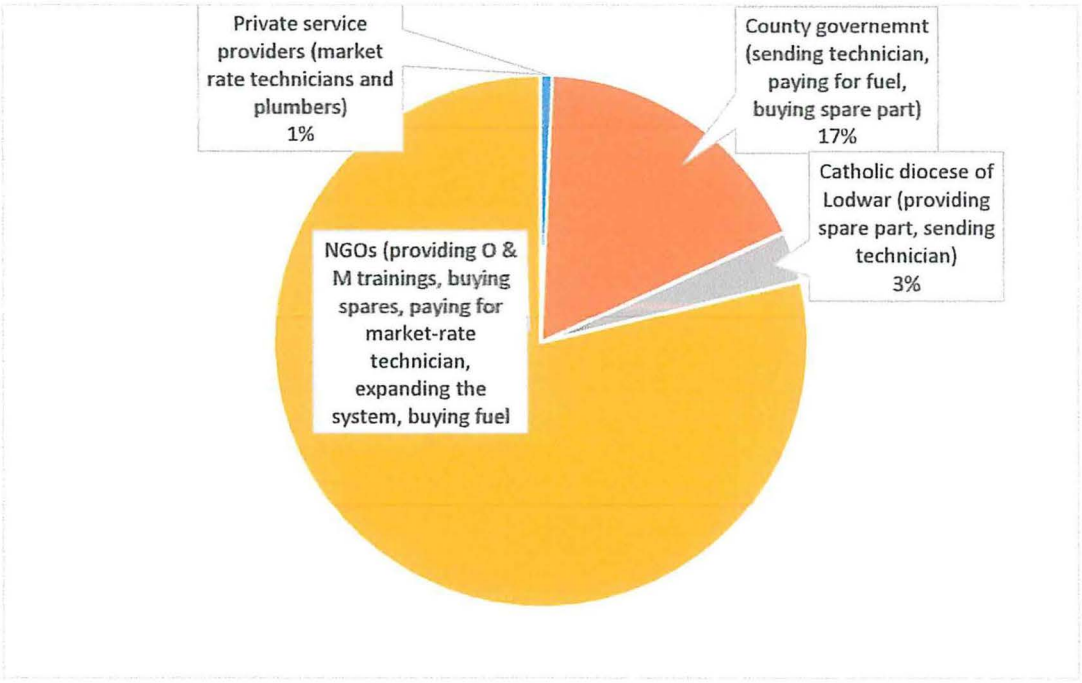

Figure 4-7:Sources and kinds of post-construction support in Turkana

As shown in figure 4-8, from the key informant interviews with county government officials and NGO staff, the development of new infrastructure and development of policies was indicated as the key role of the county government in rural water

management. They didn't consider support on regular operations and maintenance as a key role apart from responding to large repair needs that the water management committees haven't been able to respond to on time.

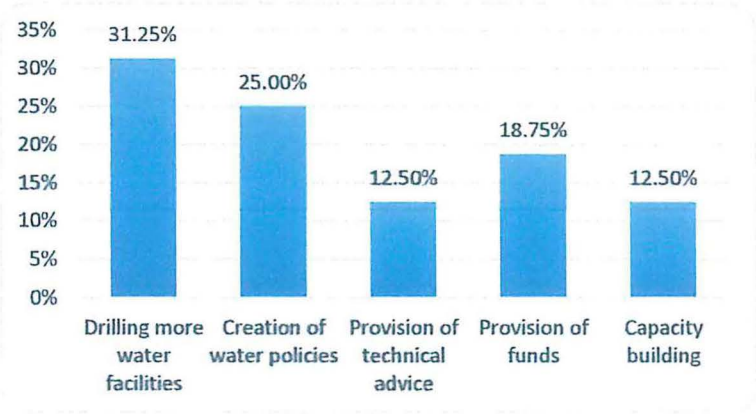

Figure 4-8: Perceptions on the role of county government of Turkana in rural water supply delivery

Limited funding occasioned by adequate county budgetary allocation, weak coordination with NGO actors and conflicts in roles between the county government and the regional water service boards emerged as the key challenges the county government face in their executing their expected direct oversight and monitoring of the activities of rural water service providers on revenue management and technical support as shown in figure 4-9. There are certain community water projects implemented by the national government and NGOs within the county that doesn't involve the local county offices leading to a lack of common understanding and communication on subsequent support mechanisms. This was cited as a significant cause of poor post-construction monitoring and technical support.

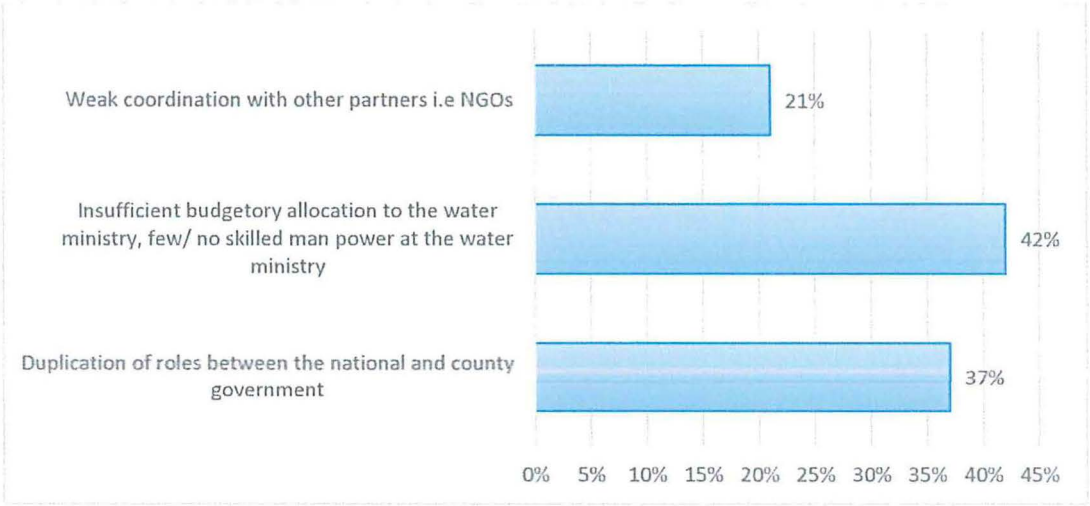

Figure 4-9: Challenges in technical support and monitoring of rural water service delivery in Turkana

4.4 Objective 2 results: Revenue management practices of service providers

The second research question sough to establish the specific ways rural water service providers in Turkana county raise are and manage revenues needed for the daily maintenance of the water schemes. From the key informant discussions with the water management committees and county officials, it was observable that 80% (8 out 10) of the water management committees were formed only after the construction of the facilities were completed and handed over to the community. Most committees were non-existence before the project started. The reason for formation of the water committees was so that, on behalf of the communities, they would collect water use tariffs, manage these to carry out on-going maintenance and repairs.

4.4.1 Availability of funds for maintenance: Revenue mobilization means and sources

When asked the different sources of funds used for operations of the system such as buying fuel, repairing broken systems, buying spare parts, as shown in figure 4-10, 87.35% of the committees indicated they collected revenue from water users to help in running the O&M of the water points. The other three sources mentioned were support by NGOs especially during breakdowns to buy spares, support from the county

government local sub-county water engineer, religious organization particularly the catholic church Diocese of Lodwar, community collections (*harambees*) especially when there's a breakdown and the system has been down for a while and in a few cases support by private individual well-wishers. It was interesting to note that the respondents ranked support from NGOs above support from the county government.

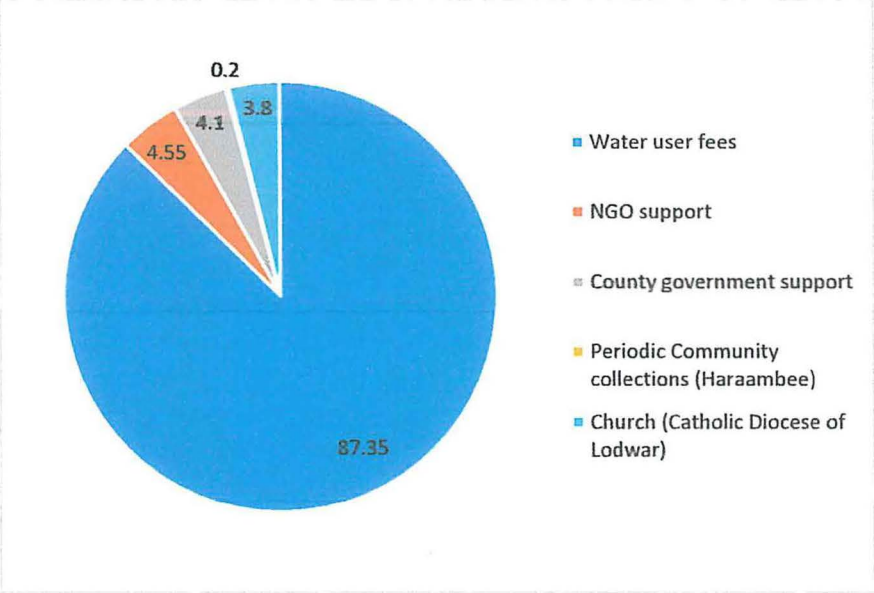

Figure 4-10: Sources of revenue for O & M in Turkana

4.4.2 Affordability and Willingness to pay for water by water users

When the households were asked whether they pay for water, 70.78% indicated they pay regularly. Of the 70.78%, 54.84% pay at the collection point i.e. kiosk per container as they fetch the water (mostly 20-liter plastic jerrycan) while 41.29% pay a fixed monthly contribution as agreed by the community while the rest, only 3.87%, pay ad hoc when asked to by the water management committee.

When asked whether they find the water tariffs affordable, 59.35 % responded that what they currently pay is too expensive compared to the kind of income they make while 40.65% concurred that the tariffs are reasonably affordable. Table 4-2 shows the average cost of water at the different sample sites. The results indicate lack of a regulated system of charging for water for the rural households in Turkana.

Table 4-2: Average cost of water in various communities in Turkana

S. No	Study Location	Average cost of a 20ltrs container of water for domestic use (Ksh.)
1	Kaaleng/Kaikor	3
2	Kakelae	8
3	Kakuma/Kabokorit	6.5
4	Kalokol	5
5	Kanamkemer	11
6	Kataboi	5
7	Lokichar	9
8	Lokichoggio	5
9	Loperot	6
10	Nakwamekwi-Lodwar town	13

In further probing, the water users' who expressed a willingness to pay indicated that the affordability and the reliability of the water points, in terms of it being functional when they need water, has the greatest influence on their willingness to pay for water when asked to. Figure 4-11 shows the factors influencing the water users' willingness to pay for water.

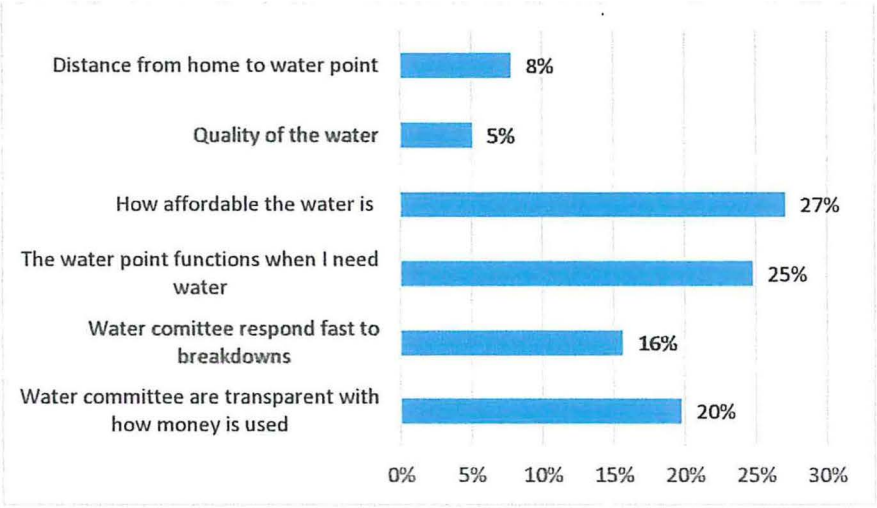

Figure 4-11: Factors influencing water users' willingness to pay for water in Turkana

Revenue collected from the water users at the various water points is used mostly for buying fuel, spare parts, pay staff and conduct annual maintenance of the water points as shown in figure 4-12.

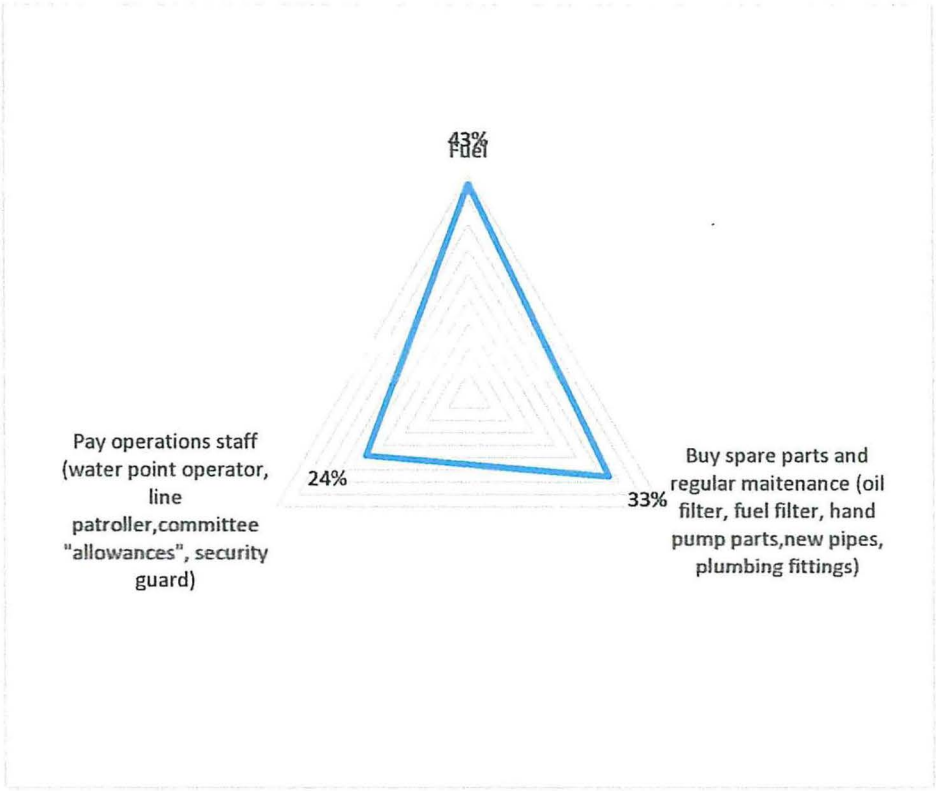

Figure 4-12: How revenues are used by rural water service providers in Turkana

4.4.3 Sufficiency of collected revenues to cover maintenance costs

Only 12.5% of the committee members indicated that the revenue they collect is enough to sustain the water point. 87.5% felt that the revenue collected is not enough to cater for the maintenance of the water points. This means that there's mostly a deficit that is required to manage the water points smoothly. This forces the committee members to seek for money from NGOs, the government and urging community members to make special contributions besides the water tariffs.

4.5 Objective 3 results: Effects of service provider practices on Functionality

The third research question sought to establish the relations between functionality, If any, with the study independent variables. The results from analysis of the maintenance and revenue management practices shows a close interaction between the independent

variables. From the analysis, it emerges that the time taken to repair broken down water facilities is the main predictor variable of functionality. Access to spare parts, access to technical support and monitoring of service delivery, sufficiency of the revenues mobilized to cover operations and maintenance costs all affect the time it takes to repair a broken water system making it endogenous.

Given that the predictor variables are largely categorical, a generalized linear model (GLM) would have been chosen for the analysis. However, the outcome variable, functionality is continuous and there is evidence of endogeneity in the predictor variables. I therefore settled on an instrumental variable regression model to address possible multicollinearity between the predictor variables.

Ex-ante, time taken to repair a broken-down water facility is determined by the type of repairs required, who's responsible for carrying out the maintenance (whether it can be done by water committee members, local technician or whether a technician must be sourced from Kitale) and whether households are required to contribute towards repairing a breakdown when it occurs. These factors are all determinants of functionality but only to the extent they are factors of time taken to repair a broken facility and restore functionality. Hence, I ran an instrumental variable regression model with these factors as instruments, while affordability as an independent predictor in the model as shown in Figure 4-13.

```
. ivregress gmm functionality afford2 (repair_time=b3.repairs b6.who_repairs hh_contribute)
Instrumental variables (GMM) regression         Number of obs   =        218
                                                Wald chi2(2)    =      15.77
                                                Prob > chi2     =     0.0004
                                                R-squared       =          .
GMM weight matrix: Robust                       Root MSE        =     1.4754
```

functional-y	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
repair_time	-.3695879	.1719429	-2.15	0.032	-.7065897	-.032586
afford2	.5383256	.1948343	2.76	0.006	.1564575	.9201937
_cons	2.514775	.7947623	3.16	0.002	.9570693	4.07248

```
Instrumented:  repair_time
Instruments:   afford2 1.repairs 2.repairs 4.repairs 1.who_repairs
               2.who_repairs 3.who_repairs 4.who_repairs 5.who_repairs
               hh_contribute
```

Figure 4-13: Regression analysis results

To test the fitness of the model, I checked endogeneity to confirm that the exclusion criterion is met. I also checked that there's indeed correlation among the variables included at the first stage regression. Figures 4-14 and 4-15 shows the results.

```
. estat endogenous

Test of endogeneity (orthogonality conditions)
Ho: variables are exogenous

GMM C statistic chi2(1) =    5.0582  (p = 0.0245)
```

Figure 4-14: Results of testing the fitness of the regression model

First-stage regression summary statistics

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	Robust F(9,207)	Prob > F
repair_time	0.0732	0.0284	0.0726	2.61849	0.0069

Figure 4-15: Results of checking for correlation among predictor variables

The endogeneity test shown in figure 4-14 indicates a significant p-value of 0.0245 at 95% confidence level. The null hypothesis that the instrumented variable, time taken to repair a broken facility, is exogenous justifying the choice of an instrumental variable

regression. On the other hand, figure 4-15 shows that the F-Statistic in the first stage regression test indicates a significant value of 0.0069 at 95% level. I therefor conclude that there is significant correlation between the variables included in the first stage regression and the instrumented variable, time taken to repair a broken-down water facility.

Summary and interpretation of regression coefficients

A further summary of the regression coefficients is shown in the table 4-3. In summary, the results show that a water system is likely to be considered functional if it takes (0.37 or 37%) less time to repair compared to the base category of less than 1 day (24 hours).

Table 4-3: Summary of regression results

Variables		functionality
func_repair_time		-0.370** (0.172)
afford2		0.538*** (0.195)
Constant		2.515*** (0.795)
Observations		218

Another factor that determines functionality is affordability of the water by the households. A water point would be functional for a longer time if households could afford the water by 54% points (price reduction recommended here to increase affordability). The results show that there exists a cyclic relationship in which affordability increases access which in turn improves functionality as more households contribute towards maintenance, hence reducing repair time.

Chapter 5 : DISCUSSION OF RESULTS

5.1 Introduction

The purpose of this study was to assess the effects of infrastructure maintenance practices of the rural water service providers (in this study mostly community-level water management committees) in Turkana county on the facilities functionality. The literature review pointed that fundamental to sustaining rural water supply infrastructure functionality is the actual maintenance practices as well as capacity and effectiveness of capturing and efficiently utilizing resources for operations and maintenance. This chapter presents a discussion of the study findings as related to the literature on maintenance practices in water services delivery as well, revenue management practices as well as on rural water sustainability and functionality as presented in chapter tow of this thesis.

The study sought to answer three research questions: (R1) What are the types of maintenance activities practiced by rural water service providers in Turkana county, (R2) How do rural water service providers in Turkana county raise and manage revenues needed for the maintenance of the schemes and lastly, (R3) How do the maintenance and revenue management practices by rural water service providers affect the functionality of the water schemes.

5.2 Summary discussions of the study findings

Majority of the maintenance activities done by the water service providers in Turkana county were only done as a reactive/curative measure after the system has broken down. There's little evidence of any scheduled preventive maintenance measures save for simple daily routine tasks such as cleaning of water access points. When a break down occurs at a water system, the time taken to respond is varied with the most common response, 69%, being that it "takes as long as money is available". Only 0.2% of breakdowns are repaired within 24 hours. In some cases, depending on the magnitude of repairs needed and access to spare parts, the response time has taken as much as 3 months to restore functionality after a breakdown. On revenue management practices, the results indicated that majority of the funds for operating and running the water systems, about 87%, come from the water

users as water tariffs or from periodic collective contributions, locally called *Harambees*. The results indicate that the communities periodically reached out to NGOs or the county government when the need for a major repair arises.

While the results reveal a high willingness to pay for water at 71% of the water users, more than half of the respondents indicated that the current amounts they were paying for water is too high. Almost half, 43% of the revenues collected are used to buy fuel for water points using diesel pumping sets. The bulk of the revenues, 57% is used to buy spare parts, pay operations staff and to carry out regular maintenance such as annual overhaul of diesel generators. 88% of the water service providers indicated that the revenues collected are not sufficient to cover their operations and maintenance needs.

The study findings revealed a close interaction between the independent variables themselves with the time taken to repair broken down water facilities emerging as the main predictor variable of functionality. The other predictor variable; access to spare parts, access to technical support and monitoring of service delivery, sufficiency of the revenues mobilized to cover operations and maintenance costs all affect the time it takes to repair a broken water system making it an endogenous variable. This necessitated an instrumental variable regression analysis to establish relations between the predictor variables and functionality status of water points. The regression results indicate that a rural water system in Turkana is likely to be functional if it takes (0.37 or 37%) less time to repair compared to the base category of less than 24 hours. Affordability of water by the households emerged as another key factor that determines functionality since it influences sufficiency of revenues needed to respond to a break down. The regression results indicate that a water point in Turkana would be functional for a longer time if households could afford the water by 54 % points (calls for a reduction of the current water tariffs by 54%). The results demonstrate a cyclic relationship in which affordability increases access which in turn improves functionality as more households contribute towards maintenance, hence reducing repair time.

5.3 Analysis of the study findings within the context of other literature

The results from this study confirm many of the concerns around sustainability of rural water supply schemes and the inefficiencies common with the community-based management model as highlighted in chapter 2. In chapter two, studies by Leclert, Nzioki, & Feuerstein (2016); Walters & Javernick-Will (2015); Skinner (2009) and Rural Water Supply Network (2010) indicated that the underlying causes of high non-functionality rates of rural water facilities lies in the ineffectiveness of the maintenance practices and revenue management practices. The findings of this study confirm these.

The results of this study indicate that the expectations of the community management model adopting a service delivery approach as proposed by Lockwood et. Al, (2010) are difficult to achieve for remote water point systems like those in Turkana. This inefficiency and ineffectiveness in service delivery is largely affected by a complex interaction of factors including insufficient self-capacity to carry out effective preventive maintenance, difficulties in accessing spare parts within the shortest time possible, constraints in getting skilled technical support for large repair works and well-plane monitoring by county government, insufficiency of collected funds from water users to cover the maintenance needs in its entirety, all which directly influence the time it takes to repair a water system when it becomes non-functional. These findings, that the different independent variables affecting ultimate functionality of water points are intricately inter-related with each other confirms the findings of Peter & Nkambule (2012); Enéas da Silva, et al., (2013); Jones, et al., (2013), Jones, Anya, Stacey, & Weir, (2012), Amjad et al., (2015) that a balance between then availability of skilled technicians, access to high quality spare parts as well as generation of sufficient revenues to cover the cost of maintenance and repairs contribute to functionality of rural water points . The water committee members in Turkana indicated that the time it takes to repair a broken system depends on availability of funds needed for the repair. On the other hand, water users' willingness to pay for water, which makes funds available, is directly affected by their perception on affordability and how reliable the water supply is. This shows how strong interactions between technical factors and financial factors affect functionality. The results concur with Walters & Javernick-Will (2015) assertion that dynamic and systemic interactions

of technical, social, financial, institutional, and environmental factors often lead to premature water system failure.

The literature asserts that the performance of water supply infrastructure depends on the maintenance regime adopted (Simukonda, Farmani, & Butler, 2018). The findings of this study pointed out that the service providers in Turkana do not have any structured preventive maintenance program instead often responding to breakdowns only when they occur. The intermittent functionality, where it takes as much as 3 months to respond to a breakdown can be attributed to a failure of the service providers to adopt a proper maintenance regime

While Kivuva (2014) observed that the sustainability of community water projects in Kutui county was attributed to the acquisition of management skills, technical operation and maintenance skills as well as acquisition of resource mobilization skills by water uses committees highly contributed, the findings from Turkana county indicates that despite all the water management committees managing the water points received training and capacity building on operations, maintenance and financial management, their effectiveness in responding to breakdowns is still low with some repairs taking as long as three months, funds are still often collected from water users when the need for a major repair arises instead of drawing from a well-managed savings account and they have no properly well planned maintenance regime. The results of this study corroborate Chown's (2014) conclusions that the community-management model is characterized by neglect of maintenance, slow and substandard repairs, and failure of committees to save sufficient funds.

The results on factors influencing the water users' in Turkana willingness to pay, highlighting reliability in terms of the system functioning when they need water, agrees with by Koehler, Thomson, & Hope (2015) who observed that payments made by water users in rural areas is highly continent on levels of service provided besides the affordability question.

Shah & Mills (2018) posited that even the poorest water users are often willing to pay for quality reliable water services but are unwilling to pay for unsatisfactory services. As a result, when service level drops due to lack of proper maintenance and responsiveness of

the service providers, the water users become less willing to pay which further constraints operations and maintenance activities. The finding of this study showing the existence of a cyclic relationship in which affordability increases access which in turn improves functionality as more households contribute towards maintenance, hence reducing repair time strongly agrees with Shah & Mills position.

Chapter 6 : CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This chapter presents the conclusions that can be drawn from the results, presents significance of this study's findings and makes recommendations for action to policy makers. Also highlighted are suggestions for further research.

From the presented study findings and the discussions in chapters 4 and 5, the following conclusions are made:

There's a tendency of the government and other actors such as NGOs of focusing mostly on the short-term new water infrastructure development for rural populations with little focus given to operations, maintenance and monitoring systems strengthening support post-construction. This negatively impacts on the long-term functionality of the facilities since communities with little technical capacity and limited financial resources are expected to manage these facilities.

Rural water service delivery in Turkana is done without a clear institutional strategy where service providers are not formally held to account on compliance or non-compliance with government service delivery standards. By virtue of the service providers under the community-management model operating in Turkana being "voluntary" and not a formally registered and regulated service provider, it is not possible to hold them to account on the quality and effectiveness of the services they offer. This is a significant policy challenge for the effective delivery of an essential public service like water.

The persistent non-functionality and frequent failure of rural water systems is a result of a cyclic relationship between poor response by the service providers leading to unwillingness to pay by water users which led to lack of adequate funds for maintenance and response to breakdowns.

Affordability of water remains a key issue for rural water users. When the water cost is too high, as most users have lamented, there is no sufficient generation of revenues to cover the cost of operations and maintenance since users can't pay up. In addition to this, there's no uniformity in water tariffs for the rural households with some household paying

Ksh. 3 while others pay Ksh. 11 for the same volume of water. This points to a significant policy gap on setting of rural water tariffs.

The prevalent "capacity building" approach for rural water service providers involve providing short-term, 5-10 days one-off training in a bid to help them acquire management skills, technical operation, maintenance skills, resource management skills. This is done without a well-organized post-constriction technical support and monitoring regime by the local government. Such a state is not likely to contribute to increased functionality of the water systems as was evident in Turkana. This is underpinned by two factors, one that the members of these committees are often village elders not well educated so their capacity to acquire the kind of knowledge expected of them is low and secondly that no matter how well trained and skilled the committee members are, they most often operate on a "voluntary" basis thus difficult to enforce regulatory standards for water services provision.

The community management model where members of the beneficiary community appoint or elected a few of them to members of a "voluntary" committee responsible for directly operating and managing the water point has proved non-responsive and ineffective in ensuring the sustained functionality of the systems. Significant changes are required in formulating the structures of how rural water services are delivered including possible models where the communities still retain the powers to oversee the management of the services but are not directly responsible for day to day operations and maintenance of the system.

6.2 Policy significance of the study findings

Sustaining rural water supply post-construction remains a significant policy issue for both the government and development assistance organizations. The averagely 30-45% rural water facilities failure rate post-construction is unacceptable given the high capital investment made into these facilities. Several approaches and models have been proposed and tested in attempts to address this policy challenge. Among these include the predominant community-based management model as well as testing private sector-led models. These have brought about mixed results. As this study points in corroboration

with other studies, the community-based management model has yielded much less than expected success with different community-led water service providers characterized by neglect of maintenance, slow and substandard repairs, and failure of committees to save sufficient funds. Attempts to bring in private sector service providers has been resisted with significant value-questions as to the motives of private sector profits orientation in supplying a public good as well as concerns around commercial viability of remote rural water points to attract private market players.

The findings of this study which casts a grim picture of the current service delivery models and practices in rural water supply calls for significant paradigm shift towards a wholistic system-view of the policy issues in rural water services delivery. Governments and development agencies need to think "outside the box' to find a sustainable solution. The policy significance of this study's findings is to call for a greater "duty of care" approach and designing rural water service provision with an imbedded sustainability from the onset. Most often, as the study has pointed out, low capacity community water users are often left alone to manage a water supply system with very minimal training for a demanding task. They are often left with little structured institutional and technical support to ensure the facilities function reliably. The government and NGOs unfortunately later on blame 'poor management by communities" on the failure of rural water facilities. Duty of care as a policy approach demands that the financiers and developers of the infrastructure establish a forward-looking system and makes explicit provisions for how the technical maintenance of the systems will be done 5 or 10 years down the line and how these will be financed. Imbedded sustainability as a policy approach calls for a well-structured maintenance regime that goes beyond curative "quick fixes" to empowering local community service providers with a technical preventive maintenance support model by the county government and less dependent on external agencies such as NGOs. This calls for local governments such as Turkana county government to review their water sector financing strategy towards a system costing strategy which allocates fund for both capital infrastructure development, subsequent operations and maintenance as well as strengthening the enabling environment for sustainability of services. A financing strategy that is informed by identified and mitigated sources of revenue leakages, leverages on non-traditional funding sources such

as private capital and capitalizes on efficiency gains such as reducing physical and commercial water loses and professional management.

6.3 Recommendations

Based on the evidence from this study, the following recommendations are made to trigger changes in water management models that will lead to improved functionality of rural water facilities. The proposed recommended solutions revolve around the policy significance of the issue and seeks to establish a duty of care and imbedded sustainability in rural water supply systems.

Turkana county government, as the government responsible water and sanitation services delivery, to adopt a system-wide approval mechanism of new infrastructure development. The project sponsors, whether the government or non-state actors like NGOs, charities should work with the communities and local government support mechanisms to design ex-ante before construction, a system of how the facilities will be maintained after construction imbedded within clear institutional structures that can be held to account on the quality of services provided. Currently the practice is to budget for the capital infrastructure development without any clear mechanisms on how the life-cycle maintenance requirement of the system will be met.

County government of Turkana to adopt a professional service delivery model for the management of rural water schemes over the current "voluntary" community-based model. Two specific models are proposed. One is having county-owned commercial water service providers such as Lodwar Water and Sanitation company Ltd directly manage the rural water points while the local community water users form a consumer association with oversight of the operations of the company. Through this, the community will still be actively engaged in the management of the services as an oversight board while the company directly executes professionally as per regulatory indicators developed by WASREB the operations and maintenance. Secondly, pilot private sector interventions to improve the management, delivery, capacity and operations of service providers through a delegated management model where the county government water department or the commercial water company whose coverage area accompanies rural

water points, contract through a performance-based service contract, a private service provider to manage a single or multiple bundled water points.

Application of a more systematic water tariffs collection and management through automated systems such as pre-paid meters. In this model, the water service provider would issue a water access tokens to registered water users/household, load it with money say Ksh.100 then they access water from the nearest kiosk to his/her dwelling. Such a system promises to seal loopholes for funds leakages which will make more funds available for maintenance and repairs needed.

Regulation of water tariffs charged by service providers to rural households. Currently, the regulation of water tariffs only covers areas served by the commercially registered water companies such as Lodwar water. There is no system for determining the amounts rural households served with point water sources pay per volume of water consumed or fixed monthly charge. The county should enact regulations specifying how much the service providers should charge say per 20 liters of water.

Setting up a county-wide Water schemes maintenance fund to ensure there's enough funds for operations and maintenance of rural water systems. The funds would be pooled from an Operations and maintenance tax ("O & M Tax") out of each new capital infrastructure development. Every new development, whether done by the government or NGOs, would be required to set a percentage of the total capital cost of the project into the maintenance fund for the system's subsequent maintenance. This could be augmented by other funding sources such specific county budget appropriations for maintenance over and above the capital development funds. Social impact investors could also be mobilized to channel their resources into this common pool fund. The funds from this pool would then be disbursed linked to specific performance indicators to service providers who would first put in an application to the fund manager for maintenance support.

6.4 Suggestions for further research

This study's scope was limited to the more "technical" issues of maintenance and revenue management practices of rural service providers. While these are important, they only but a part of a larger context political economy and governance factors. Political factors

driving community quest for justice and economic drivers giving incentives and constraining different individual and collective actors do lay a large part in which management models are chosen and their outcomes. An area for further research proposed is an exploration of the governance processes and political economy factors driving the predominant practices in rural water services delivery how these affect the functionality of rural water schemes.

The author suggests research that will analyze empirical evidence collected through mixed qualitative and quantitative methods on how formal and informal institutional arrangements, stakeholder interactions including incentives and constraints they face, social constructs and cultural norms underpinned by diverse structures affect the management model choices and their effectiveneness on sustaining rural water services provision.

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APPENDICES

APPENDIX A: ETHICAL CLEARANCE FOR DATA COLLECTION

Strathmore UNIVERSITY

4th December 2018 SU-IERC0278/18

James Origa OTIENO
P.O BOX 30577--0100
Nairobi
Kenya

Email: james.otieno@strathmore.edu

Dear James,

REF **Student Number:** MPPM/96532/2016 **Protocol ID:** SU-IERC0278/18
Effectiveness of revenue management and maintenance practices of water service providers for sustainable rural water services provision: A case of Turkana County, Kenya.

We acknowledge receipt of your application documents to the Strathmore University Institutional Ethics Review Committee (SU-IERC) which includes:

1. Cover letter dated October 31 2018
2. Research Proposal dated October 2018
3. Data collection tools dated October 2018
4. Participant information sheet and informed consent form
5. CV

The committee has reviewed your application, and your study *"Effectiveness of revenue management and maintenance practices of water service providers for sustainable rural water services provision: A case of Turkana County, Kenya"* has been granted **approval.**

This approval is valid for one year beginning **4th December 2018** until **3rd December 2019.**

In case the study extends beyond one year, you are required to seek an extension of the Ethics approval prior to its expiry. You are required to submit any proposed changes to this proposal to SU-IERC for review and approval prior to implementation of any change.

SU-IERC should be notified when your study is complete.

Thank you

Sincerely,

Amina Salim
Regulatory Affairs Fellow

STRATHMORE UNIVERSITY INSTITUTIONAL ETHICS REVIEW COMMITTEE (SU-IERC)
04 DEC 2018
TEL: +254 (0)703 034 000
P. O. Box 59857 - 00200
NAIROBI - KENYA

APPENDIX B: DATA COLLECTION TOOLS

Household questionnaires

SECTION I: LOCATION

Sub County.....

Ward/Location.....

Village.....

SECTION II: DEMOGRAPHICS

1. Gender
    - Male
    - Female
2. Age Bracket
    - Less than 18years
    - 18-30years
    - 30-40years
    - 40-50years
    - More than 50years
3. What is the highest level of education attained?
    - Never went to school
    - Didn't complete primary School
    - Primary School
    - Didn't complete secondary School
    - Secondary School
    - Technical School
    - University

AFFORDABILITY AND WILLINGNESS TO PAY

4. Do you pay for water fetched from the source for domestic and livestock use?
    - o Yes
    - o No
5. If yes, how do you pay
    - o Pay as you fetch
    - o Fixed Monthly contribution
    - o Ad hoc payment; only when asked/needed.
    - o Other (Specify .....
6. How much do you pay on average?
    - o 20 litre containers
    - o For a Fixed Monthly contribution
    - o For an Ad hoc payment only when asked/needed
    - o Other (Specify .....

    b) How much do you pay for livestock?
    - o Camel
    - o Cattle
    - o Shoats
    - o Others (Specify).....
7. Do you find the water tariff/fees affordable?
    - o Yes
    - o No
8. If No, how much would you have wanted to pay for water?

    c) 20 litre container
    d) For a Fixed Monthly contribution
    e) For an Ad hoc payment only when asked/needed
    f) Camel
    g) Cattle
    h) Shoats
    i) Others (Specify).....
9. Are you willing to pay in future?
    - o No
    - o Yes- only per 20 litres
    - o Yes- only fixed monthly contribution
    - o Yes- only when asked in case of breakdown
    - o Yes- per bucket and in case of breakdown
    - o Other (Specify)
10. What happens if you cannot afford the price of water?
    - o Fetch from alternative unsafe water sources

- o Fetch on credit
- o Pay using livestock
- o Borrow from neighbours/friends
- o Other (Explain).....

MAINTENANCE AND FUCNTIONALITY

11. a) Is the water point currently functional?
- o Yes
- o No

b) If no, why is it not functional?
- o It has dried up
- o There's a breakdown
- o There's a conflict over the water point
- o Other (Specify)

12. What is the number of days the water point has been functional in the last 2 weeks (14 days)
- o 12-14 days
- o 8-11 days
- o 4-7 days
- o Less than 4 days

13. Has your water point experienced any breakdown in the last two weeks?
- o Yes
- o No

14. a) If yes, what caused the breakdown?
- o Broken pipes and taps
- o Fault in the pump
- o Faulty storage tank
- o No fuel
- o Lack of service
- o Any other reason .....

15. How long does it normally take to repair the facility in case of any breakdown?
- o Less than 3 days
- o 3 days
- o Less than a day
- o More than a week
- o More than a month
- o Don't know

16. During breakdown of the facility, are households asked to contribute towards the repair?
- o Yes
- o No

17. Who is involved in carrying out the repairs?
    - County government engineers/technicians
    - NGO's
    - Water Management committee members
    - Technician hired from town centres (Lodwar, Kakuma, etc.)
    - County water companies e.g. LOWASCO, WAJWASCO
    - Others, specify
18. In your opinion who should pay if the water facility breaks down?
    - Government because water is a gift
    - Water Management Committee because it is their responsibility
    - Water Service Provider/Company
    - Myself; because water is something we buy
    - NGOs
    - Any other, specify
19. In your opinion, are the funds collected from water use sufficient to cover the costs of operations and maintenance?
    - Yes
    - No
20. If No, what additional sources can support O & M?

FOCUSED GROUP DISCUSSIONS GUIDE FOR THE WATER MANAGEMENT COMMITTEES

Name of Community/water point:

.....

Date of Interview:

.....

Name of Interviewer.....

.....

1. What are the key responsibilities of the committee on issues relating to management of the water facilities?

.....

.....

Collection and management of revenue needed for the daily operations of the water facility

2. Do you collect any water use tariff from the water users?

(a) Yes (b) No

3. If no, how do you raise revenue needed for O & M?

4. If yes, how was the tariff decided?

(a) By the committee

(b) By the community and the committee

(c) By the committee and community representatives

(d)others (specify).....

5. Are people willing and able to pay the rate?

(a) Yes (b) No

If no, why?

.....

.....

6. What are the collected revenues used for?

Expenditure item	**Amount used (Ksh.)**
Buy fuel	
Buy spare parts (specify which ones)	
Pay operations staff (list different staff and how much they are paid)	
Annual maintenance	
Response to breakdown	
List all other expenses.....	

7. Is the revenue information/report(s) shared with the public for review and discussions?

(a) Yes (b) No

c) If yes, how is this information dispatched to the public?

.....

.....

8. Does the community make contributions to how the revenue should be spent?

(a) Yes (b) No

9. Are the revenues raised sufficient to cover all the costs/expenditures of O & M?

(a) Yes (b) No

10. If no, how do you fill in the gap of revenues needed for O & M?

.....

.....

Maintenance

11. How often do you carry out the various maintenance activities on the water facilities?

List Maintenance activity/type	daily	weekly	monthly	Quarterly	yearly	Other(specify)

12. How long does it take to respond to breakdown/failure?

.....

13. How do you access/ get spare parts supplies to maintain the water facility? Are there any challenges in accessing the spare parts?

.....

.....

14. What is the relationship between you and the following institutions on the management of water facilities:

Institution	**Form/Nature of collaboration/Association**		
	Technical support	**Financial support**	**Others (specify)**
County water department			
NGOs (name them)			
Contractors			

Local mechanics/plumbers			
Traditional elders/authority			
Politicians/MCA/MP etc.			
Others (specify)			

15. In general, what problems/challenges do you encounter in ensuring management of water facilities?

.....

.....

16. What measures do you suggest could be adopted to address these problems/challenges?

.....

.....

INTERVIEW GUIDE OF THE COUNTY GOVERNMENT OFFICIALS AND NGOs

Designation of Respondent: .....

Date of Interview: .....

Name of Interviewer.....

1. How is the County government/NGO involved in the daily operations and maintenance and mobilization of revenues needed for the maintenance of rural water facilities in the county?

   .....

   .....

2. Is the revenue collected by water management committees sufficient to cover the full costs of operations and maintenance.....

   .....?

3. If no to question 3, what role does the county government/NGO has in ensuring sufficiency of funds to cover operations and maintenance needs.....

4. Does the county government/NGO offer technical support and monitor the operations of the service providers managing the rural water points within the county? How is the support delivered/structured?.....

   .....

5. What other problems do you encounter in the operations and maintenance of rural water facilities in the county?

   .....

   .....

   .....

   .....

   .....

   .....

6. What measures do you suggest could be used to address the problems mentioned above?

   .....

   .....

   .....

   .....

   .....

   .....

7. Any further suggestions/comments