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## Influence of Water Extraction Technology on Sustainability of Community Operated Water Projects in Central Nyakach Sub- County, Kisumu, Kenya

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### **Abstract**

*Sustainability of community operated rural water projects in Kenya remains a challenge. In spite of concerted efforts to transfer ownership of rural water projects to beneficiary communities and increasing participation of the communities in the operation of these facilities, more than a third of all rural water projects fail within the first few years of development. This study investigated the Influence of Water Extraction Technology on sustainability of community operated water projects in central Nyakach sub- county, Kenya. Employing a cross-sectional survey design, and from a target population of 1346 households, a proportionate stratified sampling technique was used to draw a sample of 142 household water users as respondents, 25 water management committee members and 6 local leaders as key informants. Data were analyzed using descriptive statistics such as frequencies and percentages. Content analysis was also done. The results revealed that the hand pump technology was more prone to breakdowns than the solar pump technology. Furthermore, spare parts and technicians were locally available to undertake repair work and maintenance, thus enhancing the water projects sustainability. There is need to replace the hand pump technology with modern and efficient technologies that would extract higher volumes of water thus meeting the needs of the community members.*

**Keywords:** *Water extraction technology, community operated water projects, project sustainability, central nyakach sub-county*

### **1. Introduction**

Access to safe drinking water is a basic human need necessary for both the wellbeing and social economic development of populations living in rural Kenya. In spite of efforts to increase access to water, many rural water supplies have either stopped operating or are not operating optimally. This has resulted in loss of service to populations living in the rural areas of Kenya (Mwangangi & Waynoka 2016). Many of the dysfunctional water sources are operated by community-based organizations such as community Water and Sanitation (WASH) Committees, Water User Associations or women groups. That 35% of improved rural water supply points in sub-Saharan Africa are non-operational and this scenario is no exception in Kenya (Ababa, 2013). Quoting USAID Kenya Oino, Kirui, Towett and Luvega (2015) notes that despite the Kenyan government effort of setting ambitious targets to provide access to safe drinking water and basic sanitation facilities to 85% of the population by 2015 and 100 % by 2025 in line with MDGs, the country still faces considerable challenges in reaching the water and sanitation Sustainable Development Goals According to Mamburi (2014), access to safe water supplies throughout Kenya is 59 percent with access in rural areas remaining as low as 47 percent , relying on unprotected wells, springs or informal water providers. Alida (2012) citing an IRC Triple-S 2010 study, noted that despite relative success in the provision of new rural water infrastructure in the last two to three decades, evidence show that between 30 to 40 per cent of facilities either do not function or are operating below capacity. In Kenya, about 25 to 30 per cent of the recently completed community managed rural water project facilities become dysfunctional within the first three years following completion (Alida, 2012), Central Nyakach is no exception. Consequently, the National governments and development partners have begun to recognize the scale of the problems associated with poor sustainability of rural water projects (IRC, 2011).

Project sustainability has been defined by the American Heritage as the ability of a system of any kind to endure and be healthy over the long term. Macharia, Mbassana and Oduor (2015) contend that project sustainability refers to the benefits realized, maintained and continue after the project has been handed over to the beneficiaries. Sustainability is also defined as the ability of an organization to develop a strategy of growth and development that continues to function indefinitely. This study will adopt the definition of sustainability as the process of ensuring an adaptive prevention system and sustainable infrastructure and interventions that can be integrated into ongoing operations to benefit diverse stakeholders (Mwangi, 2014).

Studies conducted on water projects have shown that most water projects did not function to the full capacity (Ngetich, 2009). A study conducted by Habtamu, (2012) showed that most water projects decline in performance shortly after external support is withdrawn. Studies by Airo (2009), Rimbera (2012), and Ali (2012) reported that lack of project sustainability was due to low level of community awareness, approaches used by developers and lack of proper feasibility study. Gatari, Mbabazi and Shukla (2016) note that adoption of technology and the effective operation and maintenance are key in sustainability of community-based water projects. Habtamu (2012) contend that sustainability rate of rural water supply systems increases as a result of communities owning and managing their schemes, existence of management organization at the village level, protection of the water point, communities cost recovery for operation and maintenance, technology type and availability of their spare parts and recognition of women.

In Siaya sub-county, from eighty water projects constructed by various development agencies in the last two decades, 90% were non-functional by the year 2006 (LVSWBS Inventory Report, No.25 (Oraro, 2012). Similarly, in Nyando Sub-County, UNICEF rehabilitated more than 100 failed water projects in 2009 before initiating new ones. A common denominator in these failed projects is that all are operated and managed by communities. Successful community-based Operation and Maintenance (O&M) of rural water projects therefore remains a challenge and threatens reversing the gains made in improving quality of life for rural populations in Kenya.

### 1.1. The Problem

Addressing the success rate of water projects, Mamburi (2014) noted that operational failure rates from different African countries range from 30 to 60 percent. In Kenya it is a common phenomenon to observe nonfunctional water systems just a few years after implementation. According to Mamburi (2014), some of the factors attributed to this include vandalism of solar pumping systems for boreholes, non operational shallow well hand pumps and wind mills. In central Nyakach sub-county, several water projects have been launched but majority are dysfunctional and dilapidated beyond repair. It was against this background that the study endeavored to investigate the Influence of Water Extraction Technology on sustainability of community operated water projects in central Nyakach sub- county, Kenya.

### 1.2. Research Objectives

- To examine the influence of water extraction technology on the volume of water extracted
- To determine the relationship between the water extraction technology and the sustainability of the water project.

## 2. Literature Review

### 2.1. Technology and Innovation Diffusion

According to Narayanan (2001) technology innovation and diffusion can be influenced by five attributes namely:

- Relative advantage: the level of innovation perceived as better than previous idea
- Compatibility: the degree of innovation perceived consistent with existing value or previous experience and need to the potential adopter
- Complexity: the degree of innovation perceived as difficult to be comprehended or utilized.
- Triability: where innovation can be tried on a limited scale before commercial scale, thus reduce the risks
- Observability: Result of an innovation is available for other parties.

Relative advantage, compatibility, and complexity attributes are related to benefit costs in the innovation for the adopters. Individuals or organizations would likely adopt the innovation if: a) it offers clear benefits, b) it does not drastically disturb the life style of the existing pattern, and c) it is easy to understand.

Both triability and observability attributes are related to risks. Adopters will not adopt an innovation if its trial is difficult to do or its benefits are hard to observe. These characteristics increase uncertainty level on the value of the innovation and therefore increase the risk of its adoption. Although the performance of innovation to meet the technical features and price requirements can influence the above five factors, at the end, it is the perception of the adopters which is the determining factor. This is why community participation in the choice of water extraction technology is a very important aspect in the diffusion and adoption process; and hence the sustainability of community water projects.

This theory enabled the researchers assess the community members' technological capabilities that consist of the knowledge and skills - technical, managerial, and institutional. Such capabilities allow community members to use the water extraction equipment and technology efficiently, undertake repair and maintenance and ultimately sustainability of the water projects. The successful transfer of new technologies has been limited by a low level of technological capability. Simply providing equipment and operating instructions, designs, or blueprints in most instances do not ensure the transfer of technology and sustainability of projects.

### 2.2. Water Extraction Technologies and Sustainability of Community Water Projects

There are numerous water extraction technologies in use for community-based water projects. However, across the globe, many such technologies are either non-functional or in need of repairs. Mamburi (2014) notes that in India, rural regions of Mali, and Ghana, the factors responsible for the non-functioning of boreholes range from extreme low yields, inability to raise funds to acquire spare parts, to lack of access to spare parts. In a similar study Alida (2012) investigated the financial sustainability of rural water supplies in western Kenya One of the research objectives was to compare how different technology types influenced financial sustainability. Employing descriptive survey design and

analyzing data using weighted scores, it was found that all hand-pumps under community management scored low on financial sustainability. At the government managed motorized pumps the payments were not good enough to cover the costs. The communities were not able to collect enough money to keep the system functioning in the long run. The study did not determine the actual user fees charged and also did not determine the total revenue generated. The current study endeavored to measure these metrics but it was a challenge to get the rough estimates because the water project management committees in central Nyakach sub-county did not maintain proper financial records. It should be noted that community ownership of projects is influenced by the ease of operation and availability of funds to purchase spare parts for the technology incorporated in the water systems. To gain insights into the types of water extraction technologies deployed in rural areas, explicit discussion is presented below.

The first is the spring. It is an option located where the groundwater naturally comes to the surface. Some of these springs are permanent and some dry up in the dry season. Alida (2012) notes that two types of springs are found, this are unprotected and protected springs. In the last case, the water source is encased in concrete and water flows out from a pipe instead of seeping from the ground. After the construction of this structure, the operation and maintenance consist of keeping the surroundings clean and repairing pipes or cracks in the structure (Alida, 2012). But in case of proper construction these repairs are hardly needed. At some locations a spring with a high productivity is used to supply water to a larger area with the use of pumps, lifted reservoirs and piped extensions.

The second is a hand dug well without a pump. These wells are found within the homesteads of the rural families. Water is manually drawn from these wells using a bucket with a rope. Operation and maintenance requirements for this technology are cleaning of the well site and drain, repairing of apron (if present) and rehabilitating with gravel or piping material (Alida, 2012). The last activity, rehabilitation, is very rarely needed. As the depth of a hand dug well is restricted, these wells are common in places with a high-water table.

In parts of central Nyakach Sub-County, wells or boreholes with hand pumps are found where less springs and surface water sources are found, many hand-pumps can be found (LVWSB and LVNWSB, 2011). A hand pump is a simple technology to manually pump groundwater from a well or borehole. Small repairs for the hand pumps include the replacement of worn cup seals and washers, straightening of pump rods and replacement of corroded lock nuts. Major repairs include the replacement of the pump rods, plunger, foot valve, cylinder, rising main or pump handle (Alida, 2012; Brikke, 2000).

The fourth is a well or borehole with motorized pump. The technology which is found in water supply in Nyakach, Kenya is a well or borehole with a motorized pump, using fuel solar power or electricity as a source of energy. Alida (2012) avers that the common technology for this is a permanent submersible pump, used in a deep borehole. Another option is a separate pump which is only put in the water source during the pumping hours. At wells or boreholes with a motorized pump, the water is pumped in a lifted reservoir tank with a pipe to the tap or to other extensions. These motorized pumps can pump deep water and therefore more suitable when the water table is too low.

According to Alida (2012) the daily operation of the motorized pumps requires some small activities like checking and refilling the fuel, start and stops the engine, checking and cleaning air filters and tightening of nuts and bolts. Other minor maintenance includes greasing, replacing filters and changing oil. Major maintenance includes the replacement of engine parts like the drive belt, nozzles, injectors, gaskets, bearings, or the fuel pump.

Mamburi (2014) citing studies conducted in rural India approximately a third of India's hand pumps in rural water projects are either nonfunctional or in need of repairs. (Mackenzie & Isha, 2005). Likewise, in rural Ghana the factors responsible for the non-functioning of boreholes include lack of consultation with the local community, limited maintenance and lack of financial support (Skinner, 2009). According to Gleitsmann (2005) in a study conducted in Koro region of Mali, West Africa, sustainability of various types of water supply infrastructure is dependent upon the degree to which the technology used corresponds to the needs of the local community and the community's ability to maintain and repair it over time range from extreme low yields, inability to raise funds to acquire spare parts, to lack of access to spare parts.

From the foregoing, it should be noted that water extraction technology that fails to fulfill the needs of its users, which is poorly installed or which is difficult to maintain or repair, possess significant challenges for sustainability. Water Aid sustainability study in Zambia highlighted, for example, the rapid corrosion of hand pump rising mains as a constraint to sustainable community water supplies (Abrams, 2003). Kanyanya (2011) opines that there is no such thing as a maintenance-free technology yet even gravity water supply schemes, which were expected to provide sustainable services, have failed to live up to that promise. Similarly, in central Nyakach sub-county, there are hand-pump extraction technologies that have failed. However, the underlying factors to such failures are yet to be established through in-depth studies as envisaged by the researcher.

Hardware (including pumps, pipes, and spare parts) is sourced and procured by international agencies, governments, private providers and NGOs. The questions around who buys, what is procured and how quality of hardware is assured are all important for sustainability. In particular the links between the community and the suppliers of spare parts are crucial. The community need to be trained on how to use the taps, springs, hand pumps among others and it should also be trained on how to maintain the facilities because the external institutions will not always be available in case of breakdowns. Most of the community water projects are either hand pumps or taps (which have underground pipes) or springs. These are aspects that the reviewed studies did not provide evidence of, but rather relied on the opinions of the water users to make judgment. In this study, the researcher collected and documented first hand information during repairs of broken-down hand pumps and thereby ascertained the quality of spare-parts and skills levels of the technician at work.

### 3. Methodology

This study adopted a cross-sectional survey design to collect both quantitative and qualitative data. A survey is suitable when descriptions of events such as water project sustainability. The target population comprised of 1346 households served by twenty community-based water projects in central Nyakach Sub-County. It's from this population that a representative sample was drawn. This study employed stratified random and purposive sampling techniques to select the individual respondent who ordinarily fetch water from the various project sources.

### 4. Data Analysis

The quantitative data were analysed using descriptive statistics such as frequencies, percentages and means to describe the collected data and determine the relationships between the independent and dependent variables. Qualitative content analysis from focus group discussions allowed the researcher to study selected issues in detail.

### 5. Results

#### 5.1. Project Location, capacity and Capital Cost

Information was sought from the management committee members on the location, extraction technology, reservoir capacity and project capital cost. The data is presented in Table 4.2 below.

Project Location	Year started	Extraction Technology	Capacity (litres)	Initial Capital Cost
Olwalo	2006	Solar pump	50,000	5 million
Kajunga	2012	Solar pump	50,000	13 million
Kogola-Pedo	2005	Hand pump	----	1.5 million
Kogelo	2005	Hand pump	----	1.5 million
Ragen RC	2007	Hand pump	----	1.5 million
Anyango-Oloo	2009	Solar Pump	50,000	9 million
Ragen community	2015	Solar pump	50,000	9 million

Table 1: Project Location, Extraction Technology, Capacity and Capital Cost

Results in Table 1 indicate that the water projects in central Nyakach have been in existence since 2006 (12 years) and 2015 (3 years), implying that the systems are functional. It is evident that there are two major modes of water extraction technologies in use, namely solar pumps and hand pumps. The capacity of the solar pumped system reservoirs is 50,000 litres while that of the hand pumps could not be quantified because no reservoirs were constructed to hold water prior to distribution. It is also evident the solar system water projects had far much higher initial capital costs of investment than the hand pumped systems. This is attributed to the fact that the solar system has a number of components such as the solar panel stands, water pipes being laid, reservoirs and water kiosks. The hand pump water systems had relatively low initial capital costs averaging Kenya shillings 1,500,000.00 compared to the solar that averaged Kenya shillings 9 million.



Figure 1: Solar Pump



Figure 2: Hand Pump

### 5.2. Training Received by Committee Members

The committee members were asked to state the type of training received by committee members. The results are presented in Table 2 below.

Type of Training	f	%
Management	7	28
Pump repairs	10	40
Plumbing	2	8
Tank cleaning	6	24
Total	25	100

Table 2: Operations and Maintenance Training Received by committee members

The result in Table 2 shows various operations and maintenance training that the water management committee members had received. 7 (28) had been trained in management, 10 (40) pump repairs, 2 (8) plumbing, 6 (24) tank cleaning. These findings show that most of the committee members have been trained both in general water project management skills and the technical repair and maintenance. These findings are consistent with the observations by Campos (2008) who argued that training on issues like operation and maintenance empowers communities to look after water supply systems thus enhancing sustainability. Ademiluyi and Odugbesan (2008) identified lack of community education as one of the important factors which could lead to breakdown and non-sustainability of water supply projects in developing countries. It therefore implies that the committees managing water projects in central Nyakach Sub-County are well placed to undertake repairs at the local level thereby enhancing their water projects sustainability.

### 5.3. Changes in Volume of Water Extracted

The committee members were asked to state whether there were changes in the volume of water extracted since the project was commissioned. The results are presented in Table 3 below:

Changes in Volume	f	%
Reduced	15	60
No change	7	28
Increased	3	12
Total	25	100

Table 3: Changes in Volume of Water Extracted

The results in Table 3 show that most of the respondents 15 (60) stated that water projects were operating below capacity. These results are similar to those of Ngetich (2009) and Habtamu, (2012) who aver that most water projects decline in performance shortly after handing over. The reduction in the volume of water extracted could be due to inefficiencies in the technologies used or wearing off of the major component of the hand- pumps as is the case of Kogola-Pedo seen on Plates 3 and 4 being repaired. The solar pump systems volume of water extracted increased due to the installation of additional storage capacities.



Figure 3: Hand Pump under Repair



Figure 4: Hand Pump Vent under Repair

Water Extraction Technology	SA	A	NU	D	SD
Decision on choice of technology	12 (8.5)	18 (12.4)	25 (17.2)	39 (26.9)	48 (33.1)
Frequency of break down	30 (21.1)	21 (14.8)	19 (13.4)	53 (37.3)	19 (13.4)
Routine Maintenance	13 (9.2)	30 (21.1)	19 (13.4)	54 (37.3)	19 (13.4)
Availability of spare parts	53 (37.3)	59 (41.5)	18 (12.7)	10 (8.5)	2 (1.4)
Cheap to operate	20 (14.1)	31 (21.8)	24 (21.8)	50 (35.2)	17 (12.0)

Table 4: Water Extraction Technology and the Sustainability of Community Water Projects

The results in Table 4 indicate that a paltry 12 (8.5) strongly agreed to participating in decision on choice of water extraction technology, 18 (12.4) agreed to taking part in the decision while 25 (17.2) were neutral in their response, 39 (26.9) disagreed to participating in decision on choice of water extraction technology, With 48 (33.1) strongly disagreeing that they participated in decision on choice of water extraction technology.

On functionality, 30 (21.1) of the respondents strongly agreed water extraction technology frequently breaks down, 21 (14.8) agreed that technology frequently breaks down, 19 (13.4) were neutral in their response, while 53 (37.3) disagreed water extraction technology frequently breaks down, while 19 (13.4) strongly disagreeing that water extraction technology frequently breaks down.

On routine maintenance of the equipment, 13 (9.2) of the respondents strongly agreed that this is routinely done, 30 (21.1) agreed the equipment were routinely maintained, while 19 (13.4) were neutral in their response. Nonetheless, 54 (37.3) disagreed that equipment was routinely maintained, with 19 (13.4) strongly disagreeing that equipment was routinely maintained.

As regards spare parts, 53 (37.3) strongly agreed spare parts are locally available, 59 (41.5) agreed that spare part is locally available, 18 (12.7) had neutral response, while 10 (8.5) disagreed that spare part is locally available with 2 (1.4) strongly disagreed that spare part is locally available.

On cost of operating the technology, 20 (14.1) of the respondents strongly agreed that water extraction technology is cheap to operate, 31 (21.8) agreed the technology was cheap to operate, 24 (21.8) were neutral in their response, while 50 (35.2) disagreed that the water extraction cheap to operate, with 17 (12.0) strongly disagreeing that it is cheap to operate the water extraction.

These findings are in assonance with Kanyaya (2014) that the use of appropriate technology is integral to the local level operation and maintenance. The researcher concurs with Mamburi (2014) that the aspects of technology used such as cost and availability of spare parts, ease of operation and maintenance as well as user acceptability are paramount to sustainability of community water projects in central Nyakach sub-county.

## 6. Conclusions and Recommendations

The use of appropriate water extraction technology is integral to the sustainability of community operated water projects in central Nyakach Sub-County. The aspects of technology used such as cost and availability of spare parts, ease of operation and maintenance as well as user acceptability are paramount to sustainability of community operated water projects.

Basing generalizations on the findings of this study, the researchers recommends that given the frequent breakdown of the hand pump technology, the water management committees need to replace this technology with modern and efficient technologies that would extract higher volumes of water that would meet the needs of the community members. In addition, local technician's skills should be up-scaled so as to be able to undertake routine maintenance and repair services.

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