FACTORS INFLUENCING SUSTAINABILITY OF WATER SUPPLY PROJECTS FOR RURAL COMMUNITIES IN ARID AND SEMI ARID LANDS: A CASE OF GARBATULA SUB COUNTY IN ISIOLO COUNTY, KENYA

Emmanuel Steve Olela
Master of Arts in Project Planning and Management, University of Nairobi, Kenya

Dr. Luketero Wanyonyi
Senior Lecturer, School of Mathematics, University of Nairobi, Kenya

International Academic Journal of Information Sciences and Project Management (IAJISPM) | ISSN 2519-7711

Received: 24th November 2018

Accepted: 29th November 2018

Full Length Research

Available Online at:

http://www.iajournals.org/articles/iajispm_v3_i2_516_537.pdf

Citation: Olela, E. S. & Wanyonyi, L. (2018). Factors influencing sustainability of water supply projects for rural communities in arid and semi arid lands: A case of Garbatula Sub County in Isiolo County, Kenya. *International Academic Journal of Information Sciences and Project Management, 3*(2), 516-537

ABSTRACT

Access to water is key in promoting resilience and livelihoods in arid and semi-arid lands. Sustainable management of water supply projects would ensure water for drinking, domestic, livestock and other productive uses is enhanced to support inhabitant's livelihoods. The government and civil society organizations have implemented many projects worth millions of investments but still facing sustainability challenges over a period. The study objectives were to evaluate the choice of technology influence on sustainability, to determine the level at which socio-economic factors influence sustainability, to evaluate influence of socio cultural factors on sustainability, to identify influence of water tariffs on sustainability and finally to determine the influence of specialized training of service teams on sustainability of water supplies projects for rural communities in Arid and Semi-Arid Lands. The research was guided by four capital model theory. The research adopted a descriptive research methodology to collect quantitative and qualitative data from a sample size of 384 from a target population of 32, 226 served by 17 boreholes, focus group discussions with three water management committees and three key informants. Simple random sampling technique was used to select respondents who are water supplies projects beneficiaries. Data was collected using well-structured questionnaires, interview schedules and focus group discussion guides. The data was cleaned of errors, verified and coded. Using statistical package for social sciences (SPSS version 21), descriptive and inferential statistics was used to analyze quantitative data while qualitative data was analyzed thematically, and the findings presented. The study findings show that there is a positive relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio-cultural factors, water tariffs and specialized training of service teams. The significance values for relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills influence of magnitude 0.000, 0.004, 0.006, 0.000 and 0.001 with water tariffs and choice of technology being the most significant factors. Training, availability of spare parts and water abstraction technology were prerequisite towards sustainability resulting to reliable access to water dur to minimal breakdowns. There was lack of involvement and participation in water supply development process including tariff setting with household consumption a major factor to consider in tariff setting. Socio-cultural factors were found not to influence sustainability of water supply projects. Researcher recommends selection of appropriate technologies such as solar powered systems in place of generators to reduce costs of regular maintenance due to lack of trained technicians, Training of service team and water committees technical and management of water supply projects and advocacy for local entrepreneurs to become stockiest of spare parts required for existing systems. Finally, water supply projects conduct life cycle cost analysis to

help in setting tariffs able to raise operations and maintenance. Further study is recommended on factors influencing sustainability of water supply projects for rural communities in Arid and Semi-Arid lands.

Key Words: *sustainability, water supply projects, rural communities, arid and semi arid lands, Garbatula Sub County, Isiolo County, Kenya*

INTRODUCTION

Many initiatives have been made to reduce the gap of water scarcity by large investments in water supply infrastructure among other interventions in the water sector. Gains have been made in the water provision since the year 2015 where 91% of the world's population were able to access water from an improved source of drinking water compared to 76% in the year 1990 (UN, The Millennium Development Goals Report, 2015). Despite these gains, what can governments, public society organizations, the private sector players and the community do to reduce the chances of fall back? Are there systems in place to ensure sustainability of the investments already made?

Investments in the water sector has focused on economic value of time and cost savings through improved water systems which would enable people to use the saved time and costs in other productive activities which in turn boosts the chances of sustainably managing the systems. An improved water supply is defined as a system which provides water reliably, of potable quality, and of sufficient quantity to meet basic household needs like drinking, bathing, cooking, and washing around the house (Cook, 2017)

According to Abrams (2018) defines sustainability as "whether or not something continues to work over time". He further elaborated that it is the test of sustainability is whether water continues to be abstracted at the same rate and quality as when the supply system was designed, continue to function and be used as planned, and whether environmental quality continues to improve. In his writings, he identified key factors that influence sustainability including availability of money for recurring expenses and occasional repair, acceptance from users of the service, adequacy of service providers, appropriate design and quality of works.

The sustainability of the commissioned projects are enhanced by ensuring that only projects prioritized by the beneficiaries are implemented, building the capacity of the beneficiaries and enhancing project ownership. Project implementers ensure that a management and sustainable operations concept is established to ensure projects continues to meet the needs of the recipients over time. This is through key stakeholder's involvement from project preparation phase. (Irrigation, 2016)

Isiolo County is located in Kenya's lower eastern region is categorized as an ASAL region (ASALs). It is to the north of Marsabit County, west of Laikipia and Samburu Counties, south

east of Garissa County, North East of Wajir County and south of Kitui and Tana River Counties. The County is 25,605 square kilometers in size and a population of 143,294 according to the 2009 census. It is divided into ten wards all within 3 sub Counties including Isiolo, Garbatula and Merti and is broken down into six managerial divisions namely Central, Sericho, Garbatula, Merti, Oldonyiro and Kinna. Merti and Garbatula have a larger rural population and drier parts of the County.

STATEMENT OF THE PROBLEM

According to the Joint Monitoring Plan report by UNICEF and WHO, 2017, by 2015, out of three people living in the rural areas, only one is using safely managed drinking water services (1.9 billion). That means still many rural populations are still not getting safely managed water systems. It was also reported that 263 million persons spent more than 30 minutes per round trip to fetch water from an improved source in 2015 (constituting a limited drinking water service) (UNICEF, 2017). However, since water use generally needs a lot of infrastructural investment and management systems, tenure concerns not only access the rights to water, but the capability to set up water related technologies as well, and relationships with other users who shared certain water sources. According to Isiolo County National Drought Management Authority EWS Bulletins for the last 3 years, water sources have been boreholes, sand dams, rivers and shallow wells which have and still are faced with frequent breakdowns with common recommendation of repairs of the broken pumps, water storage tanks, hand pumps, generators etc. The most affected areas include Drought Reserve Boreholes in Garbatula and Merti sub Counties which serve livestock from other Isiolo and neighboring counties (NDMA, 2017). These challenges affect sustainability of water infrastructure which are key to livestock which is the economic backbone of the County. Funds received by Isiolo County Government from the National Government over the past three years have increased from Ksh. 21.4 billion in financial year 2013/14 to Ksh. 31.8 billion in financial year 2014/15, and KSh33.55 billion in financial year 2015/16 (Irrigation, 2016). In the draft Mid Term Plan for 2018-2022 for the water sector, a key lesson learnt included unsustainable water projects operating with a reliance on fuel due to high costs of power despite several projects in the rural area being developed with fuel powered systems (Devolution, 2018). From the County Water Points Database 2016, Garbatula Sub County had documented 14 known out of 38 known boreholes that are in major centers in the County are non-operational. This is only for boreholes recorded in the database excluding those that have not been document by the County government as at the time of the study. Drilling of new boreholes has continued with non-operational boreholes being abandoned or revived at high costs. The value for money in these investments is not realized when the WASH assets are not sustainable. It is therefore necessary to find a solution to ensure existing and new borehole projects are sustainable through appropriate planning, management, operations and maintenance.

PURPOSE OF THE STUDY

The main aim of this research is to investigate factors that influence the sustainability of projects that focus on water supply for rural communities in the ASAL in Kenya with emphasis in Garbatula Sub County of Isiolo County.

SPECIFIC OBJECTIVES OF THE STUDY

1. To evaluate influence of choice of technology on sustainability of water supply projects for rural communities in Garbatula Sub County,
2. To determine the level to which socio-economic factors affect sustainability of water supply projects for rural communities in Garbatula Sub County,
3. To evaluate the influence of socio-cultural factors on sustainability of water supply projects for rural communities in Garbatula Sub County.
4. To identify the influence of water tariffs on sustainability of water supply projects for rural communities in Garbatula Sub County.
5. To determine the influence of specialized training of service teams on sustainability of water supply projects for rural communities in Garbatula Sub County.

THEORETICAL FRAMEWORK

The research study was guided by four-capital model theory to explain the concept sustainability and the components to explore for an in-depth understanding. According to Paul Ekins, 2008, in their article of the four-capital model, explain that sustainable development according to the World Commission on Environment and Development (1987) as that, that meets the essentials of the present without necessarily compromising the future generations' capability to meet their needs. They elaborated this involved the socio-economic development that allows future generations to ability to ensure well-being. They expressed the four-capital model as a concept where assets provide continuity of goods and services that helps in human health (Ekins, Dresner, & Dahlström, 2008). Four capitals in their analysis explained the concept has gone beyond quantity of human labor with a shift of focus to quality, natural resources and environment, organization of labor which ensures economic process ad continuity of well-being.

According to Erik, 1997, the four-capital model is related to manufacturing, human, social and natural capital to the process of production and the generation of human welfare. Examples of the four capital models include manufacturing capital such as machines, tools, which are used to produce other goods and services, natural capital which include components of nature such as energy, water, timber directly or indirectly linked to the well-being of humans; Human capital which refers to the health, well-being and productive potential of an individual. This is the aspect of motivation and skills of an individual towards ensuring productive output on the responsibilities bestowed upon him or her. It is through this theory that wellbeing associated to

good health is linked to improved opportunities encouraging economic growth through a productive workforce.

Lastly is Social capital which explains the social networks that support associations, civic organization to address common problems are important towards ensuring a conducive environment that promote political stability, social justice among other social factors important towards ensuring sustainability of water supplies in this context (Ekins, Dresner, & Dahlström, 2008). Therefore, sustainability can be considered through the analysis of the four capital models which if put together creates an opportunity for sustainability of any development including water supplies systems.

EMPIRICAL REVIEW

According to Virjee and Gaskin (2004) paper presented in a conference for sustainability of energy, water and environment systems, "Sustainability is defined as that which meets the needs of the present without compromising the ability of future generations to their own" quoted from (WCED, 1987). Sustainability of water supply projects is influenced by environmental quality, financial management and institutional capacity. In developing countries there should be guiding principles to which these projects should be implemented to meet the user needs namely water should be managed as an economic good as well as a social good, women should play a key role in management of water and a holistic approached employed. The two stated that cost recovery is crucial for sustainability through user payments intended to meet costs of operations and maintenance" (Afgan, Bogdan, & Duic, 2004).

According to Ashley, Blackwood and Jowitt (2004) sustainability factors focus on economic, environmental, social and technical aspects. They further elaborated indicators for each factor where life cycle costs, willingness to pay, affordability and financial risk exposure were identified under economic factor; resource utilization, service provision, environmental impact were identified under environmental factors, impact on risks to human health, acceptability of stakeholders, participation ad responsibility, public awareness and social inclusion were identified under social factors and finally performance of the system, reliability, durability, flexibility and adaptability indicators were identified under technical factors (Ashley, Blackwood, & Jowitt, 2004).

A study in Tanzania identified that many latent and manifest conflicts over water. The availability of water during the dry season is diminishing, because of erosive land use-patterns, poor management, population increase, and the rising number of commercial and small-holder irrigation systems. Conflicts vary from possible legal disputes over incompatible desires from different of users, to issues relating to vandalism and even violence. These disagreements are seldom straightforward, but administration problems and disputes over water are mostly symptoms of uncertainties over 'ownership' of the water (Huggins, 2000)

From previous studies by researchers and scholars, there is still a gap in defining a practical standardized sustainability index to guarantee sustainability of water projects in rural semi-arid and arid regions that would guide donors, governments and the community themselves in implementing sustainable water projects. By practically implementing findings of these studies, governments and water sector stakeholders can confidently implement water projects putting in place measures to ensure these factors are in play to increase chances of continues water provision. Many scholars have done tremendous studies and research of the same to define sustainability using major factors that influence sustainability.

It is the mandate of both local communities and institutions to work on achieving sustainable development goal (SDG) 6.1.1 which is to ensure that the population consuming safely managed drinking water services. To realize this goal, we must identify what measures that need to be in place to not only improve safe water provision but ensure they are able to serve future generations. Sustainability has been loosely defined as the summation of man-made and natural resources remains constant for the predictable future, so that the well-being of future generations does not deteriorate (Tom Kuhlman, 2010). Sustainability in the context of water and sanitation has also been defined as the provision of services which continue to work overtime and endure changes for a long duration of time. In his book he also noted that sustainability requires one to consider non-technical aspects of technology, social implications, and constraints in the economy and environment (Abraham & Sheldon, 2006).

Looking at sustainability factors and possible indicators, Martin, 2012, in his study, categorized sustainability of water supplies into place, performance and persons. He defined place as the relationship between water supply management with its environment and cultural location. To further expound on this identified environment indicators such as water availability, water quality, changes in aquifer, water wastage and water pollution. He defined permanence as institutional aspects and planning ability to solve problems and local capacity to improve the management. Lastly, by personal involvement in management, accountability, community participation through meetings and public audience, sustainability can be achieved even in times of scarcity and unequal access to water. In his study, participation in this case was viewed in terms of attitudes and values that would motivate individuals to get involved in the overall management of a water system (Iribarnegaray & Seghezzo, 2012).

Governments and water sector stakeholders have worked hard in ensuring improvement in institutional capacities through policies and guiding frameworks for sustainable service delivery. There is need to move beyond infrastructure development to ensuring water service providers receive capacity building with a focus on governance, technical capacity and equipping with information. It has become a challenge financing rural water supply projects since these projects cannot recover costs, capital maintenance, cost of operations and maintenance yet they collect revenues from the sale of water. Rural schemes may require cost recovery in this line of thought. The government is usually called to fix broken parts or replace infrastructure without considering Life Cost Cycle approach (The World Bank, 2017).

According to Montgomery, Bartaram and Elimelech 2009, identified three factors to consider planning for sustainability of water projects which include effective societal demand, cost recovery, local financing and dynamic operation and maintenance. Effective community demand is achieved through participation and involvement in planning. However, this has faced challenges such as limited incentives, choice of technology and limited awareness. Local financing and cost recovery is linked to local borrowing and savings, community-based subsidies which is faced with lack of transparency and accountability. Dynamic operations and maintenance was identified to face challenges such as isolation of rural communities and unmotivated local technicians who are not well incentivized (Montgomery, 2009).

Sustainability factors have been looked in different perspectives with different scholars and researchers looking at different variables that would guarantee sustain water systems. According to Moriarty, 2013, community participation, ownership, willingness and ability to carry out operation and maintenance defines sustainability (Moriarty & Butterworth, 2013). However, he also highlighted that these factors come with assumptions to have a holistic thinking around sustainability including willingness for communities to manage the technical systems which according to Harvey and Reed, 2006, found to be cultural ideologies of rural communities.

According to MacDonald, Alan; Davies, Jeffrey; Calow, Roger; Chilton, John (2005) research on development of ground water, indicate that the expenses of new water projects seem to rise in with relation to the cost of construction per unit of water supplied. This increase is as a result of the increasing remoteness of sources where the water is being tapped, and the need for a more complex supply system. Therefore, it may prove to be more effective in terms of the expenses in the thereafter to invest in training and policy measures which would create more efficient and equitable water distribution. ASAL with minimal chances for underground exploitation, thereby necessitating a mixture of surface water systems such as earth dams, protected water pans, sub-surface dams, sand dams and rainwater harvesting structures. These may not be expensive even though the remoteness of some areas leads to high transport costs for materials. Arid areas also require a comprehensive strategic planning of water resource development since the effects of water availability on the nomadic movements and settlements (MacDonald, Davies, Calow, & Chilton, 2005).

RESEARCH METHODOLOGY

Research Design

Research design technique provides a framework through which the researcher gathers and presents data. This study employed a descriptive research methodology. According to Mugenda, 2003, descriptive survey design focuses objectives formulation, data collection tools design, data collection, data processing, analysis and reporting of findings. A descriptive survey involves issuing out the questionnaires in person, via mail and telephone. This research design method was used because the method provides an opportunity to obtain in depth information from quite a

large sample of respondents. By employing this research design, both quantitative and qualitative data was collected from a section of the community members at household level, members of water management committees and key informants from Sub County Water officer and Ward Administrator.

Target Population

This research was conducted in Garbatula Sub County in Isiolo County with a population of 43,118 (KNBS, 2010) with a 2018 population projection of 13,401. The study focused on the three wards within the sub county namely Kinna, Garbatula and Sericho. The Sub County has 17 main boreholes that have been reliably serving a population estimated 32,226. 10 operate on diesel generators that experience frequent breakdowns because of poor servicing and replacement of parts and use of dirty fuel. The 17 boreholes are the main water sources for the settlements (centers) in Garbatula Sub County. It's from this population that a representative sample was drawn and administered questionnaires. These boreholes operate under community management.

Sample Size and Sampling Technique

The methodology for determining the sample size of the study borrows from previous studies, published formulas and census for small populations. According to Mugenda and Mugenda 2003, a quality research must be characterized by affordability in terms of finances, time sensitive and enough human resource. Sample sizes should not be too large or too small to be within the confidence levels of a study outcome. The sample size for the study therefore was calculated using Fishers formula given by:

$$n = \frac{pqZ^2}{d^2}$$

Where: n = the desired sample size (if the target population is greater than 10000); Z = the standard normal deviation at the required confidence interval; p = Proportion in the target population with characteristics being used and q=1-p; d = the level of statistical significance set.

According to Mugenda and Mugenda, 2003, fifty percent of the estimate number of the target population presumed to have characteristics of interest is not given. If the p is not known in advance 50% should be used.

P=0.5, q=1-p=1-0.5=0.5, d=5%

Z=1.96 at 95% confidence interval, $n=1.96^2 x 0.5 x 0.5/0.05^2=384$

The water projects serve a population of 32,226

A sample of 384 was required for this study. Using convenience sampling, conducted one focus groups discussion of 8 participants each was conducted. Key informants included Sub County Water Officer and Kinna Ward administrators were interviewed. The study was employ simple random sampling technique to identify 344 respondents.

Research Instruments

In this study, the instruments of research that was be used to collect include questionnaires and interview schedules to collect primary data. The questionnaire and key informant interview guides was used for households, Focused group discussions and specific informant interviews. The key informants were Kinna Ward administrator and Garbatula Sub County Officers. The questionnaire comprised of sections consisting of questions on demographic characteristics, choice of technology, socio economic factors, socio cultural factors, tariff and specialized training.

Data Collection Procedures

Researcher seeked for a permission to conduct research following receipt of introductory letter. The researcher employed three research assistants who was be trained on the data collection procedures, communication skills and ethical considerations. The research assistants were engaged in the study for 13 days due to challenges with access roads. Garbatula town was set as the meeting place and collection point for all questionnaires.

Data Analysis Techniques

Upon completion of data collection, questionnaires were checked for errors and data was be entered in Statistical Package for Social Scientists (SPSS V.21) software for it to be cleaned. After cleaning, data was coded where responses were put in categories and numbers to allow for analysis. Qualitative and quantitative techniques of data analysis from SPSS V.21 software was used and presented in percentages, means, frequencies and standard deviations. During analysis both descriptive and inferential statistics which included frequency tables and cross tabulation was be executed. The software was used because of its flexibility and most commonly used.

RESEARCH RESULTS

Choice of technology influence on sustainability of water supply projects for rural communities Garbatula Sub County

The first objective of the study was to evaluate the choice of technology influence on sustainability of water supply project for rural communities in Arid and Semi-Arid Lands in Garbatula Sub County. This was investigated with a focus on the type of technology, participation in technology selection, frequency of breakdowns, duration of repairs and

maintenance, availability of skilled technicians and availability of funds for operations and maintenance. The study revealed that the main technology for water abstraction is powered through generators followed secondly by solar powered technologies in Garbatula Sub County. Ninety four percent of the water supply projects beneficiaries do not take part in the selection of the technologies used with an explanation that it is the County Government and development organization who implement the projects chose the technologies. It also revealed that majority of the community, 76.4% of respondents did not have knowledge on issues to consider when selecting technologies. It was reported majority of the breakdowns are caused by leaking/busted pipes followed by generator mechanical issues. Findings established that it took longer for repairs to be done due to the fact that there were lack of spares parts shops and untrained local technicians. This was supported by explanation that the beneficiaries would source for skilled trained technicians from outside the area/ward or sub county. It was also important to note that responsibility of the repairs and maintenance was done by water management committee where as in some instances 23.5% respondents reported it was the County Government addressed repairs of breakdowns. The above findings are in line with observations made by Reed, 2004, that adopted technologies must have available spare parts to aid in replacements and lack of available spare parts in the rural societies resulted to lack of capability to sustain water systems. He also observed that pipeline dug over long kilometers faced challenges with detection thus dalayed response further leading to loss of revenues through loss of water in turn unsustained systems. Findings from studies conducted by Adaka, 2017 and Mamburi ,2014, in Isiolo County, reiterates that breakdowns are due to poor operations and maintence espcially on the generator powered systems which require regular oil change as was reported by key information (Sub County water officer).

Socio-economic factors influence on sustainability of water supply projects for rural communities in Garbatula Sub County

Findings indicate that majority of respondents pay for water while also consuming 80 litres of water for domestic use. There appears to be high demand for water given majority would still want more than 100 litres. Over eighty percent pay for water while the rest do not make any form of payment. The reasons behind nonpayment was because water was free at the kiosk, water is available through surface rivers and sixteen mentioned the price of water is too high. 6.6% (n=12) respondents reported poor management and longer repairing period as demotivating factor towards payment for water. Majority of respondents pay water an average of ksh. 400 per month while a significant few pay per 10 litre jerrycan. There is willingness from the respondents to pay more should there be good water services. It was found respondents in the study area rely mainly on sale of livestock as their major source of income. The relationship between demand and supply is important for sustainability in aspect of spending involved during demand which would help generate revenues in turn ensuring availability of funds for maintenance (Nketiah-Amponsah, Aidam, & Senadza, 2009), from the findings there was no

significant relationship between water demand as respondents not willingness to pay for water still consumed 80 litres and would still want more water.

Socio-cultural factors influence on sustainability of water supply projects for rural communities in Garbatula Sub County

The was no significant relationship between cultural factors and sustainability of water supply projects for rural communities in ASAL. However, it is important to note that men still were regarded as important decision makers in water supply projects despite women involvement. The study found there no positive or negative cultural practices that respondents were aware or not aware that could be sufficiently and directly linked to sustainability of water supply projects. It was noted that selection of water management committee members was based on tribe and clan which could have a negative connotation as reported by six percent of the respondents. Other findings involved beliefs that water should not be for sale attributed by 4.7% of the respondents. It could also be noted that protection of available water sources was key as a social practice as reported by 15.3% of the respondents. The findings echoed observations by Beneye (2012) that women participation was still low in the development of water supply projects where important decisions are made.

Water tariffs influence on sustainability of water supply projects for rural communities in Garbatula Sub County

The study found out that over 80 percent of the respondents do not take part in tariff setting despite reporting it's the responsibility of the community together with the water management committee to set the tariffs. Majority indicated community income as major factor to consider in tariff setting followed by repairs and maintenance. On average respondents pay Ksh. 1 per 10 litre jerrycan, between Ksh. 2 – Ksh. 5 per 20 litre jerrycan and average of Ksh. 510 per month for metered connection while flat rate at Ksh. 400 per month. Forty four percent of respondents agreed current tariff was sufficient, however the rest reported it was not enough for repairs and maintenance due to non-consistent payments and poor management. 187 respondents were found to be willingness to pay more water if the services were improved with regards to access, safety and reliability. The rest of the respondents indicated not willingness to pay more even if there were any improvements in the water supply services. The findings are in line with Huggins, 2000, observation that people might not be represented during water tariff setting which may lead to prices being too high for the poor. He noted there is need to raise awareness and encouraging everyone to pay for water and giving the choice of accepting small amount of water to every individual at subsidized rate which could ensure income that could be used to sustain water supply systems (Huggins, 2000). He also observed water tariffs need to project on the cost of the water supply system, as well as allow for repairs and the development of new amenities when the areas experienced increased demands by the population. The findings also concur with

findings from a study conducted in Kitui by Mwangangi, 2016, that willingness to pay and tariff setting needs to consider financial capacity of communities. (Mwangangi P. M., 2016).

Specialized training of service teams influence on sustainability of water supply projects for rural communities in Garbatula Sub County

The study established many beneficiaries have not undergone specialized training. This could be linked to the fact that repairs are majorly done by untrained local technicians. However, it is important to note that only 9.1% (n=43) of respondents have undergone training with some undergoing training on water treatment and operations and maintenance. Respondents could also attribute importance of training to learning about causes of diarrhea, water treatment and hygiene. Majority of the respondents agreed that rural water supply sustainability depends on two main factors such as book keeping (4.81) and customer involvement (4.53). It was important to note that tariffs and feedback mechanism and reporting is not of great value and applicability to the community. During Key informants' interviews, it was reported the members of the committees which form part of the operations and maintenance (service teams) have been trained but mainly on general good water management practices that include basic plumbing works and book and record keeping methods. The service teams do not have adequate training and equipment's. The key informants reaffirmed that the training is quite important as it enhances smooth operations of the water systems. It was also reported by key informant that the remuneration of the technicians, plumbers is a challenge when committees don't manage funds well thus may shy from offering services. According to a study in Woreda in Ethiopia, 2012, there was found to be a relationship between training and functionality of water systems that would have some influence on their sustainability (Beyene, 2012). This finding supports findings of delayed response to repairs by untrained local technicians. Due to weak managerial skills of water management committees as observed by Bhandari and Grant, 2007, they recommended institutional strengthening through capacity building (education) on holistic water management systems to ensure sustainability.

INFERANTIAL STATISTICS

The researcher used a linear regression model to establish the level of significance of the relationship between the independent variables; choice of technology, socio-economic factors, socio-cultural factors, water tariff and specialized training and the dependent variable which was sustainability of water supply projects for rural communities in Garbatula Sub County. The researcher used Statistical Package for Social Sciences (SPSS) to enter, clean, code and compute the measurements of the linear regression.

To study the effect of choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills on sustainability of water

supply projects, a multiple regression analysis was carried out. The results are represented as shown below;

Table 1: Model summary

Model	R	R square	Adjusted R square	Std. error of the estimate
1	.998[a]	0.995	0.995	0.047320175782655

a. predictors: (constant), specialized training on technical knowledge and skills, choice of technology, socio-economic factors, water tariffs, socio cultural factors

The study results in Table 1 show the model summary and overall fitting statistics. Both the adjusted R^2 and R^2 of the model is 0.995. This means that the regression explains 99.5% of the variation in the data.

Table 2: Analysis of Variance (ANOVA)

Model		Sum of Squares	df	Mean Square	F	P-value
1	Regression	11.827	5	2.365	1056.331	.000[b]
	Residual	0.054	302	0.002		
	Total	11.880	307			

a. Dependent Variable: Sustainability of water supply projects

b. Predictors: (Constant), Specialized training on technical knowledge and skills, Choice of technology, Socio-economic factors, Water tariffs, Socio cultural factors

The study findings in Table 2 shows the analysis of variance which has the null hypothesis that there is no linear relationship between the variables in the regression model, that is, $R^2 = 0$. Since p-value<0.05, the level of significance, we conclude that there is a linear relationship between the dependent variable (sustainability of water supply projects) and the predictor variables (specialized training on technical knowledge and skills, choice of technology, socio-economic factors, water tariffs, socio cultural factors).

Table 3: Regression results

Model		Unstandardized Coefficients		t	P-value
		B	Std. Error		
1	(Constant)	0.839	0.072	0.541	0.004
	Choice of technology	0.041	0.021	0.053	0.008
	Socio-economic factors	0.023	0.022	1.044	0.017
	Socio cultural factors	0.339	0.145	2.342	0.028
	Water tariffs	1.209	0.019	51.903	0.000
	Specialized training on technical knowledge and skills	0.331	0.149	2.220	0.036

a. Dependent Variable: Sustainability of water supply projects

The study findings in Table 3 give the regression coefficients, the constant and the significance of all the coefficients and the constant of the model. We establish that our linear regression analysis estimates the linear regression model to be:

Sustainability of water supply projects = 0.839+0.041choice of technology+0.023socio-economic factors+0.339socio cultural factors+1.209water tariffs+0.331specialized training on technical knowledge and skills. The above model indicates that there is a positive relationship between the predictor variables and the dependent variables. This implies that a unit change in the predictor variables there a positive change in the sustainability of water supply projects by the coefficients of the predictor variables. In our linear regression analysis, the test, tests the null hypothesis that the coefficients are all 0. The t-test finds that both intercept and variables are significant ($p < 0.05$) and thus we might say that they are different from zero.

To quantify the strength of the relationship between the variables, we used Karl Pearson's coefficient of correlation. The Pearson correlation coefficient is a measure of the strength of a linear association between two variables and is denoted by *r*. The Pearson correlation coefficient, *r*, takes a range of values from +1 to -1. A value of 0 indicates that there is no association between the two variables. A value greater than 0 indicates a positive association, that is, as the value of one variable increases so does the value of the other variable. A value less than 0 indicates a negative association, that is, as the value of one variable increases the value of the other variable decreases.

The study findings indicated that there is a positive relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills influence of magnitude 0.677, 0.541, 0.309, 0.997 and 0.316, respectively. The positive relationship indicates that there is a correlation between the factors influencing sustainability and sustainability of water supply projects with water tariffs having the highest value and specialized training on technical knowledge and skills having the lowest correlation value. The study findings further indicate that, all the factors had a significant p-value ($p<0.05$) at 95% confidence level. The significance values for relationship between sustainability of water supply projects and choice of technology, socio-economic factors, socio cultural factors, water tariffs and specialized training on technical knowledge and skills influence of magnitude 0.000, 0.004, 0.006, 0.000 and 0.001, respectively. This implies that water tariffs and choice of technology were the most significant factor, followed by specialized training on technical knowledge and skills, socio-economic factors and socio-cultural factors, respectively.

KEY INFORMANTS ON THE WATER MANAGEMENT COMMITTEES

From the key informants' perspectives, there are only three active members including chairman and two other members. Furthermore, the gender composition of the committee includes five males and four females. It was further indicated by the key informants that committee

contributes in monitoring of water rationing patterns and then convene meetings for contribution towards the water supplies in the area. In addition, it was indicated that the general community assist in the management of water supply through occasional meetings with the county office that collect fuel and distribute to water points.

On the training of the committee, the key informants indicated that the members of the committees have been trained but mainly on general good water management practices that include basic plumbing works and book and record keeping methods. The key informants reaffirmed that the training is quite important as it enhances smooth operations of the water systems.

It was indicated that the committee charges for water supply but occasionally. This is because the existing committee is weak and whenever the committee runs out of money to operate, the members call for contributions from the community to enable it to meet its financial obligations. The water tariffs are collected on monthly basis though the less fortunate groups are exempted from paying for water. Furthermore, it was indicated that the money collected from the fees and or tariffs is used for paying the watchmen and those tasked with the maintenance of the water systems.

It was indicated by the key informants that the revenue collected is not enough to do major repairs and replacement on the water systems. They argued that the payments are made through contributions and so there is no systematic revenue collection method in place. In addition, the committee only collects money for basic repairs such as pipe bursts and replacement while the county does major services such as generator servicing. On the technology used in water abstraction and availability of spare parts for the water supply projects' equipment, the key informants indicated that the solar and generator power work well if properly managed since most spare parts are not locally available. Nonetheless, with the solar power, the community would be spared on spending on fuel.

It was indicated by the key informants that the main problem facing water management committee is the conflict among the committee members and the use of politics when it comes to the management of the water points. On the other hand, the main problem facing communities in the area with regards to water, payment and involvement in the management to ensure sustainability is the unwillingness to pay for the water as they believe that water should be free. Furthermore, since there are alternative sources like a nearby spring, they don't want to pay for water. However, whenever an issue arises, meetings are called to solve.

It was also indicated that there are no feedback mechanisms for the communities to raise concerns on water issues and they only communicate to the area MCA or discuss among the committee to solve the issues whenever they arise. The key informants' contribution to the water supplies in the area is through proposal writing for support for additional boreholes and also doing basic repairs and maintenance.

CONCLUSIONS

Water plays a significant role in the daily lives of every individuals. It is the most important basic need of life and no living organism can do without. Thus, it can be regarded as the basic unit needed in life. It's uses range from drinking, cooking and washing. This explains the importance of the resource and hence the need for its sustainability especially in ASAL areas of Kenya where the main economic activity is nomadic cattle rearing.

The study has revealed that most of the residents of Garbatula Sub County of Isiolo County lack formal education. This can be attributed to the nomadic nature of the residents in search of pasture for their livestock. The study further revealed that community members constitute the biggest proportion of water management committee. It can be deduced that this is due to encouragement of local involvement of the local residents in the management of the water supply in the region so that they are involved in the water sustainability programmes. It can also be deduced that most of the residents are conversant with water supply projects in the area. The research has also established that the main source of drinking water is borehole of which most of them are functional. However, the other water sources that are non-functional arise from mechanical issues originating from the generator.

The study has established the main technology used water abstraction is the use of powered generators followed by solar powered technology. However, the residents indicated that they do not take part in the selection of the technology used in water abstraction. In addition, it is the water stakeholders that are involved in management and running of the operation of the rural community-based water projects. It has also been revealed that most of the residents didn't know about the choice of technology used in water and therefore didn't know about the issues to consider when selecting a technology. In addition, the findings indicate that the residents' respondents had their water supply broken leading to water interruption. The breakage in water supply is mainly caused by busted/leaking pipes. The findings also show that when such breakage occur in the water supply, it takes considerably longer time before they are repaired. The respondents cited various reasons as to which it takes long for the broken supply system to be repaired. The most common reason is lack of spare parts and lack of specialized technician.

The study has revealed that untrained local technicians are the ones who repair or replace the parts of the water supply system during breakdowns with little responsibility from indicated that ministry of water, energy, environment and natural resources. Furthermore, the study has shown that the repairs and replacement of the broken water systems are paid by water management committee with revenues collected. However, the biggest impediment to repairs and replacement is the lack of shops within the area that stock spare parts for water supplies systems in the area. This is could be the reason as to why the repairs and or replacement take too long to be affected as earlier reported in the study. In addition, the residents believe that the revenue raised from the water supply is enough to sustain system repairs and replacement. However, it was also found

that in some instances, the residents' highlighted misuse of revenues collected thus unwillingness to pay.

On the socio-economic factors affecting water sustainability, the study has established that the demand of water is high and most of the residents use the water points more due to the demand for extra water to meet their needs. The residents do pay for the water they use which is mostly done on a monthly basis in which the payment is consistent and or regular. The study has also revealed that the residents are willingness to pay for water by other consumers if there are good water provision services as well as reliability. It has been established that the chief source of income in the area is proceeds from the sales of livestock. This explains the main economic activity in the area.

The study has revealed that residents have never taken part in the processes of development of the water project. This means that the residents have little say in the development process of water projects and supply in the area. Furthermore, during the project development the residents have never had any form of participation. It is important to note that during the decision making about water in the community, both men and women are equally involved as reported. The study has also revealed that the residents are not ware or simply don't know of existence of traditions that positively influence management of water supply. However, it is established that protection of available water sources is a tradition that can positively influence management of water supply. The findings suggest that community members are simply not aware of practices that can improve water supply and sustainability. Thus, there is need for creating awareness on good practices that can positively sustain water supply in the area. On the other hand, the study has established that the residents believe that selection of committee based on tribe and clan negatively influence the water supply management.

The study reveals that the residents have never heard of life cycle cost analysis and hence have never participated in tariff setting process since it is set mainly by the water management committee. Further to this, the study has established that community income should be major factor to be considered when setting water tariffs. On average, the community members pay Ksh 510 as water tariffs per month. It is clear from the study findings that majority of the community members have not received any specialized training on water management. However, the few residents that have received specialized training, were mainly on water treatment and operations and maintenance.

RECOMMENDATIONS

Water supply sustainability is a critical project that ensures that there is continuity in supply of water. Various actors need therefore to come together to develop a proper policy aimed at efficient operations of water supply. In view of this, the recommendations below are made:

1. The training of residents on water sustainability and maintenance of water sources should be reinforced. As per the study findings, most of the residents have no formal education. This implies that the professionals are needed to help the community learn essentials of water source maintenance. Furthermore, training may never be conducive for the residents due to lack of formal education. It is thus recommended that the policy makers should come up with a friendly water sustainability and maintenance curriculum and affordable fees to encourage adequate training of the residents.
2. With the establishment that the biggest challenges facing water supply projects is frequent breakdown such as pipe bursts and generator with longer down times, there is need to promote alternative systems such as solar systems, training of local technicians on both current technologies that are easy to operate and maintain.
3. It is also recommended for government to promote spare parts stockiest or private sector engage on Private Public Partnerships models that may involve provision of spare parts among other services to reduce on mechanical or technical challenges that could be faced by service teams or management committees.
4. County government to conduct life cycle cost analysis to help in setting realistic tariffs from which revenues can be collected would help raise money for major or expensive parts. This would help in awareness raising link between cost of establishing a water infrastructure and cost of both minor and major replacements.

REFERENCES

Abebe Tadesse, T. B. (2013). Rural Water Supply Management and Sustainability: The Case of Adama Area, Ethiopia. *Journal of Water Resource and Protection*, 217-219.

Abraham, M. A., & Sheldon, R. (2006). Sustainability Science and Engineering. Amsterdam: Elservier B.V.

Abrams, L. (2018, 1 Accessed 10). *Sustainability: Understanding Sustainability of local water services*. Retrieved from African Water: http://africanwater.org/sustainability.htm

Adaka, V. (2017, March 2018 Accessed 10). *University of Nairobi Research Archive.* Retrieved from University of Nairobi: http://erepository.uonbi.ac.ke/handle/11295/101852

Afgan, N., Bogdan, Z., & Duic, N. (2004). Sustainable Development of Energy, Water and Environment Systems. *Proceeding of the Conference on Sustainable Energy, Water and Environment Systems, 2-7 June 2002 Dubrovic, Croatia* (pp. 57-58). Lisse: A.A Balkema.

Arsano, Y. (2007, March Accessed 28). Ethiopia and the Nile; Dilemmas of National and Regional Hydropolitics. Zurich, Switzerland.

Ashley, R., Blackwood, D., & Jowitt, D. B. (2004). *Sustainable Water Services: A procedural guide.* London: IWA Publishing.

Barbara Rose Johnson, L. H. (2012). *Water, Culture Diveristy and Global Enviromental diversit and environmental change; Emerging Trends, Sustainable Futures?* Paris: UNESCO.

Behailu, B. M., Pietila, P. E., & Katko, T. S. (2016, April Accessed 4). *Indigenous Practices of Water Management for Sustainable Services: Case of Borana and Konso,*

Ethiopia. Retrieved from Sage Journals: http://journals.sagepub.com/doi/pdf/10.1177/2158244016682292

Beyene, H. A. (2012). *Factors Affecting the Sustainability of Rural Water Supply Systems: The Case of Mecha Woreda, Amhara Region, Ethiopia.* New York: Cornell University.

Bhandari, B., & Grant, M. (2007). User satisfaction and sustainability of drinking water schemes in rural communities of Nepal. *Sustainability: Science, Practice and Policy*, 19.

Bredero, F. B. (20003). *Linking technology choice with operation and maintenance in the context of community water supply and sanitation.* Geneva, Switzerland: World Health Organization Publications.

Carter, R. C. (1999). Impact and Sustainability of Community Water Supply and Sanitation programmes in Developing Countries. *Journal of the Chartered Institution of Water and Environmental Management, Vol 13*, 292-296.

Chowns, E. (2015). Is Community management an efficient and effective model for public service delivery? Lessons learnt from the rural water supply sector in Malawi. *Public Administration and development*, 262-276.

Cook, J. &. (2017, Dec Accessed 12). *Environment for Development: The Costs of Coping with Poor Water Supply in Rural Kenya.* Retrieved from Environment for Development Initiative: http://www.efdinitiative.org/sites/default/files/publications/efd-dp-15-09.pdf

County, I. (2018). *Isiolo County Intergrated Development Plan, CIDP 2018-2022.* Isiolo: Isiolo County Government.

Devolution, K. V. (2018, January accessed 26). *THE THIRD MEDIUM TERM PLAN (2018 - 2022) FOR VISION 2030.* Retrieved from MTP: http://www.mtp3.go.ke/portal/data/apis/uploads/site/downloads/CONCEPT%20NOTE%20MTP3.pdf

Ekins, P., Dresner, S., & Dahlström, K. (2008, April 2018 Accessed 4). *The four-capital method of sustainable.* Retrieved from Research gate: https://www.researchgate.net/publication/227682358

Fielmua, N. (2011). The Role of the Community Ownership and Management Strategy towards Sustainable access to Water in Ghana (A Case of District). *Journal of Sustainable Development Vol 4, No. 3*, 179.

Homann, S. (2005). *Indegenous Knowledge of Borana pastoralists in natural resources mnagement: A case study from southern ethiopia.* Germany: Cuvillier Verlag Gottingen.

Howard, G. (2003). Domestic Water Quantity, Service Level and Health. *WHO/SDE/WSH/03.02*, 1-22.

Huggins, C. (2000). *Rural Water Tenure in East Africa, A comparative Study of Legal Regimes and Community Responses to Changing Tenure Patterns in Tanzania and Kenya.* Nairobi: Waterfund.

Iribarnegaray, M. A., & Seghezzo, L. (2012). Governance, Sustainability and Dimenstion Making in Water and Sanitation Management Systems. *Sustainability: ISSN 201-1050*, 2931-2936.

Irrigation, M. o. (2016). *Annual Water Sector Review 2014/15 - 2015/16.* Nairobi: Ministry of Water and Irrigation.

John Scanlon, A. C. (2006). *Water as a Human Right.* Gland, Switzerland and Cambridge: IUCN, Gland.

Kithinji, F. K. (2015, April 2018 Accessed 15). *Factors influencing households access to drinking: The case of communities in Imenti South, Kenya.* Retrieved from Look for URL

Kithoka, K. B. (2014, April Accessed 10th). *erepository.* Retrieved from Universirty of Nairobi: http://erepository.uonbi.ac.kexmlui/bitstream/handle/11295/73606/kivuva

KNBS. (2010). *The 2009 Kenya Population and Housing: Volume 1C, Population Distribution by Age, Sex and Administrative Units.* Nairobi: Kenya National Bureau od Statistics.

Koskei et al, E. C. (2013). Effects of Socio-economic factors on access to improved water sources and basic sanitation in Bomet Municiplaity, Kenya. *Research Journal of Environmental and Earth Sciences 5(12)*, 714-719. Retrieved from Find URL

Kwena, R. (2015). Determinants of Sustainability of Rural Water Projects in Kenya: A case study of Netherrlands Development Organization (SNV) supported water schemes in Kajiado County. *The strategic Journal of Business and Change Management: ISSN: 2312-9492, Vol 2, Issue 2, (124)*, 2072.

Law, K. (2018, January accessed 26). *Laws of Kenya: Constitution of Kenya, 2010*. Retrieved from Kenya Law: http://www.kenyalaw.org/lex/actview.xql?actid=Const2010

MacDonald, A., Davies, J., Calow, R., & Chilton, J. (2005). Developing groundwater: a guide for rural water supply. In A. MacDonald, J. Davies, R. Calow, & J. Chilton. Rugby, UK: ITDG Publishing.

Mahonge, C. (2013). Factors behind sustainability of activities in the post-project period in Matengo highlands in Tanzania. *Journal of Environmental Sustainability Vol. 3, Iss. 3, Article 5*, 92.

Mamburi, P. N. (2018, March Accessed 10). *University of Nairobi Research Archive.* Retrieved from erepository University of Nairobi: http://erepository.uonbi.ac.ke/handle/11295/74022

Mati, B. M. (2005). *Workig paper: Assesing water availability in Pastoral livestock systems in drought prone Isiolo District, Kenya.* Colombo: International Water Management Institute.

Mihelcic, J. R. (2007). Adapting Life-Cycle Thinking Tools to Evaluate Project Sustainability in International Water and Sanitation Development Work. *Environmental Engineering Science, Vol. 24, Number 7*, 937 - 941.

Montgomery, e. a. (2009). Perspective: Increasing Functional Sustainability of Water and Sanitation Supplies in Rural Sub-Saharan Africa. *Environmental Engineering Science, Vol. 26, Number 5*, 1018-1019.

Moriarty, P. S., & Butterworth, J. a. (2013). Trends in rural water supply: Towards a service delivery approach. *Water Alternatives Volume 6, Issue 3*, 331.

Mwangangi, P. M. (2016). Analysis of factors affecting sustainability of community borehole water projects in Kyuso, Kitui County, Kenya. *International Journal of Economics, Commerce and Management, Vol. IV, Issue 10, October*, 958-971.

Mwangangi, P. M., & Wanyoike, D. M. (2016). Analysis of factors affecting sustainability of community borehole water projects in Kyuso in Kitui County. *International Journal of Economics, Commerce and Management*, 966-968.

Mwangangi, P., & Wanyoike, D. (2010). Analysis of factors affecting sustainability of community borehole water projects in Kyuso, Kitui County. *International Journal of Economics, Commerce and Management, ISSN 2348 0386, Vol. IV, Issue 10*, 966-967.

Nakagami, K., Setiawan, J. K., & Indra, B. (2016). *Sustainable Water Management: New Perspectives, Designs and Practices.* Singapore: Springer.

Nations, U. (2018, August 25). *Sustainable Development Goals: Knowledge Platform*. Retrieved from Sustainable Development Goal 6: Ensure availability and sustainable management of water and sanitation for all: https://sustainabledevelopment.un.org/sdg6

Ndaw, M. F. (2015). *Unlocking the potential of Information Communications Technology to Improve Water and Sanitation Services.* World Bank Group & WSP.

NDMA, N. D. (2017). *Isiolo County Bulletine December 2017.* Isiolo: NDMA.

Nketiah-Amponsah, E., Aidam, P. W., & Senadza, B. (2009, April Accessed 10). *Socio-economic Determinants of Sources of Drinking Water: Some Insight from Ghana.* Retrieved from Check URL

Oino, P. G., Towett, G., & Luvega, K. K. (2015). The dilemma in sustainability of community based projects in Kenya. *Global journal of advanced research*, 762 - 763.

Paul Hutchings, R. F. (2017). Community Management of Rural Water Supply: Case Studies of Success from India. New York: Taylor & Francis.

Reed, P. H. (2004). Rural Water Supply in Africa: Building Blocks for Handpump Sustainability. Leicestershire: WEDC Loughbothough University.

Svinicki, M. D. (2010). *A Guidebook On Conceptual Frameworks For Research In Engineering Education.* Retrieved from Centre for Research on Learning and teaching in Engineering: https://crlte.engin.umich.edu/wp-content/uploads/sites/7/2013/06/Svinicki-Conceptual-Frameworks.pdf

The World Bank. (2010). *Water and Development: An Evaluation of World Bank Support, 1997-2007.* Washington D.C: The International Bank for Reconstruction and Development/The World Bank.

The World Bank. (2017). *Global Water Practice: Sustainability Assessment of Rural Water Service Delivery Models, Findings of a Multi-Country Review.* 1818 H Street NW, Washing DC: The World Bank.

Tom Kuhlman, J. F. (2010). What is sustainability. *Sustainability : ISSN 2071-1050*, 3442-3445.

UN. (2015). *The Millennium Development Goals Report.* New York: UN.

UN. (2018, 2 Accessed 28). *Sustainable Development Goals, 17 goals to transform the World*. Retrieved from United Nations: http://www.un.org/sustainabledevelopment/energy/

UNICEF, W. a. (2017). *Joint Monitoring Program: Progress on Drinking Water, Sanitation and Hygiene.* Switzerland: WHO Library Cataloguing-in-Publication Data.

WASREB. (2018, January accessed 26). *Water Act 2016.* Retrieved from WASREB Water Services Regulatory Board: https://wasreb.go.ke/the-water-act-2016/

WHO, U. (2017). *Progress on Drinking Water, Sanitation and Hygiene: 2017 Update and SDG Baselines.* Switzerland: World Health Organization (WHO) and United Nations Children Fund (UNICEF).