FACTORS AFFECTING SUSTAINABILITY OF URBAN WATER SUPPLY SYSTEMS IN SOUTH WESTERN UGANDA

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DECLARATION

I, Eng. Herbert Nuwamanya, declare that this is my original work, and that it has not been presented to any other Institution or University for the award of a degree.

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APPROVAL

This dissertation has been submitted with my approval as the overall supervisor

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DEDICATION

This work is dedicated to my family; my dear parents Mr. David John Rwandaragi and Mrs. Juliet Katayi Rwandaragi, my beloved wife Christine Atukunda Nuwamanya, my son Collins Amanya and daughters Martha Ampaire and Faith Atuhaire.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variances
DWD	Directorate of Water Development
MoFPED	Ministry of Finance, Planning and Economic Development
MUK	Makerere University, Kampala
MWE	Ministry of Water and Environment
NEWAH	Nepal Water for Health
O&M	Operation and maintenance
SWTWS	South Western Towns Water and Sanitation Project
SWUWS	South Western Umbrella of Water and Sanitation
TSU	Technical Support Unit
UMI	Uganda Management Institute
UNHS	Uganda National Housing Survey
UPPAP	Uganda Participatory Poverty Assessment Programme
WHO	World Health Organisation

ABSTRACT

This study examined factors affecting sustainability of urban water supply systems in South Western Uganda. Five objectives were set, namely: to examine the effect of age on sustainability, establish the influence of technology on sustainability, assess the impact of social-political dynamics on sustainability, to assess the effect of use of alternative water sources on sustainability, and to establish the relationship between affordability and sustainability. Data on five independent variables of system age, technology, social-political dynamics, affordability and use of alternative water sources and the dependent variable (sustainability) were collected from 16 water systems through documentary review, observation and interviewing at least 30 respondents (comprised of operators, board members and representatives from consumers) from each of the water supply systems. The data was summarised and analysed using frequency distributions, correlation and regression analysis, independent samples t-test and one way ANOVA. The study established that sustainability of urban water supply systems in South Western Uganda is an issue that requires urgent attention and that sustainability; is negatively affected by the age of the system, is influenced by the technology options adopted in the design of the system, is significantly negatively impacted by the social-political dynamics (population growth and conflicts) of a given area have, is significantly and positively related to affordability of the service, and is negatively affected by the use of alternative water sources. The study recommends seasonal monitoring of water source yields, use of a more comprehensive tool of measuring sustainability of water supply systems, continuous implementation of strengthened capacity building programs (that include conflict resolution) during the entire life of the system, timely resolution of conflicts, addressing the triggers of use of alternative water sources, further studies involving more towns and other regions and a study on water consumption pattern with a view of revising the per capita per day consumption rate used in water supply designs given the rampant underutilisation of installed capacities.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter is divided into ten sections covering the background, the problem, and purpose of the study, study objectives, research questions, hypotheses, conceptual framework, justification, scope and operational definitions of terms.

The study examined factors that affect sustainability of urban water supply systems in South Western Uganda. It followed realisation in the Ministry of Water and Environment (MWE) (2006, 2007, and 2008) reports that despite increased funding, access to safe water had stagnated at 63% for the previous three years largely because of partial functionality and total collapse of some systems that made originally served areas to fall back to un-served. Sustainability was examined in relation to the independent variables of the system age, technology, social-political dynamics, affordability and use of alternative water sources.

1.1 Background to the Study

Lack of sustainability of water supply systems manifests itself in three forms: partial functionality, total collapse of water supply systems and failed ecosystems (Alexia, 2006). It retards efforts to increase access to safe water and yet access to safe water is a pre-requisite to health (NEWAH, 2006) and is linked to development and environment (Alford, 2007). Furthermore, lack of sustainability affects all nations whether developed or developing (Len, 2001).

Partially functional water supply systems are unreliable for they operate occasionally and users cannot predict when they are likely to be operating. Total collapse occurs when the system fails and the users are unable to restore it for a long period of time. Ecosystems may fail because of two reasons: one, when most of the water is diverted, organisms which originally depended on it suffer and two, when untreated waste water is discharged into water bodies, the resulting changes in the nutrient content may result in unfavorable conditions for certain organisms and increased cost of water treatment if the water body is a source for a water system (Cubillo, 2003).

Therefore, lack of sustainability results in falling back to un-served of areas which are originally served and consequently reduced water coverage. This in turn results in the disappearance of the economic and health benefits of access to safe water since according to Alford (2007), access to safe water is linked to all the eight Millennium Development Goals (figure 1). Increased access to safe water reduces walking distance and prevalence of water borne diseases. It saves time, energy and money that would otherwise be used in fetching water from long distances and nursing the sick. These savings enhance eradication of poverty and hunger, children's school attendance, gender equality and women empowerment. Reduced diseases reduce child mortality and directly improve maternal health. Avoiding over extraction and contamination with the waste water ensures environmental sustainability while development of trans-boundary water resources enhances global partnership for development.

Figure 1: The Eight Millennium Development Goals (MDGs)

1. Eradicate extreme poverty and hunger 2. Achieve universal primary education 3. Promote gender equality and empower women 4. Reduce child mortality	5. Improve maternal health 6. Combat HIV/AIDS, malaria and other diseases 7. Ensure environmental sustainability 8. Develop a Global Partnership for Development.

Improved access to, affordability and quality of water is important in improving people productivity, poverty status and health. Improved access to safe and reliable water reduces productive time wasted in walking long distance to and waiting at crowded points thereby allowing people to engage in other productive activities (Nalwoga, 2008).

1.1.1 Global and Regional Perspective

Globally, sustainability is considered primarily in terms of continuing to improve human well-being whilst not undermining the natural resources base on which future generations will have to depend (Len, 2001). In 2004, 1.1 billion people across the globe lacked access to an improved source of drinking water (JMP, 2006a). In recent years there has been growing international concern on the issue, reflected in the inclusion of water and sanitation within the Millennium Development Goals, the declaration of 2005-2015 as the International Decade for Action 'Water for Life', and moves to explicitly recognize water as a human right within international human right mechanisms, amongst many others.

Despite these laudable international efforts, sustainable progress is proving complex to put into practice in many areas of the world. The WHO/UNICEF Joint Monitoring Program for Water and Sanitation which tracks progress towards the MDG target to 'reduce by half the proportion of people without sustainable access to safe drinking water', reported in the JMP (2006a) that the world was still moving towards achieving the target but that the rate of progress was deteriorating and at that rate would miss the target.

According to Len (2001), lack of sustainability of constructed facilities is faced by all developed and developing countries. MWLE (2003) estimated between 30-40% in-operative water supply systems in low income countries worldwide.

At the regional level sustainability is looked at as whether something continues to work overtime and is measured in terms of functionality (Len, 2001). According to Alexia (2006), at least 35% water supply systems in sub-Saharan Africa are none-operational at any one given time which is close to Miert and Binamungu (2001) findings of 30% none-operational water systems in Tanzania.

1.1.2 The Situation in Uganda

There exists high level commitment within government to prioritize the sector: the legal framework is conducive, the volume of available funds has been enhanced and sector reforms are well-advanced (ODI and WaterAid, 2004). However, increase in water coverage and the level of sustainability of the facilities do not measure up to this commitment. For example, whereas the Government has gradually increased funding by 234% (from 47.4 Billion Uganda shillings in the 1996/1997 financial year to 157.4 Billion Uganda shillings in the 2007/2008 financial year) safe water coverage has increased by a mere 20% (from 47% to 63% where it has remained stagnant for the last three financial years). Furthermore, MWE (2007) reports that since 2004, 17% of all water supply systems and 50% of public water kiosks are non operative at any given time.

Government's Commitment to Prioritize the Sector

The existing laws and policies are conducive for the development of the water and sanitation sector. For example, the Uganda Constitution (1995) entitles every person access to clean and safe water. The National Water Policy (1999) promotes an integrated and sustainable, development, management and use of the national water resources, with the full participation of all stakeholders. According to MWLE (1999), specific objective for water supply is: "to provide safe water within easy reach based on management responsibility and ownership by users, to 77% of the population in rural areas and 100% of urban population by the year 2015 with an 80%-90% effective use and functionality of facilities".

The MoFPED (1997, 2000, and 2004) in its Poverty Eradication Action Plan (PEAP), the key framework through which the Government allocates its funds, prioritizes access to safe water because it has a direct impact on the quality of life and productivity. As a result of this prioritization, Government has gradually increased funding from 47.4billion in the 1996/97 to 157.4billion for the 2007/08 financial year (MWE, 2008).

Safe Water Coverage and Sustainability

Safe water coverage, which is defined as the percentage of the population that accesses safe water within a walking distance of 1.5 Km for rural areas and 0.200 Km for urban areas, stands at 63% (MWE, 2008). Although initially there was a remarkable increase from 47% in 1997 to 63% in 2006, it has stagnated at 63% for the last three financial years and is expected to remain at the same level during the 2008/09 financial year (MWE, 2006, 2007, and 2008).

Sustainability of the facilities is measured by functionality which is defined as the percentage of the improved water sources that are functional at the time of spot-check. According to MWE (2007 & 2008) reports, functionality has stagnated at 17% for all water facilities and at 50% for public kiosks that serve the poor. The implication of this is that since 2004, 17% of all water supply systems and 50% of public water kiosks are non operative at any given time.

According to Mukaila (2008), the major reason for this stagnation is the rapid population growth and lack of sustainability that results in "fallback" of originally served areas and sucks a portion of the funding into rehabilitation. For example, expenditure on borehole rehabilitation alone increased by 163.4% from 0.82 billion UGX in 2005/6 financial year to 2.16 billion UGX in 2007/08 financial year (MWE, 2008).

Relevant Water Sector Reforms

In response to failure of investments to achieve the desired increases in coverage and service levels expected, and further driven by the allocation of HIPC funds (Robinson, 2002), the Ugandan Water Sector has undergone considerable reform in recent years. The reforms aim at providing water and sanitation services with increased performance and cost effectiveness, and at reducing the financial burden on Government but not at the expense of equitable and sustainable service provision (Cong, 2005). The move from supply driven approach to demand driven approach, community participation and involvement, community capacity building, introduction of operation and maintenance conditional grants, formation of O&M support structures such as umbrella organization, use of commission-paid private operators and sector wide approach as opposed to project approach point to the search for the illusive sustainability.

1.2 Statement of the Problem

The primary objective of most governments in the field of water supply and sanitation is sustainable water service delivery at local level (Len, 2001). In Uganda, the objective is to provide sustainable safe water which is managed by the users to 77% of the population in rural areas and 100% of urban population by the year 2015 with an 80%-90% effective use and functionality of facilities (MWE, 2008). To achieve these set targets, the Government has prioritized the water sector by setting up a conducive legal framework, increasing the volume of available funds and reforming the sector (ODI and WaterAid, 2004).

However, the increase in water coverage and the level of sustainability of the facilities do not measure up to the Governments efforts and targets. For example, safe water coverage has stagnated at 63% for the last three financial years, functionality for all water supply systems has stagnated at 83% and functionality of public water kiosks has stagnated at 50 since 2004 (MWE (2007). Some of the water supply systems that had been planned and constructed to be sustained by the users for the entire design period of 20 years have been reported in SWUWS (2008) to have failed within the second year of operation. The stagnation in safe water coverage is partly attributed to lack of sustainability that make originally served areas to fall back to un-served and consequently suck in reasonable resources into rehabilitation. Expenditure on borehole rehabilitation alone increased by 163.4% from 0.82 billion UGX in 2005/6 financial year to 2.16 billion UGX in 2007/08 financial year (MWE, 2008).

If sustainability is not improved, originally served communities will fall back necessitating use of funds, which would otherwise be used to construct new facilities to increase coverage, on rehabilitation projects. Ugandans (especially women and children) will continue dying of preventable water borne diseases, trekking long distances in search of safe water and thus wasting time which would be used for economic activities and schooling. Ultimately, Uganda will fail to achieve her targets on poverty eradication.

Performance on sustainability is measured by establishing whether systems are functional on spot-checking. According to ODI and WaterAid (2004), this is inadequate because functionality is only one element of sustainability. Other elements such as the quality of water supplied, effective usage, maintenance of the facilities, financial and the ecological concerns need to be considered. This study examined sustainability of urban water supply systems in South Western Uganda basing on more comprehensive sustainability measurement indicators.

1.3 Purpose of the Study

The purpose of this study was to examine factors that affect sustainability of urban water supply systems in South Western Uganda.

1.4 Objectives of the Study

The following objectives guided the study:

1. To examine the effect of age of the system on water supply system sustainability
2. To establish the influence of technology on sustainability of water systems.
3. To assess the impact of social-political dynamics on sustainability.
4. To establish the relationship between affordability and sustainability
5. To assess the effect of use of alternative water sources on sustainability.

1.5 Research Questions

The following questions were posed during the study:

1. How does age of the system affect sustainability of urban water supply systems?
2. How does technology influence sustainability of urban water supply systems?
3. What is the impact of social- political dynamics on sustainability of urban water supply systems?
4. What is the relationship between affordability and sustainability of water supply systems?
5. How does use of alternative water sources affect sustainability of urban water supply systems?

1.6 Hypotheses of the Study

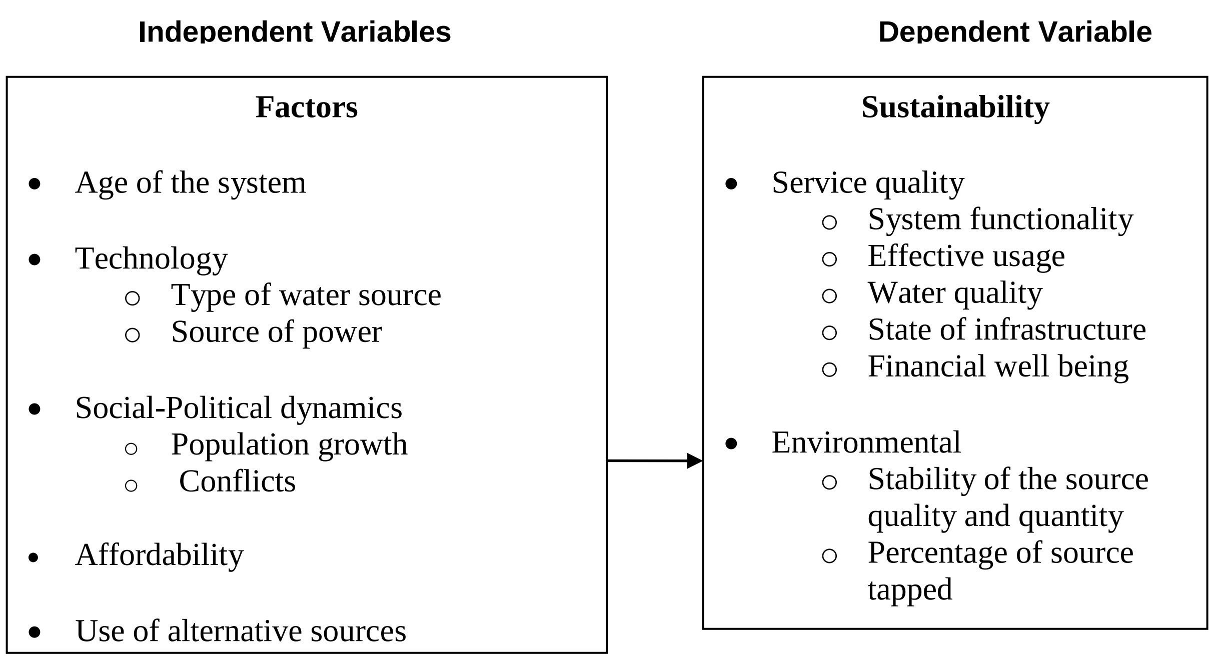
The following hypotheses guided the study:

1. The age of an urban water supply system affects its sustainability.
2. Technology influences sustainability of urban water supply systems.
3. Social-political dynamics has a significant impact on sustainability of urban water supply systems.
4. There is a significant positive relationship between affordability and sustainability of urban water supply systems.
5. Use of alternative water sources affects sustainability of urban water supply water systems.

1.7 The Conceptual Framework

The conceptual framework that guided the study is shown in figure 2 below:

Figure 2: The Conceptual Framework of the Factors Affecting Sustainability of Urban Water Supply Systems



Adapted from Cubillo (2003)

The study conceptualized that sustainability of an urban water supply system could be predicted by its age, technology, social political dynamics of a given area, affordability and use of alternative water sources. According to Cubillo (2003), sustainability of water supply systems is mainly determined by two criteria: their capacity to fulfill service quality requirements and their capacity to keep all the water masses affected by the supply in a good ecological state. For this study, therefore, system sustainability is operationalised by capacity to fulfill service quality requirements and capacity to fulfill environmental requirements. The system's capacity to fulfil service quality requirements was measured by its functionality, its effective usage, its water quality, state of repair of its infrastructure, and its financial well being while the system's capacity to fulfil the environmental requirements was measured by the stability of the source quality, the stability of the source quantity and the percentage of source yield that is tapped.

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As a system ages, its components such as pipes, fittings and pumps break down more frequently necessitating overhaul and replacement which results in increased leakages, reduced supply hours, poor quality water, less revenue and increased expenditure, increased rate of abstraction which enhances undesirable ecological effects (Alexia, 2006) and (NEWAH, 2006).

The type of water source determines the quality of raw water and the treatment requirements. According to Kesavan, etal, (2008) and Alexia (2006) simple to use and readily available technologies such as gravity flow schemes using spring sources, are easier and cheaper to operate, maintain and sustain while pumping systems using surface water sources that require comprehensive treatment works fail more often.

Social-political dynamics of a given area such as population growth, community resistance, community conflicts and political pressure affects the quality of service and the environmental sustainability. Rapid population growth leads to increase in consumption which frequently can not be satisfied by available water resources and infrastructure (Khatri and Vairavamoorthy (2007). Political pronouncements such as, “water is a social good”, influence the setting of “no-cost – recovery-tariff” (Len, 2001). The pronouncements can also influence willingness to pay, incidences of illegal connections, the level of vandalism and therefore maintenance costs.

According to Alexia, (2006) and Khatri & Vairavamoorthy (2007), the social economic status of the beneficiaries determines affordability which has a large bearing on usage. A system raises more revenue by using more water if more people afford the service. This improves its financial well being but affects its environment if the resource is over exploited. If more people use alternative sources, system capacity is under utilized and less revenue is collected. If there are no alternatives, community members will put in extra efforts to ensure that the only system is sustained. Even if the service is not affordable, the community will swallow the bitter pill by foregoing other essentials.

1.8 Significance of the Study

The findings of this study are important for several reasons. The study established why some urban water supply systems are sustainable while others are not. This finding will help policy makers, engineers, planners and implementers to focus on the factors that strengthen and those that undermine sustainability. By identifying what works and what does not, the study may benefit the central and local governments to formulate better policies, help engineers and planners on choice of water supply systems. It may help increase access to safe water by increasing sustainability which saves Government money for constructing new systems. Ultimately, the study may reduce the burden of fetching water and prevalence of water borne diseases, improve the health of the beneficiaries and therefore have an effect on poverty reduction and achievement of the Millennium Development Goals.

1.9 Justification of the Study

The Government of Uganda has developed a number of urban water supply systems hoping that the systems would be managed and sustained by the users (MWE, 2008). However some of the water supply systems have been reported in SWUWS (2008) to have failed within the second year of operation while MWE (2008) reports some systems that have been running well beyond their design period of 20 years. The failed systems have contributed to stagnation of safe water coverage at 63% kiosks since 2004 by sucking in reasonable resources into rehabilitation (MWE (2007). The government system of measuring sustainability by establishing whether systems are functional on spot-checking is according to ODI and WaterAid (2004) inadequate because functionality is only one element of sustainability.

Previous studies on performance of water supply systems in Uganda seem to have largely focused on point sources and large urban water supply systems and ignored rural growth centres. The studies further show that some communities appear to have been relatively successful, while others have had some serious difficulties in sustaining their water systems. Although a number of factors have been identified to influence sustainability of water supply systems, none have been tested in the rural growth centres in South Western Uganda. The current state of knowledge about sustainability of urban water supply systems in Uganda thus clearly warrants further investigations, and it was against this background that the present study was undertaken.

1.10 Scope of the Study

Geographically, this study covered rural growth centres in ten South West Ugandan districts of Bushenyi, Kabale, Kanungu, Kisoro, Mbarara, Isingiro, Ibanda, Kiruhura, Rukungiri, and Ntungamo. This area was selected because it has a concentration of a number of urban water supply systems planned, implemented and that are being operated under a similar approach.

Urban piped water systems formed the focus of this study because a number of studies have concentrated on the large towns (more than 10,000 inhabitants) and point sources serving villages with scattered homesteads (less than 500 inhabitants) but ignored the rural growth centres which is the major target of this study.

Systems that have been operational for at least two years were studied. This is because in the newer systems, deterioration of the facilities and some of the social dynamics such as population growth will not have manifested themselves.

1.11 Operational Definition of Terms

Affordability is defined as the percentage of the households who reported that the water tarrif is affordable.

Age of the system is the period in years from the time the system started operating

Alternative sources are the sources of water other than the one under study.

Environmental sustainability. A system is environmentally sustainable if at least 30% of its safe yield is left untapped for ecological purposes.

Financial wellbeing of a water supply system is the ability of the system to pay for operating expenses using its revenue

Social-political dynamics is defined in terms of population growth, community conflicts, community resistance and political pressures.

South Western Uganda refers to the Ankole and Kigezi districts of Bushenyi, Kabale, Kanungu, Kisoro, Mbarara, Isingiro, Ibanda, Kiruhura, Rukungiri and Ntungamo.

Survival on savings is the ratio of total savings divided by the average annual expenditure.

Sustainability of water supply system is the capacity of the system to continue providing water of the same or better quantity and quality for the period for which it was designed without adversely affecting the environment.

System effective usage is the measure of the system utilization as a fraction of the design capacity. It is measured by determining the percentage of the intended beneficiaries that actually use the system and daily water consumption as a fraction of water tapped.

System functionality is defined as the extent to which the system fulfils the requirements of having an operator and a board that meets monthly, keeping audited records and supplying water 24 hours per day. A system is said to be fully 'functional if it supplies water 24 hours per day, has systems operator and a board that is meeting monthly and keeps audited records.

System technology is defined in terms of technical options such as type of water source (spring, lake, river, etc) and source of power (gravity, national grid, solar, petroleum)

Urban water supply system is a system supplying a population ranging from 500 to 10,000 people.

Use of alternative water sources is the percentage of the population who report using alternative sources of water most of the times.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of the available related literature. It is divided into four sections: theoretical review, sustainability and sustainable development, factors affecting sustainability and summary of the literature review.

2.1 Theoretical Review

This study is grounded in the system theory (Bertalanffy, 1968) and threshold (Len, 2001) theory and therefore explains sustainability in terms of threshold requirements and examines factors that affect system components and system's environment.

To understand the systems theory we need to define a system. A system is any collection of component elements that work together, within a given environment, to perform a task (Encarta, 2006). According to McNamara (2008), a system features the continual input-processing-output stages and a malfunction in any of the stages or components, or any change in the system's environment affects the entire system. A water supply system will therefore be affected by a malfunctioning component (such as a reservoir tank, pipeline, pump or taps) and changes in the system's environment (such as changes in technology, economy, environment or political situation). Sustainability of the entire system is affected if, for example, the manufacturing of certain pumps and spares stop, crops fail in an agricultural based economy, water sources dry up due to the global warming, and residents flee the area because of insecurity.

To satisfy users of a service, there is a minimum level of service (threshold) that must be provided and to sustain this level of service a pre-determined minimum number of capacity requirements (thresholds**)** must be in place (Abrams, 2001). In any particular community, a certain level of community awareness, technical, financial and administrative capacity must exist. Where this capacity is less than the threshold capacity required for sustainability, capacity building will need to be undertaken to ensure that the threshold is reached. The threshold in all categories must be achieved in order to ensure sustainability. For example, if all other thresholds are reached but community acceptance is lacking, revenue will be difficult to collect which may result in the failure of the scheme.

2.2 Sustainability and Sustainable Development

According Guio- Torres (2007) sustainable development has a number of definitions but the most common is the one from The World Commission on Environment and Development (WCED) (1987) report: “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs”. The international Council for Local Environmental Initiatives (1994; cited in Hiessl et al, 2001) gave a practical and local interpretation of the concept of sustainability as it applies to urban areas: “development that delivers basic environmental, social and economic services to all residents of a community without threatening the viability of the natural, built and social systems upon which the delivery of these services depend”. Len (2001) defines sustainability as: “whether or not something continues to work over time”. Sustainability of a water supply system would therefore mean that water continues to be available in the same quantity and at the same quality as it was designed through out the design life. ASCE (1998) and UNISCO (1999) defines sustainable water resource systems as those systems designed and managed to fully contribute to the objectives of the society, now and in future, while maintaining their ecological, environmental and hydrological integrity.

Borrowing from each of the above definitions, this study defined a sustainable water supply system as that system which continues to avail water to the intended users at the same or better quality and quantity throughout the design period without adversely affecting the environment.

2.2.1 Sustainability of Water Supply Systems

According to Lundin (1999) dimensions of sustainability vary with the level of development. In developing countries, the main requirement is access to safe water and some kind of sanitation while in industrialized countries environmental concerns have grown focusing on the quality of ground water, recycling of nutrients and reduction of environmental effects.

In defining and measuring sustainability, authors from developed countries such as Lundin (1999), Herald et al (2001) and Water UK (2007), emphasize environmental sustainability while authors in developing world such as Len (2001), MWE (2008), Kesavan et al (2008) and Alexia (2006) emphasize continued supply. Probably this is because the developed world has overcome operational problems and supply is assured while the developing worlds are engulfed in a series of operational problems (such as unreliable power supply, lack of chemicals, spare parts, equipment and skills, insufficient financial resources etc) and the issue is whether water at the taps can continue flowing.

Lundin and Morrison (2002), ranked sustainability of systems into four levels: A, B, C and D depending on the score on identified indicators. At the lowest level (D) the basic objective of ensuring human health is not met while at the highest level (A), the system not only meets the basic requirements but also operates efficiently. Schilling (2004) agrees but divides the levels in descending order as resting, sleeping, booming and crawling. Shuping etal, (un-dated) recommends the four levels as well.

This study considered both the continued supply of water and environmental concerns. It categorized sustainability into five levels A, B, C, D and E (i.e. very good, good, fair, poor and very poor respectively).

2.3 Factors Affecting Sustainability of Water Supply Systems

According to Beers (2006), sustainability in rural areas is hampered by dispersed habitat, limited financial resource, and lack of skills to manage complex maintenance requirements of complex technologies such as hand pumps. He further stresses institutional arrangements (legal framework, policy, strategy issues, monitoring etc), social context (community issues, religion, local leaders, pro-poor arrangements etc), technical issues (adapted technology, spare parts, cost recovery etc) and environmental factors (availability and quality of water resources, etc) as the factors that affect sustainability.

Koestler (2008) identified suitable management model (community management, private sector management or a combination of the two) for levels of economic development, and efficient and sustainable support mechanisms as crucial for sustainability.

Khatri and Vairamoorthy (2007) identified climate change, population growth and urbanization, globalization and economic development, deterioration of infrastructure, governance and privatization, changes in the public behavior, emerging technologies, risks on critical infrastructure systems and increase in fuel costs but stresses climate change, population growth & urbanization, and aging & deteriorating infrastructure as the main ones.

Although a great number of factors have been reported to affect sustainability of water supply systems, seven major factors come out, namely: institutional arrangement (model of management, support mechanism, etc), social- political context (community issues, religion, cultural beliefs, settlement pattern, population growth rate, urbanization etc), technological issues, environmental factors (availability of water resources, climatic change etc), economic issues (limited financial resources, increase in fuel costs, etc), aging and deteriorating of infrastructure and implementation approach. Due to the time and resources limitation, and because the areas to be studied followed a relatively similar approach in implementation and institutional arrangement, the remaining five factors of age, technology, social political, economic and environmental factors will be studied under this study. In the next section the researcher reviews how each of the factors affects sustainability of water supply systems.

2.3.1 Age and Sustainability of Water Supply Systems

Age and poor maintenance of the infrastructure are some of the challenges in water infrastructure sustainability (Mwakalila, 2007). As the system ages, its components break down more frequently necessitating overhaul and replacement which results in reduced supply hours, water quality and collections but increased leakages and expenditures (Alexia, 2006) and (NEWAH, 2006). However, this contradicts with other authors such as SWTWS (2006) and Abrams (2001) who argue that age should not be an issue as a sustainable system should plan early and raise enough money so that it is able to replace the aging components when the need arises.

There seem to be no research specifically conducted in Uganda to establish the relationship between age and sustainability of water supply systems. The available literature, however, seem to be contradictory. For example, whereas some of the water supply systems have been reported in SWUWS (2008) to have failed within the second year of operation, MWE (2008) reports some systems that have been running well beyond their design period of 20 years and yet SWTWS (2006) claims that age should not be an issue as a sustainable system should plan early and raise enough money so that it is able to replace the aging components when the need arises.

2.3.2 Technology and Sustainability of Water Supply Systems

In this study, technology refers to the type of source of water and the type of power source. The type of source of water influences the quality of raw water and treatment requirements and as found out by Tiwaitu (2007) water from deep wells is sometimes hard which leads to system abandonment. Bariira (2001) reported abandonment of boreholes because of objectionable tastes of their waters. DWD, (2000) prefers springs, boreholes and surface water in this order because of the quality of the raw water and the likely ease of treatment.

The sources of power commonly used to pump water range from manual, gravity, solar, national grid and petroleum based products (DWD, 2000). According to Bariira (2001) boreholes were shunned because it is strenuous to use the hand pumps and are sometimes abandoned when they breakdown because of lack of spare parts and limited skills in their repairs.

According to Kesavan, etal, (2008) and Alexia, (2006) simple technologies (low cost, easier to maintain, simple to use and readily available) such as gravity flow schemes are easier to sustain. The technology chosen has a bearing on skills and costs required for maintenance and therefore sustainability of a water supply system. Although the studies conducted in Uganda such as Tiwaitu (2007) and Bariira (2001) agree with these findings, the Ugandan studies seem to have concentrated on point source (boreholes and springs) where human power is the only source power used to deliver water from the source to the consumers and none targeted the piped water supply systems.

2.3.3 Social-Political Dynamics and Sustainability of Urban Water Supply Systems

Social political dynamics such as political pressures, community resistance, community conflicts and population growth) influence sustainability. According to Guio-Torres (2007), some of the challenges faced by urban water supply systems are: the centres are growing in population and territory but water with good quality is becoming scarcer, extension and maintenance of the existing systems is increasingly expensive and financial resources are not enough for the works, conflicts are arising with other users upstream and down stream due to effects of existing urban water supply systems.

Where as rapid population growth leads to increased consumption which may not be satisfied by the available sources and infrastructure (Khatri and Vairavamoorthy, 2007), declining population results in under utilization of the infrastructure and poor financial well being of the system (SWTWS, 2006). Furthermore, Hummel and Lux, (2007), found out that migration changes population distribution, density, household population structure and age composition which enhances different lifestyles and therefore changes in amount of water consumed.

Political pronouncements, such as “water is a social good”, result in a no “cost –recovery” tariff and un-willingness to pay. Community resistance leads to vandalism, illegal connections and unpaid bills (SWTWS, 2006).

The relationship between social political-dynamics of a given area and the sustainability of water supply systems in the area has hardly been researched ion Uganda. Therefore this research could be the first attempt to study the relationship between social political-dynamics of a given area and the sustainability of water supply systems within the area.

2.3.4 Affordability and Sustainability of Water Supply Systems

Milne (2004) defines affordability in utilities as “the ability to pay for necessary levels of consumption within normal spending patterns. There are a number of systems to measure affordability of services. Development banks and financing institutions generally consider that expenses on water and sanitation should not exceed 5% of the household income (Frank et al, 2007). Other systems advanced by Milne (2004) are: household bills in arrears, disconnections for debt, percentage of income and percentage of spending. In Uganda, affordability of water services is measured using two methods; one by establishing the percentage of people that purchased any water in the previous month and establishing the share of household expenditure allocated to water (MWLE, 2003).

For this study, the direct method of measuring affordability by asking the beneficiaries to indicate whether water is affordable or not was adopted because most of the beneficiaries in the study water systems were known to be none salary earners and therefore their income s hard to estimate which rendered the 5% of household income not suitable and because the majority use public kiosks and are not connected to other utilities (such as electricity, telephone etc) and therefore disconnections for debt, household bills in arrears and percentage of expenditure could not apply.

According to Alexia, (2006) and Khatri & Vairavamoorthy (2007), the social economic status of the beneficiaries determines affordability of the service. Affordability determines usage and as Len (2001) states “a system where 20% of the intended beneficiaries (the poor) cannot use the system because of the cost cannot be said to be sustainable”. Setting up of a full cost recovery tariff is necessary for sustainability but full cost recovery may not be affordable (Frank et al, 2007).

Previous studies conducted in Uganda such as UPPAP (Undated) and UNHS (1999) as reviewed in (MWLE, 2003) established that affordability is not an important concern and therefore it should not affect sustainability of the systems.

2.3.5 Use of Alternative Water Sources and Sustainability of Water Supply Systems

When a system is not reliable or is not affordable the community will seek and invest in alternatives and if there are no feasible alternatives, community members will put in extra efforts such as foregoing other essentials to ensure that the only system is sustained (SWTWS, 2006) and (Shuping et al, undated) . This agrees with the findings of other studies conducted in Uganda such as Koestler (2008) who attributed success in sustaining hand pumps in Katakwi and Amuria districts to high motivation to maintain their sources because of limited alternatives. According to Mengesha et al (2002) reasons for use of alternative sources are system breakage, long distances to the source, inability to pay the service fee, quality of water and lengthy waiting time for water collection at a congested source.

2.4 Summary of the Literature Review

This study is grounded in systems theory (Bertalanffy, 1968) and threshold theory (Len, 2001). Sustainability of water supply systems is an issue affecting all nations whether developed or developing. Whereas authors in developed countries measure sustainability by environmental impact those in developing countries emphasize continued supply of water at the tap. Studies have greatly concentrated on factors that affect system's components (i.e. age, technology and affordability) and largely ignored factors that affect the system's environment (i.e. social political dynamics and use of alternative sources of water).

In this study, emphasis will be put on fulfilling both service quality and ecological requirements and therefore factors that affect the system's components and the system's environment will be examined.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This chapter explains the methodology that was used in the study. It covers the research design, the area of study, study population, sampling, data collection methods and instruments, procedure for data collection, measurement of variables and data analysis.

3.1 Research Design

This study used correlational cross-section survey design that involved triangulation (i.e. use of multiple data collection techniques). The study examined how age, technology, social-political dynamics, affordability and use of alternative water sources affect sustainability of piped urban water supply systems in South Western Uganda. The correlation design was chosen because according to Kombo and Tromp (2006, p. 71) and Mugenda (2008, p.67&282) correlation designs enable a researcher to assess the degree of relationships that exist between two or more variables.

3.2 Study Population

According to Sekaran (2003, p. 265), population refers to the entire group of people, events or things of interest that the researcher wishes to investigate. From SWTWS (2008), total number of systems that fall within the scope of this study was 16. For this study, the study population are the 16 urban piped water supply systems. Basing on the Krejcie and Morgan sample size selection table (1970; cited in Sekaran, 2003), all the 16 water supply systems were studied. The population of each of the urban centres was estimated to range from 800 people to 10,000 people. Due to the limited time frame of this study and the need to collect data from relevant sources purposive stratification was used to obtain the accessible population. Three categories (i.e. system operators, water board members and household heads) were purposively identified based on two main criteria, namely: (a) the active role of the stakeholder on the management of the water supply system, and (b) the extent of the likely involvement of the stakeholder on taking a decision on use of, and payment for the service. Table 1 shows categories of the accessible population which total up to 2,696 people. Out of this population are 16 water supply system operators, 80 water board members and 2,600 heads of households.

3.3 Sample Size and Selection

The sample size was determined through non-probability means using the Krejcie and Morgan sample size table (1970) as adopted by Sekaran (2003). The sample size table method was preferred to other methods because it is simple to use as the only information required to use the table is the population size. Based on the stratified information given in table 1 the sample size is determined as 562 which is composed of all the 16 water supply system operators, 66 of the 80 water board members and 480 of the 2,600 household heads.

Table 1: Categories of Study Population and Sample Size:

No.	Study Population Category	Accessible Population	Sample Size	Sample strategy
1	System operators	16	16	Purposive sampling
2	Water board members	80	66	Purposive sampling
3	User household heads/ representatives	2,600	480	Area and random sampling
	Total	**2,696**	**562**	

*Sample size for system operators and water boards was determined using the Krejcie & Morgan (1970) sample size table while a minimum of 30 respondents per scheme was considered for the "should be users " as recommended by Roscoe (1975) in Sekaran 2005, p.295) when the samples are to be broken into sub-samples.

3.4 Sampling Techniques and Procedure

The sampling was based on both probability and non-probability sampling techniques. The sample from the household heads was selected using a two stage sampling technique where area sampling followed by simple random sampling was used. The area sampling was chosen because it is less expensive than most other probability sampling designs (Sekaran, 2003, p.275) and ensures that pertinent information especially on quality of service is collected. Samples were chosen from the water supply area zones such as areas closest to the source, areas farthest from the source, the high pressure and low pressure zones, the central business and the fringe areas. Households within these zones were randomly selected. The none-probability sampling technique of purposive sampling in which the researcher chooses subjects who, in his opinion, are relevant to the study and are capable of providing the desired information as recommended by (Sekaran, 2003, p.277) was used to get water supply system operators and the water board members.

3.5 Data Collection Methods

Both secondary and primary data was collected using documentary review, observation and interview methods.

Documentary review

Existing documents such as design reports, system operators' reports and SWUWS reports were used to get information on age of the systems, yield and quality of water to establish stability, and system functionality. This method was preferred to others because it is saves time and money and it helps to validate data collected using other methods (Sekaran, 2003, p.223). Some of the information required such as stability of the source quality and quantity could only be obtained by looking at the different results obtained over the years.

Observation

Observation method was used to supplement data collected using other methods on state of the physical infrastructure, use of alternative sources and the technological options applied in developing the systems. Observation method was chosen because it is one of the most common ways of finding out about things and it helps the researcher to collect first hand information about objects which is more valid than reported information in other methods (Amin, 2005, p.170) and (Kothari, 2004, p.96)

Interview

Semi-structured personal interviews were conducted with system operators, household representatives and board members to collect data on all the variables. Although interviewing as a method is comparatively more costly and time consuming, it was chosen because most of the respondents were known to be semi-illiterate and therefore not able read and handle complex and long questionnaires. Furthermore, according to Amin, (2005), it gives more clarity and yields the biggest response rate. Interviewing gave the researcher insight into the water users' the board members' and the operator's thoughts, ideas and memories in their own words rather than those of the researcher. Further more the face to face interaction helped the researcher to delve deeper into the issues and to clarify any doubts that would arise.

3.5.1 Data collection instruments

Observation checklist and semi structured questionnaire (see appendix 2 & 3) are the instruments that were used in collection of primary data while documentary review structured forms was used to collect secondary data (see appendix 1).

Documentary Review Structured Form

Structured forms were used to collect secondary data from available reports as recommended by Kothari (2005, p.110). Appendix 2 gives the documentary review structured forms used.

Observation Checklist

Structured observation checklist as recommended by Amin (2005, p.170) and Kothari (2004, p.96) were used to collect data on state of physical infrastructure and use of alternative water sources. Appendix 2 gives the structured observation checklist used.

Semi-Structured Questionnaire

Both qualitative and quantitative data was collected using interviewer administered semi-structured questionnaire. This type of questionnaire was chosen because it largely provides fixed choice answers and has room for more detailed responses for better understanding of certain issues. The fixed choice answers provide uniformity of responses that can easily be compared from person to person, are easier to analyze and are economical in terms of time and money. Appendix 3 gives the questionnaire that was used.

3.5.2 Pre-Testing (Validity and Reliability)

The developed data collection instruments and the recruited-and-trained research assistants were tried in Kabwohe town water supply system which was seen to portray characteristics similar to the other study systems. An assessment of the data obtained and the feedback from the respondents helped the researcher to revise, refine and improve the instruments before they were used to collect the actual data. Improvement of the instruments included addition of coding numbers in the questionnaire, rephrasing some questions, addition of an extra question and deleting questions which the respondents identified to seem to have been repeated or seemed irrelevant to the study.

Validity

Validity is defined as the degree to which an instrument measures what it purports to measure (Mugenda, 2008, p. 256). The validity of the research instruments was checked using face and content validity approaches, the objective of which was to ensure that the instruments included an adequate and representative set of items that tap the key concepts of the study. This was done using the expert judgment of both the work-based supervisor and UMI-based supervisor, as suggested by Sekaran (2003, p.206) and Amin (2005, p.286). Secondary, prior to distribution of the data-collection instruments, the draft formats were discussed with both the work-based and UMI-based supervisors, corrected and refined until an acceptable format was drawn up.

Reliability

Reliability is a measure of the degree to which a research instrument would yield the same results or data after repeated trials (Mugenda, 2008, p.250). The observation method was used to collect data on the physical state of the infrastructure. As recommended by Mugenda (2008, p.251) the inter-ratter method of estimating reliability was used. Four research assistants independently collected data on the state of repair of the water source, tanks, office and kiosks in Kabwohe, the pre-test rural growth centre (RGC) where each of the infrastructure were examined and rated basing on a 5 point scale where 5 is the very well maintained and 1 is very poorly maintained. A total of 15 items were rated and the results from the four research assistants were correlated. Table 2 shows the resultant inter-rater matrix which shows very strong, significant positive correlations and therefore no need for re-training of the research assistants.

Table 2: Inter-Rater Correlation Matrix

		RA1	RA2	RA3	RA4
Research Assistant 1 (RA1)	Pearson Correlation	1	.827(**)	.839(**)	.730(**)
Research Assistant 2 (RA2)	Pearson Correlation	.827(**)	1	.817(**)	.814(**)
Research Assistant 3 (RA3)	Pearson Correlation	.839(**)	.817(**)	1	.778(**)
Research Assistant 4 (RA4)	Pearson Correlation	.730(**)	.814(**)	.778(**)	1
N=15; ** Correlation is significant at the 0.01 level					

3.6 Procedure of Data Collection

Data collection instruments were developed, research assistants recruited, trained and tried in Kabwohe RGC. Data obtained was assessed and it helped the researcher to revise, refine and improve the instruments; and retrain the research assistants. Appointments were made with the respondents, interviews and observations conducted, and data collected.

3.7 Measurements of Variables

Nominal, interval and ratio scales were used to measure variables. According to Sekaran (2005, p.185-192), nominal scales allow a researcher to assign subjects to certain mutually exclusive and collectively exhaustive categories, ordinal scales allow the researcher to not only categorize the subjects but also to rank-order the categories, the interval scale lets the researcher measure the magnitude of the difference between any two points on the scale, while a ratio scale in addition to having the properties of all the other scales taps the proportions in differences and has a unique zero origin. The nominal scale of measurement was mainly used on the general information about the respondents and the water supply system which comprise items such as gender, occupation and technology. Ordinal scale was used where elements not only required categorization but also ranking in some orders such as highest completed level of education and state of repair of the systems infrastructure. Ratio scale was used where exact numbers on objective (as opposed to subjective) factors are called for such as age of the system. The use of the scales on the variables is summarized below:

3.7.1 Age of the system

The age of the system (measured in years from the time the scheme started operating to the time of collecting the data) was measured using a ratio scale.

3.7.2 Technology

Technology refers to the type of source of water (i.e. spring, river/stream, lake, hand dug well, borehole), and source of power for pumping the water into the system (i.e. gravity, solar, grid, petroleum products). It was measured on a nominal scale.

3.7.3 Social –Political Dynamics

Social –Political dynamics were measured on a ratio scale using frequency of occurrence of conflicts and population growth which was defined as the percentage of the population that is constituted by the "newcomers" (respondents who were not yet resident in the water supply area at the time the system started operating).

3.7.4 Affordability

Affordability was measured by determining the percentage of households that said their water tariff was affordable.

3.7.5 Use of Alternative Water Sources.

Use of alternative water sources was measured by determining the percentage of the population who reported use of alternative sources of water most of the times.

3.7.6 Sustainability of Water Supply System

The researcher used performance indicators to measure sustainability of the water supply systems, which according to Lundin (1999) is a common procedure for water utilities wishing to monitor their performance in comparison with others. A total of eight indicators were developed and grouped into two dimensions basing on the requirement to fulfil the two major objectives of the systems: continuous provision of quality service and fulfillment of the environmental requirements.

The indicators used to measure the system's capacity to fulfil the service quality requirement were functionality, effective usage, perceived water quality, state of the physical infrastructure and financial wellbeing. Indicators for measuring the system's capacity to fulfil environmental requirements considered the system's likelihood to adversely impact on its upstream environment and signs of environmental degradation within its source catchment. The system's possibility to negatively impact on its upstream environment was measured by the percentage of the system's safe yield that is left untapped. Signs of environmental degradation within the system's catchment were measured by the seasonal stability of source quality and source yield (quantity).

All the indicators, the system's capacity to fulfill service quality requirement, the system's capacity to fulfill environmental requirements and the overall system sustainability were measured on a percent scale where a system that scores 100% is the best performer and the one that scores zero is the worst performer. The system's capacity to fulfil service quality requirements and the system's capacity to fulfil environmental requirements were measured by obtaining the mean scores on all the indicators under the requirements while the overall sustainability of the system was computed by obtaining the mean score of the capacity to fulfil service quality and capacity to fulfil environmental requirements. In the next section, we detail how each of the above sustainability indicators were measured.

3.7.6.1 Functionality

In this study, a system is said to be fully functional if it has an operator, a constituted board that meets as regularly as required (12 times a year), keeps audited books of accounts and supplies water to the beneficiaries 24 hours per day. Functionality was measured by establishing the level to which the system fulfils these functionality indicators. A system with an operator, a constituted board and with audited books of account would score 100% on each while the system without any of these would score 0% on each of the missing indicator. The performance of the systems on the remaining indicators (24-hours-per day supply requirement, record keeping, and board meetings) was measured by obtaining the percentage of the requirement met. For example a system that on average supplies water for 8 hours per day would score 8/24 x100 which is equal to33.3%, a system that met 6 times in 2008 would score 6/12 x 100 which equals 50% while a system that keeps 2 of the three major records would score 2/3 x 100 which is 66.67%.

Functionality of the systems was computed as the mean score on all the indicators. In this study, however, all the systems were found to have functional water and sanitation boards, system operators and they had audited books of account and variation in functionality was therefore limited to the mean score on percentage of the required 24-hours-per day supply requirement met, percentage of the three major records (minutes, receipt books and accounts register) kept and the percentage of the12 board meetings expected in a year 2008 held.

3.7.6.2 Effective Usage

Effective usage was defined as the percentage of actual consumption over the expected consumption. It was computed as outlined below:

- The design population (P_d) was projected to the 2008 population (P_{2008}) using the formula $P_{2008} = P_d\ (1+r)^{n}$ taking population growth rate (r) as 3% and n as the system age.
- The projected population was multiplied by the daily per capita consumption of 20 litres and 30 days to get the expected monthly consumption.
- Actual monthly consumption which was obtained as secondary data was divided by the expected consumption and multiplied by 100 to get the effective usage.

3.7.6.3 Perceived Water Quality

Respondents were further required to rate (on a 5 point scale ranging from5= very good to 1= very poor) the suitability of their water for cooking, washing and drinking. The overall perceived water quality for a respondent was computed by computing the mean rating for the three main purposes. The perceived water quality for the entire system was established by computing the mean for the individual scores of all the respondents in the particular system. The perceived water quality was converted to a percent scale by dividing the mean score by the maximum possible score of 5 and the result multiplied by 100. For example, a scheme with a mean score of 4 would score 4/5 x100 which is 90%. This was done in order to match and facilitate further computations with the other indicators which were measured on the percent scale.

3.7.6.4 Financial Wellbeing

Financial wellbeing was defined as the ability of the system's revenue to pay for operating expenses. It was measured by computing the mean of the profitability ratio, collection efficiency and survival on savings. Collection efficiency, profitability ratio and survival on savings were computed (basing on the 2008 South Western umbrella of Water and Sanitation secondary data) using the formulae below:

1. $$\text{Collection efficiency} = \frac{\text{amount collected}}{\text{Amount billed}} \text{x100}$$

2. $$\text{Profitability ratio} = \frac{\text{(Sales - Expenditure) x100}}{\text{Sales.}}$$

3. $$\text{Survival on savings} = \frac{\text{Total savings x 100}}{\text{Annual expenditure}}$$

3.7.6.5 State of the Infrastructure

Through observation, the state of repair of the physical infrastructure (comprising of the water source, reservoir tanks, office and the public tap stands/kiosks) were rated using a 5 point scale of very good (5), good (4), fair (3), poor (2) and very poor (1). The overall state of the physical infrastructure was computed as the mean rating. As in the perceived water quality indicator, this was converted to a percent scale by dividing the mean score by the maximum possible score of 5 and the result multiplied by 100 in order to facilitate further computations with the other indicators which were measured on the percent scale.

3.7.6.6 Percent of the Source Yield Left Untapped.

According to MWE (2000), at least 30% of the system's source yield should be left for the environment. In this study, a system that leaves at least 30% of its yield untapped scores 100% while a source that leaves less than 30% scores a correspondingly less percentage. For example, a system that leaves only 20% of its source yield untapped would score 20/30 x 100 which is 66.67%.

3.7.6.7 Stability of the Source Yield (Quantity)

A water source yield is the lowest quantity of water that a water source can provide and is usually measured at the end of the driest period in a year. A good water source should have minimal seasonal variation as a large seasonal variation implies surface water which is prone to contamination by surface runoff (MWE, 2000). Because there was no secondary data on seasonal variation of the source yield (quantity) and it was not feasible to collect primary data because of limited time, the researcher used seasonal stability of the supply to measure the seasonal stability of source yield. Respondents were requested to indicate whether they notice any seasonal variation in the quantity supplied. The percentage of the respondents that reported seasonal stability of the supply was taken as a measure of water source yield stability.

3.7.6.8 Stability of the Source Quality

Stability of source quality was measured using the coefficient of stability of turbidity (a measure of how clear the water is). The coefficient of stability was computed using the formula below:

Coefficient of stability = 100-coefficient of variation

$$\text{Coefficient of variation} = \frac{\text{Standard deviation x 100}}{\text{Mean}}$$

Table 3 summarises the measurement of sustainability, capacity to fulfil service quality requirements, capacity to fulfil environmental requirements and all the indicators.

Table 3: Measurement of Sustainability of Water Systems

INDICATORS	REQUIREMENT	SCORING BASIS	MAX. SCORE
	Service on a 24 h/day basis, system operator recruited and a board that meets regularly and keeps audited records in place	Daily supply hours/24 x100	100
		100 operator present, otherwise 0	100
		100 board present, otherwise 0;	100
		No of meetings in a year x 100/12	100
		Percent of the three (Minutes, receipt books, accounts register) records kept.	100
		1 for annual audits, otherwise 0	100
1. Functionality	= mean score on the above indicators		100
2. Effective usage	Capacity usage correspond to age	Actual consumption x100 / Projected consumption	100
3. Water quality	All users perceive good quality.	Fraction of users that perceive good quality	100
	Source, tanks, office & kiosks maintained in good state.	Each of the components will score marks according to the judgement as indicated: Very good (5), good (4), fair (3), Poor (2), Very poor (1)	
		Source.	5
		Reservoir tank.	5
		Office.	5
		Kiosks.	5
4. State of infrastructure	Mean score on the source, tank, office and kiosks x 100/5		
5. Financial wellbeing	Profitability ratio	Profit x 100/Sales	100
	Collection efficiency	Collections x100/consumption	100
	Survival on total savings	Total savings x100/Mean annual expenditure	100
A. Capacity to fulfil service quality requirements = Mean score on functionality, effective usage, perceived water quality, state of the physical infrastructure and financial wellbeing.			100
6. Percentage of the source yield left untapped	At least 30% of the system's source yield should be left for the environment	A system that leaves at least 30% of its yield untapped scores 100% while a source that leaves less than 30% scores a correspondingly less percentage	100
7. Source quality stability	Stable source quality	Coefficient of variation of source turbidity	100
8. Source quantity stability	Stable source quantity	Coefficient of variation of source yield	100
B. Capacity to fulfil environmental requirements = mean score on source quality stability, source yield stability and percent of the source tapped.			100
C. Sustainability =mean score on capacity to fulfil service quality requirements and capacity to fulfil environmental requirements			100

Adapted from: Lundin & Morrison (2002), Cubillo (2003), Schilling (2004) and Shuping etal, (2008)

3.8 Data Analysis

The collected data was edited by examining the raw data to detect errors or omissions and correct them when possible. Editing was done to ensure that data are accurate, consistent with other facts gathered, uniformly entered and well arranged to facilitate coding and tabulation as recommended by Kothari (2004, p.122). Coding which refers to the process of assigning numerals or other symbols to answers so that responses can be put into a limited number of categories was included in the instruments so as to make it possible to key punch from the original instruments and minimize coding errors. The raw data was manually keyed into the computer through SPSS computer package.

The data was analyzed using three major categories of data analysis namely: descriptive analysis, inferential analysis and narrative analysis. Under descriptive analysis, frequency distribution tables were used to describe the demographic composition of respondents, technological options of the water supply systems and the social-political dynamics of the system supply areas. Inferential analysis was carried out to establish the magnitude and direction of relationship between sustainability and the quantitative independent variables of age, use of alternative sources and affordability. Under the narrative analysis, qualitative data collected through the un-structure parts of the questionnaire were examined organized and reconfigured. The emerging patterns and common themes emerging in responses dealing with specific items were identified, summarized in forms of recurrent responses and the interesting stories emerging from the responses were narrated. The results were interpreted and recommendations made.

CHAPTER FOUR

PRESENTATION, ANALYSIS AND INTERPRETATION OF FINDINGS

4.0 Introduction

This chapter presents the findings of the study, the analysis and interpretation. The findings are based on primary quantitative and qualitative data that was collected from a cross-section of respondents selected in accordance with sampling procedure that was presented in chapter three. The primary data is supplemented with secondary data that was collected from pertinent documents that were obtained from the water supply system operators, the South Western Umbrella of Water and Sanitation (SWUWS), South Western Towns Water and Sanitation (SWTWS) Project and the Ministry of Water and Environment.

The findings are presented, analysed and interpreted using descriptive, relational, and inferential statistics. The researcher utilised statistical measures such as frequencies and measures of central tendencies, followed by tests for correlations between independent variables and the dependent variable. The presentation, analysis and interpretation were done following the respective study objectives.

4.1 Response Rate

The respondents who participated in this study comprised of the system operators, water and sanitation board members, users and none users. A total of 16 water supply schemes were studied and as expected when one uses interviewing to collect data, the study was able to get good response (95.9%) from all the categories of the respondents. Table 4 shows that all the 16 water supply system operators (100%), 46 of the 48 water board members (69.7%), 477 of the 480 targeted (99.4%) water users responded.

Table 4: Response Rate

Description	System operators	Board members	Users	Total
Targeted number of respondents	16	66	480	562
Total number of responses	16	46	477	539
Response Rate (%)	100	69.7	99.4	95.9

The study attracted a relatively low response from the board members (69.7%) because some board members especially sub-county chiefs and councillors who were in most cases none-residents and none-beneficiaries were difficult to get for the interviews. In Rwenshama, the board chairperson was too sick to be interviewed; as a matter of fact, he passed away that same evening he was to be interviewed.

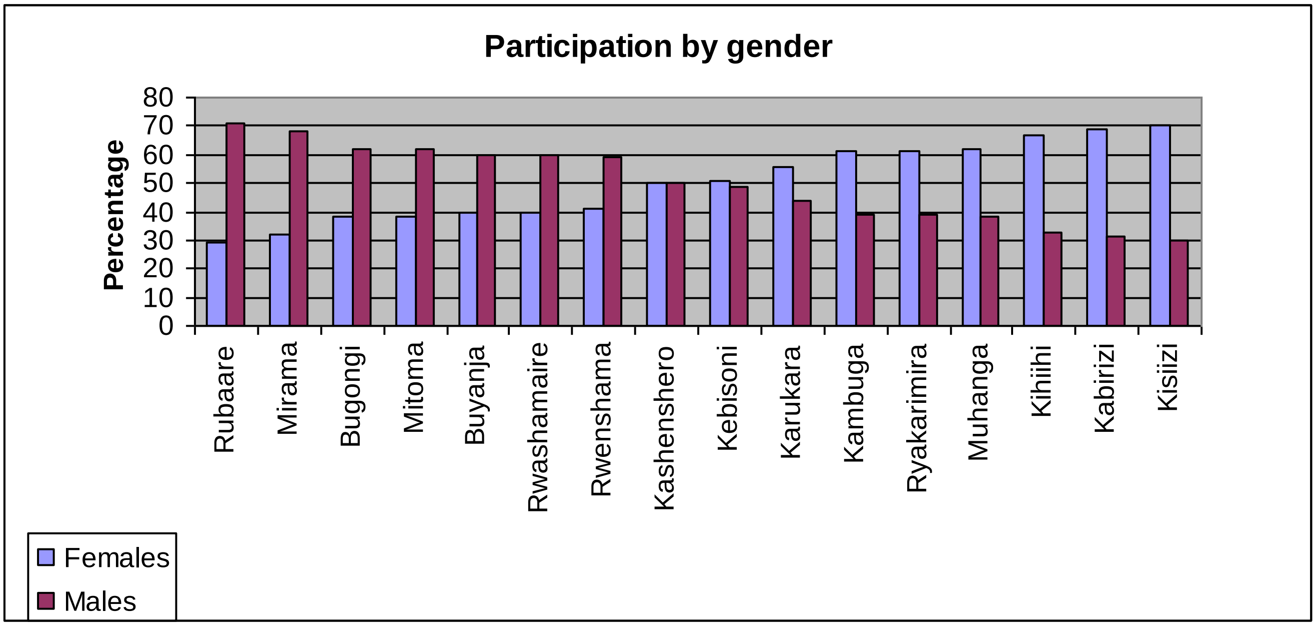
4.2 Demographic Characteristics of the Respondents.

This section presents the findings on the respondents' gender, age and highest level of education attained all of which were considered important for this study.

4.2.1 Gender of the Respondents

The gender of the respondents was considered important for two reasons. One; women are known to be the main users of the water supply systems and therefore more likely to be affected by a failed system. Women were therefore expected to be more knowledgeable on issues such the quality of the water and the frequency of water supply system breakages. Men on the other hand are known to be the financiers and were therefore expected to be knowledgeable on issues of affordability. To ensure more balanced information, the researcher ensured that both men and women were represented in the respondents. Figure 3 is a bar graph showing participation by gender in each of the system.

Figure 3: Participation by Gender



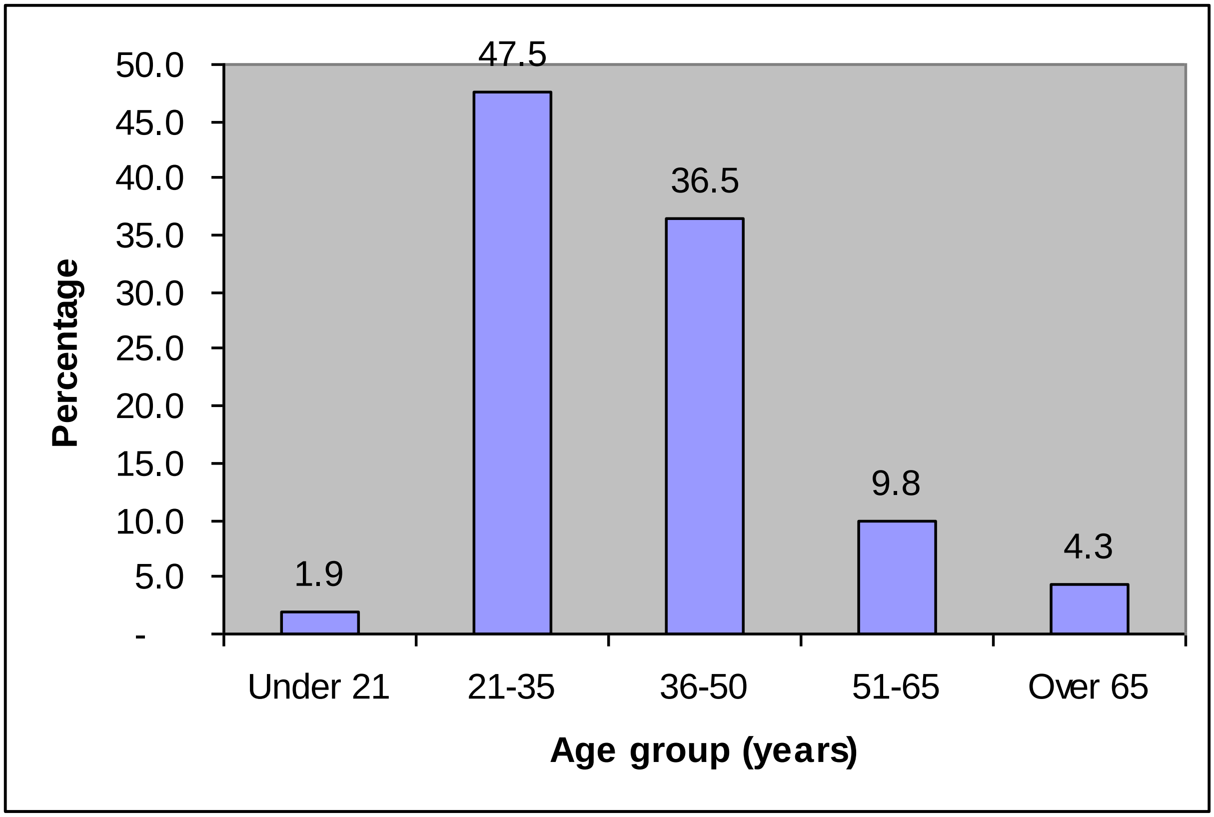
The response from all the water supply systems was 50% females and 50% males. However there was a big variation within the individual water supply systems. Rubaare had the lowest female participation at 29% and the highest male participation at 71% while Kisiizi had the highest female participation at 70% and the lowest male participation at 30%. Kashenshero had the most balanced participation at 50% for both females and males.

4.2.2 Age of the Respondents

The researcher considered age of the respondent as an important factor in gauging the extent to which the respondent understood the dynamics of water supply system sustainability, is actively involvement in economic activities and therefore contributing to sustainability of the systems by directly paying for the service. To that effect the respondents were required to give their age in the instrument, results of which are presented in the figure 4 below which shows that the 21 to 35 years age group (47.5%) dominated the respondents followed by the 36 to 50 years age group (36.5%).

Figure 4 further shows that only 4.3% of the respondents were over 65 years and 1.9 % of the respondents were below 20 years.

Figure 4: Age groups of the respondents



The age groups that are actively involved in economic activities and therefore contributing to sustainability of the systems by directly paying for the service (i.e. (21-35 and 36-50) constituted 84% of the respondents.

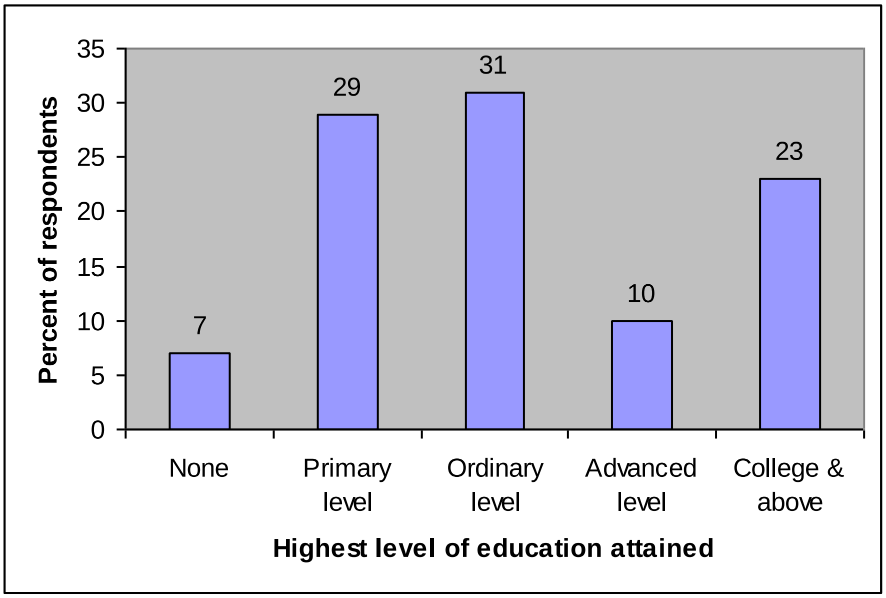
4.2.3 Highest Level of Education Attained by the Respondents

The highest level of education attained by the respondents was considered important for two reasons. One, it would help the researcher to gauge the extent to which the respondent understood the dynamics of water supply system sustainability and two, it would prove or disapprove the assumption made in choosing the interview method of data collection that most of the respondents are semi-illiterate and would therefore not understand the questionnaire. Table 5 shows that Rwenshama had the highest number of people who did not complete any level of education (22%) followed by Kabirizi (19%). At 50%, Rubaare had the highest number of respondents who had completed college and above.

Table 5: Respondents' Highest Level of Education Attained.

Name of the system	Number of respondents	Percent of the respondents that had attained level of education				
		None	Primary Level	Ordinary level	Advanced level	College & above
Bugongi	34	6	24	26	9	35
Buyanja	35	6	40	29	3	23
Kabirizi	32	19	31	22	6	22
Kambuga	33	6	30	33	18	12
Karukara	34	12	38	15	15	21
Kashenshero	34	0	26	26	9	38
Kebisoni	35	3	20	31	11	34
Kihiihi	33	0	30	39	9	21
Kisiizi	33	0	45	36	9	9
Mirama	34	6	15	35	32	12
Mitoma	34	6	15	41	6	32
Muhanga	34	12	24	44	3	18
Rubaare	34	3	6	32	9	50
Rwashamaire	35	6	11	37	17	29
Rwenshama	32	22	53	19	0	6
Ryakarimira	33	12	52	21	6	9
Total	**539**	**7**	**29**	**31**	**10**	**23**

Figure 5: Highest Level of Education Attained by the Respondents



Over all, the biggest number (31%) of the respondents had attained ordinary level followed by primary level (29%), college and above (23%), advanced level (10%) and those that had not completed any level of education 7%.The majority of the respondents (93%) had attained at least primary level of education and could therefore understand the topic under study.

The proved right the assumption made in choosing the interview method of data collection that most of the respondents are semi-illiterate and would therefore not understand the questionnaire. Overall, 36% of the respondents (7% that had not completed any level of education and 29% that had completed primary level) could not understand the questionnaire and fill it on their own. In some schemes such as Rwenshama (75%), Ryakarimira (64%), Karukara (50%) and Kabirizi (50%) the majority of the respondents would never understand and fill the questionnaire on their own.

4.3 The Independent Variables

This section presents the findings on the independent variable, namely, age of the systems, technology, social political dynamics, affordability, use of alternative sources and technology. The findings are summarised in table 6 below.

4.3.1 Age of the water supply systems

Age of the system refers to the period in years from the time the system started operating to March 2009, the time of collecting data for this research. The time the systems started operating was collected from secondary data from the end of implementation report for South Western Towns Water and Sanitation Project, the South Western Umbrella of water and sanitation database and from the individual scheme records, namely, the accounts registers, minutes and receipt books. Table 6 shows that Rwenshama water supply system had the lowest age of 2 years, Muhanga had the highest age of 13 years and that the average was 7.3 years.

4.3.2 Social-political dynamics

Social-political dynamics was defined in section 1.10 in terms of population growth and conflicts.

4.3.2.1 Population Growth Rate

For this study, population growth was defined as the percentage of the population that is constituted by the "newcomers". This statistic was considered very important for this study because the newcomers would have missed programs geared towards creating a sense of ownership of the system and building the capacity for operation and maintenance of the system. A system with a bigger number of newcomers is therefore expected to be less sustainable than one with a lesser percentage of newcomers.

The results, as indicated in the table 6 show that the biggest percentage of newcomers was in Kebisoni (70.3%) followed by Kihiihi (67.6%) while the lowest was in Rwenshama (15.9%) and the average was 51.9%. This implies that in most of the towns the majority of the residents are "new - comers" The lowest increase in Rwenshama is attributed to the fact that the system was the youngest system.

Table 6: The Independent Variables

SCHEME	AGE (YRS)	SOCIAL-POLITICAL DYNAMICS		AFFORD-ABILITY (%)	USE OF ALTERN-ATIVE SOURCES (%)	TECHNOLOGY	
		POP'N GROWTH (%)	CONFLICT (%)			SOURCE	POWER
Bugongi	5.0	57.4	14.7	88.2	2.9	Spring	Gravity
Buyanja	9.0	61.4	34.3	80.0	28.6	Borehole	Grid
Kabirizi	9.0	64.3	50.0	68.8	50.0	Spring	Gravity
Kambuga	12.0	40.0	27.3	78.8	27.3	Spring	Gravity
Karukara	8.0	50.5	52.9	70.6	38.2	Spring	Gravity
Kashenshero	4.0	25.8	8.8	94.1	11.8	Spring	Gravity
Kebisoni	9.0	70.3	34.3	74.3	25.7	Spring	Gravity
Kihiihi	9.0	67.6	27.3	78.8	36.4	Spring	Solar
Kisiizi	8.0	59.6	27.3	81.8	45.5	Spring	Gravity
Mirama	3.0	59.1	17.6	100.0	0	Spring	Gravity
Mitoma	5.0	35.9	8.8	94.1	14.7	Spring	Grid
Muhanga	13.0	58.3	50.0	67.6	38.2	Spring	Gravity
Rubaare	4.0	61.4	8.8	97.1	5.9	Borehole	Grid
Rwashamaire	6.0	35.9	17.1	91.4	11.4	Spring	Grid
Rwenshama	2.0	15.9	12.5	87.5	6.3	Borehole	Solar
Ryakarimira	11.0	66.9	33.3	69.7	9.1	Spring	Solar
SUMMARY							
Maximum	13.0	70.3	52.9	100.0	50.0	Springs (13)	Gravity (9)
Minimum	2.0	15.9	8.8	67.6	0.0	Borehole (3)	Grid (3)
Mean	7.3	51.9	26.6	82.7	22.0		Solar (4)

4.3.2.2 Conflicts

Respondents were required to indicate whether they know of any water related conflicts within the beneficiaries and to explain how the conflicts were affecting the service delivery. Reported conflicts were summarised to determine the frequency of occurrence. Table 6 shows that Karukara, at 53%, had the biggest number of respondents that reported conflicts while Mitoma, Kashenshero and Rubaare at 8.8% had the lowest. The commonest conflict, as indicated in table 11, is unfair tariff (80 respondents) which was followed by compensation to former land owners (33 respondents), unfair public tap distribution (9 respondents) and water resource ownership (8 respondents).

Table 7: Summary of the Reported Conflicts

Causes of conflicts	**No**	**%**
None	398	3.84
Unfair Tariff	80	4.84
Payment to former land owners	33	6.12
Unfair Tap stand distribution	9	1.67
Water resource ownership	8	1.48
Unfair sharing of the water resource	3	0.56
Pipeline Passage through people's land	2	0.37
Revenue collection between two sub-counties	2	0.37
Unfair/ un-favourable Fetching time	2	0.37
Grazing animals in the source area	1	0.19
Source protection bush breeds vermin (rats, snakes & mosquitoes	1	0.19
	539	100.0

Respondents considered the tariff unfair when the neighbouring systems were charging cheaper rates, or charging a flat rate irrespective of how much water one consumes, or charging ad hock contributions for repairs whenever systems break down. Other respondents expressed unkind words to the board members and scheme operators; they feel they are overcharged so that the water managers get what to steal.

Some respondents saw no reasons for a former landowner paying for water. They felt that in addition to monetary compensation for their lands, they should as well be given free water and paid royalties since in their opinion the land owners own the resource.

All the respondents that reported conflicts believe the conflicts are the causes of vandalism and theft of water infrastructure. In two systems communities around the source area were reported to be in the habit of vandalising the system whenever their tap stands break down. For example a respondent in Muhanga had this to say:

"They must contribute to the maintenance of our system because we gave them our water otherwise we will always ensure they as well have no water whenever ours breaks down).

A similar sentiment was echoed in Mirama.

4.3.3 Affordability

Respondents were requested to show whether their water was affordable and to explain why they think so. On average 82.7% of the respondents indicated that the service was affordable. Muhanga (67.6%) followed by Kabirizi (68.8%) had the lowest number of respondents that indicated their service was affordable. In Mirama all the respondents indicated that their service was affordable.

Respondents considered their water affordable by either comparing its cost with other household consumables, neighbouring systems and the cost of water before their system was constructed. For example a respondent in Rwenshama said, *"This water is very cheap. What else can you buy with 50 shillings? I use the funds from selling one fish for the whole month*!"

In Mirama, another respondent had this to say:

"*It is affordable; a 20 litre Jerry can of dirty water used to cost us 300 shillings. We actually still pay that much when our system breaks down"* Dirty water in this response was referring to the untreated, heavily silted and contaminated water from the Kagera river.

And yet another respondent in Kabirizi said,

"This water is very expensive; you see we do not have a daily income, why should I spend the little I have on water when I can fetch freely from a spring"

Similar sentiments were echoed by other respondents in Muhanga and Kambuga.

4.3.4 Use of Alternative Sources

Use of alternative sources of water was defined as the percentage of people who reported using the alternative sources of water most of the times. Respondents were requested to indicate the walking distances to alternative water sources. They were further requested to indicate the frequency of use and the reasons for using the alternative water sources.

A total of 490 (90.9%) households reported having alternative water sources within 1.5km from their houses but only 21.9% of the respondents reported using alternative sources with the biggest percentage being in Kabirizi where 50% of the respondents were using alternative sources, followed by Kisiizi at 45.5%. Mirama at 0% had the lowest number of respondents that use alternative sources followed by Rubaare at 6%. On further probing, it was established that the only alternative water sources for Mirama and Rubaare were the heavily silted streams which explains why most people do not use the alternatives.

The reasons advanced for using alternative sources, which are summarised in table 10, were: when the main system breaks down (78.1%), to save on costs (9.6%), the alternative sources are nearer (5.9%), the main system is too expensive for the respondent (3.9%); the alternative sources have better quality (1.5%) and shorter waiting time at the alternative sources (1.1%).

Table 8: Reasons for Using Alternative Water Sources

No.	Reasons for using alternative water sources	Respondents	
		Number	Percent
1.	When the main system breaks down.	421	78.1
2.	To save on costs.	52	9.6
3.	The alternative source is nearer.	32	5.9
4.	The main system is too expensive.	21	3.9
5.	The alternative source has better quality	8	1.5
6.	There is shorter waiting time at the alternative source.	6	1.1
	Total	539	100

4.3.5. Technology of the Water Supply Systems

Technology was defined in terms of technological options of the water and power sources. A total of 13 water supply systems were using springs as their sources of water while the rest (3) used boreholes. Three different sources of power, namely gravity, grid and solar were found to be used in the water supply systems. Nine water supply systems were utilizing gravity, three utilizing the national electricity grid while four were utilizing solar as the source of power for pumping water.

4.4 The Dependent Variable: Sustainability of Water Supply Systems

As discussed in section 3.7, this study measured sustainability using two dimensions: the system's capacity to fulfill service quality requirements and the system's capacity to fulfill environmental requirements. Indicators of functionality, effective usage, perceived water quality, state of the physical infrastructure and financial wellbeing measured the system's capacity to fulfill service quality requirement while the indicators of percentage of the system's safe yield left untapped, seasonal stability of source quality and seasonal stability of source yield (quantity) measured the system's capacity to fulfill environmental requirements. This section presents the study findings on each of the indicators and dimensions.

4.4.1 Functionality

Functionality of water supply system was defined as the extent to which the system fulfils the requirements of having an operator, a board that meets regularly, keeping audited records and supplying water 24 hours per day. The findings on functionality are summarised in Table 9 which shows that the least functional system was Kisiizi (49%) followed by Kihiihi (52%) while the most functional system was Kebisoni (98%) followed by Mitoma (93%) and Rubaare (93%).

The worst performer on the 24-hours per day supply requirement was Kihiihi (22%) followed by Kabirizi (52%) while the best performer was Kebisoni (93%). On average, Kihiihi is able to supply water for only 5.3 hours instead of the required 24 hours. This poor performance was due limited supply hours on public kiosks and none availability of kiosk attendants when needed.

Kambuga had the lowest number of board meetings (25%), followed by Kisiizi and Kihiihi both at 33% of the required 12 meetings in a year. Kisiizi was the worst in record keeping (33%), followed by Kambuga (67%). The rest of the schemes had all the required records kept.

Table 9: Functionality of the Water Supply Systems

Scheme Name	FUNCTIONALITY (%)						
	Supply hours per day		Board Meetings per Year		Major Records Kept		Mean (%)
	No.	100x Supply Hours / 24	No.	100x Meetings / 12	No.	100x Records / 3	
Kisiizi	19.6	82	4	33	1	33	49
Kihiihi	5.3	22	4	33	3	100	52
Kambuga	21.8	91	3	25	2	67	61
Muhanga	15.6	65	4	33	3	100	66
Kabirizi	12.6	52	6	50	3	100	67
Ryakarimira	16.8	70	11	92	3	100	87
Rwenshama	17.1	71	12	100	3	100	91
Bugongi	19.1	80	11	92	3	100	91
Rwashamaire	17.4	72	12	100	3	100	91
Kashenshero	17.4	72	12	100	3	100	91
Buyanja	19.5	81	11	92	3	100	91
Karukara	21.8	90	10	83	3	100	91
Mirama	18.2	76	12	100	3	100	92
Rubaare	19.0	79	12	100	3	100	93
Mitoma	19.4	80	12	100	3	100	93
Kebisoni	22.4	93	12	100	3	100	98

4.4.2 Effective Usage

Effective usage was defined as the percentage of actual consumption over the expected design consumption. As described in section 3.7, it was computed basing on the expected consumption of the projected to the 2008 population (P_{2008}) and the actual consumption which was obtained from the secondary data. Projection of the population used a 3 % growth rate (r), the age of the system (n) and based on the design population (P_d). The results are shown in Table 10 which shows that all the systems were underutilising the installed capacities. The best performer was Rubaare which was utilising 53% of her installed capacity, followed by Mitoma (44%), Rwashamaire (41%) and

Muhanga (41%). The worst performers were Buyanja (7%) followed by Kabirizi and Kisiizi both at 8%.

Table 10: Effective Usage of the Systems.

	Age (n) Years	Design population (P_d)	Projected Population P_{2008} $P_d(1+r)n$	Projected consumption (Q_{2008P}) $\frac{P_{2008} \times 20}{1000}$ (m3/day)	Actual Consumption (Q_{2008A}) (m3/day)	Effective Usage $\frac{(Q_{2008A})}{Q_{2008P}} \times 100$
Bugongi	5	4,330	5020	100.39	21.56	22
Buyanja	9	7,439	9706	194.12	12.96	07
Kabirizi	9	1,500	1957	39.14	3.29	08
Kambuga	12	5,000	7129	142.58	17.78	13
Karukara	8	5,324	6744	134.89	13.13	10
Kashenshero	4	5,879	6617	132.34	27.80	21
Kebisoni	9	11,444	14932	298.64	28.26	10
Kihiihi	9	13,600	17745	354.90	52.57	15
Kisiizi	8	3,260	4130	82.59	6.57	08
Mirama	3	4,614	5042	100.84	25.52	25
Mitoma	5	3,853	4467	89.33	39.15	44
Muhanga	13	1,600	2350	46.99	19.32	41
Rubaare	4	5,674	6386	127.72	67.06	53
Rwashamaire	6	5,000	5970	119.41	48.88	41
Rwenshama	2	2,441	2590	51.79	10.29	20
Ryakarimira	11	1,700	2353	47.06	17.69	38

4.4.3 Perceived Water Quality

Qualitative data was collected first from the scheme operator and water board members and finally from the consumers. Respondents were asked to describe the taste of their water and its effect on, food when they use for cooking, utensils and clothes as they use it for washing. Findings from the interviews showed a marked difference between borehole water and spring waters with regard to drinking and washing but no difference for cooking purposes.

A respondent in Rwenshama one of the borehole based system had this to say about the water.

"*You cannot drink this water. It is very salty. We have to get the drinking water from very far which is very expensive. Otherwise the water is good.*"

In Buyanja, another borehole based system, a respondent responded as follows:

"*It takes a lot of soap when washing. I actually fear using it to bathe my baby because I think it can harm her. It forms a yellowish thing on top on boiling.*"

And yet another respondent in Buyanja had this to say.

"*This water is horrible; when washing it takes a lot of soap, when cooking it turns the food black and when you try drinking some fattish things on top cannot allow you drink it comfortably*"

Yet in spring based systems most of the respondents were praising the quality of their systems. In Kambuga, a respondent had this to say,

"Our water is perfect and pure; it is soft when washing and tastes perfect, you cannot sport any impurities".

Respondents were further requested to rate the suitability of their water for cooking, washing and drinking using a 5 point scale of very good (5), good (4), fair (3), poor (2) and very poor (1). The overall perceived water quality for a respondent was obtained by computing the mean rating for the three main purposes. The perceived water quality for the entire system was established by computing the mean for the individual scores of all the respondents in the particular system. The findings are presented in Table 11 which shows that the worst rated system for all purposes was Rubaare at 3.3, followed by Buyanja (3.4) and Rwenshama (3.6) while the best rated systems were Kebisoni, Kisiizi and Kambuga at 4.8.

Table 11: Perceived Water Quality

Name of the scheme	Rating of the systems on their suitability for three main purposes			Mean rating for all purposes (Mean)	
	Drinking	Cooking	Washing	Mean rating	Mean rating x100 5
Rubaare	3.3	3.8	2.9	3.3	66
Buyanja	3.4	3.3	3.4	3.4	68
Rwenshama	2.4	4.2	4.3	3.6	72
Karukara	3.9	4.2	4.1	4.0	80
Kihiihi	3.9	4.0	4.0	4.0	80
Ryakarimira	3.8	4.2	4.1	4.0	80
Kabirizi	4.0	4.3	4.2	4.2	84
Muhanga	4.1	4.4	4.3	4.3	86
Bugongi	4.6	4.6	4.6	4.6	92
Kashenshero	4.6	4.6	4.6	4.6	92
Mitoma	4.6	4.6	4.6	4.6	92
Rwashamaire	4.6	4.7	4.7	4.6	92
Mirama	4.6	4.6	4.7	4.7	94
Kambuga	4.6	4.8	4.9	4.8	96
Kebisoni	4.8	4.8	4.8	4.8	96
Kisiizi	4.6	4.8	4.8	4.8	96

For drinking purpose, Rwenshama was the worst rated at 2.4 followed by Rubaare (3.3) and Buyanja (3.4) while for cooking purposes, Buyanja was rated the worst at 3.3 and Rubaare at 2.9 was rated the worst for washing purposes.

The researcher contacted the water quality analyst of SWUWS to get a technical explanation of this community rating. The water quality analyst had this to say;

"*This rating is no surprise at all. The worst three rated systems (Rubaare, Buyanja and Rwenshama) are ground water /borehole based which in most cases are highly mineralised which renders the water hard and/or sweet." For example, the water in Buyanja and Rubaare is hard while that in Rwenshama contains common salt (sodium chloride). Where as this state of affairs of the water do not pose any known health problem, it affects the aesthetic properties. Hard water does not form* *lather with common soap and therefore wastes a lot of soap while washing. Hard as well as salty water is tasty and hence unpleasant to drink".*

For the spring based systems that were rated lowest (Ryakarimira and Karukara) the water quality analyst again had this to say;

"*The pipes and tanks in Ryakarimira have been corroded by its acidic water which results in rusty water from taps especially in the mornings or when the water has been stagnant over time. In Karukara the recent heavy rains had eroded the soil cover on the protected spring which resulted in the runoff water mixing with the spring water. Although this has been rectified, it is still fresh in the minds of the consumers and therefore must have influenced their rating".*

4.4.4 State of the Infrastructure

Through observation, the state of repair of the physical infrastructure (comprising of the water source, reservoir tanks, office and the public tap stands/kiosks) were rated using a 5 point scale of very good (5), good (4), fair (3), poor (2) and very poor (1). This rating was based on evidence of fence maintenance, pipe and fittings leaking or not, structural integrity of the infrastructure (any visible cracks or damages), painting and general cleanliness. The overall state of the physical infrastructure was computed as the mean rating of the water source, reservoir tanks, office and the public tap stands/kiosks.

The findings are presented in table 12 which shows that , the worst at maintaining her infrastructure was Buyanja which was rated at 2.8 while the best were Kashenshero (4.8) followed by Rwenshama (4.7).

Table 12: State of Repair of the Physical Infrastructure

Name of the scheme	State of repair of the physical infrastructure					
	Source	Tanks	Office	Kiosks	Mean rating	Mean rating x100 5
Buyanja	2.0	2.0	3.0	4.0	2.8	56
Muhanga	3.0	2.0	4.0	3.0	3.0	60
Kabirizi	3.0	3.0	3.0	4.0	3.3	66
Kebisoni	3.0	4.0	3.0	3.0	3.3	66
Kihiihi	4.0	4.0	3.0	3.0	3.5	70
Kambuga	5.0	3.0	3.0	4.0	3.8	76
Karukara	4.0	3.0	4.0	4.0	3.8	76
Rwashamaire	3.0	4.0	4.0	4.0	3.8	76
Ryakarimira	4.0	4.0	3.0	4.0	3.8	76
Bugongi	4.0	5.0	4.0	3.0	4.0	80
Kisiizi	4.0	4.0	4.0	4.0	4.0	80
Mirama	4.0	4.0	4.0	4.0	4.0	80
Rubaare	4.0	4.0	4.0	4.0	4.0	80
Mitoma	4.0	5.0	4.0	4.0	4.3	86
Rwenshama	4.0	5.0	5.0	5.0	4.7	94
Kashenshero	5.0	5.0	5.0	4.0	4.8	96

In Buyanja which was rated the worst, the door to the source area where the pump is located was found to have been broken, their reservoir tanks had their plaster cracked and peeling off and all the fences broken. In Kashenshero, the best rated, the entire infrastructure was well maintained and the only blemish was on the cleanliness in and around the water kiosks. Rwenshama's good rating could probably be because her infrastructures were relatively newer sine Rwenshama had been operating for only two years.

4.4.5 Financial Wellbeing of the Schemes

Financial wellbeing was defined as the ability of the system's revenue to pay for operating expenses. It was measured by computing the mean of the profitability ratio, collection efficiency and survival on savings.

Collection efficiency was defined as the ratio of amount of money collected over the amount of money billed. It therefore refers to the percentage of the water sold that is actually paid for. A system with high collection efficiency has most of its bills paid for and therefore has cash at hand while one with lower collection efficiency has most of its bills in debt and is therefore cash strapped. Profitability ratio was defined as the ratio of profit over sales. A system with a higher ratio has higher chances of getting out of any breakdown than the one with a lower ratio.

Profitability ratio was computed as sales less expenditure expressed as a percentage of sales. To incease this ratio, one would have to either increase the sales or minimize the expenditures. Higher expenditures may mean that the system is breaking down quite frequently and the system may be difficut to sustain. The higher this ratio is the healthier the system is.

Survival on savings was defined as the ratio of total savings over annual expenditure. This ratio therefore refers to the number of years the system can survive on its savings without any other income. The higher this ratio is the better the scheme is in terms of its ability to continue running and to withstand any eventuality.

The ratios were computed basing on the 2008 secondary data available at the South Western umbrella of Water and Sanitation. The results are shown in table 13 below from which it is clear that overall; Buyanja was the most financially unwell at 13% followed by Mirama (25%) and Kabirizi (33%). Kisiizi with collection efficiency of 55% was the worst at collecting her debts while Buyanja (-25%) was the worst at making profits. The most financially well system was Rwenshama at 71%.

Table 13: Financial Wellbeing of the Systems

Name of the scheme	Financial wellbeing (%)			
	Collection efficiency	Profitability ratio	Survival on savings	Mean
Buyanja	63	- 26	03	13
Mirama	77	- 12	10	25
Kabirizi	76	11	12	33
Kambuga	67	36	01	35
Karukara	88	04	44	45
Ryakarimira	68	27	43	46
Kashenshero	100	18	21	46
Kihiihi	81	59	01	47
Bugongi	94	- 02	50	47
Kisiizi	55	20	69	48
Rwashamaire	87	26	38	51
Rubaare	77	20	65	54
Mitoma	100	48	30	59
Muhanga	100	53	27	60
Kebisoni	97	34	77	69
Rwenshama	87	33	94	71

To establish why some systems performed very badly while others were performing very well; the researcher sampled and contacted some system operators. In Buyanja, the system operator, attributed the low collection efficiency to the educational institutions which form the majority of his clients who usually pay at the beginning of terms when students have just returned and paid the school dues or when the Government releases the funds due to the schools. He further attributed the negative profitability ratio and low survival on savings ratio to the recent replacement of the burnt out pump motor. In Mirama and Bugongi, the operators explained that the negative profitability ratio was due expenditure on extensions and major rehabilitation on the source respectively

4.4.6 Percentage of the Source Yield Left Untapped.

All the sixteen systems were found to be fulfilling the requirement of leaving at least 30% of their safe yield for the environment and therefore all scored 100 %. And since this measure was not showing any variation, it was excluded from further analysis.

4.4.7 Stability of Source Quality

Stability of source quality was measured using the coefficient of stability of turbidity (a measure of how clear the water is). The coefficient of stability was computed using the formula below:

$$\text{Coefficient of stability} = 100 - \text{coefficient of variation}$$

$$\text{Coefficient of variation} = \frac{\text{Standard deviation} \times 100}{\text{Mean}}$$

The results, which are summarised in table 15, show that Ryakarimira (12%) had the most unstable quality followed by Muhanga (26%). Rubaare (100%) had the most stable quality. The poor performance of Ryakarimira was attributed to acidity of its water that has overtime corroded the pipes and tanks.

4.4.8 Stability of Source Yield

Source yield is the lowest quantity of water that a water source can provide and is usually measured at the end of the driest period in a year. A good water source should have minimal seasonal variation as a large seasonal variation implies surface water which is prone to contamination by surface runoff (MWE DWD, 2000). Because there was no secondary data on seasonal variation of the source yield (quantity) and it was not feasible to collect primary data because of limited time, the researcher used seasonal stability of the supply to measure the seasonal stability of source yield. Respondents were requested to indicate whether they notice any seasonal variation in the quantity supplied. The percentage of the respondents that reported seasonal stability of the supply was taken as a measure of water source yield stability. With the exception of Kihiihi more than 90% of the respondents reported a stable supply in terms of water quantity. In Kihiihi where only 18% of the respondents reported stable supply a board member had this to say;

"This system has out grown its design period. The town's major infrastructure were constructed in 1991 but rehabilitated in 1999.The town has existed since 1991!"

4.4.9 System's Capacity to Fulfil Service Quality Requirements

The capacity of a water supply system to fulfil the service quality requirement was measured by functionality, effective usage, perceived water quality, state of the physical infrastructure and financial well being. Table 14 summarises the systems' capacities to fulfil service quality requirements while the subsequent sections give the details on each of the dimensions.

Table 14: Water Supply System's Capacity to Fulfill Service Quality Requirements

Name of the system	Capacity to fulfill service quality requirements (%)					
	Functionality (%)	Effective usage (%)	Perceived water quality	State of infrastructure (%)	Financial wellbeing (%)	Mean (%)
Buyanja	91.0	6.7	67.6	55.0	13.3	46.7
Kabirizi	67.4	8.4	83.3	65.0	33.2	51.5
Kihiihi	51.8	14.8	79.2	70.0	47.0	52.5
Kambuga	60.9	12.5	95.6	75.0	34.8	55.7
Kisiizi	49.5	8.0	95.4	80.0	48.1	56.2
Karukara	91.4	9.7	81.0	75.0	45.2	60.5
Muhanga	66.1	41.1	85.5	60.0	60.1	62.6
Mirama	92.0	25.3	93.1	80.0	24.8	63.1
Ryakarimira	87.3	37.6	80.6	75.0	46.2	65.3
Bugongi	90.5	21.5	92.5	80.0	47.1	66.3
Kebisoni	97.8	9.5	96.4	65.0	69.2	67.6
Kashenshero	90.8	21.0	91.8	95.0	46.4	69.0
Rubaare	93.1	52.5	66.7	80.0	53.9	69.2
Rwenshama	90.5	20.5	72.5	94.4	71.2	69.8
Rwashamaire	90.8	40.9	92.8	75.0	50.6	70.0
Mitoma	93.6	43.8	92.9	85.0	59.4	75.0

Table 14 shows that Buyanja had the least capacity to provide quality service (46.7%) followed by Kabirizi (51.5%) and Kihiihi (52.5%) while Mitoma at 75% had the highest capacity to meet the service quality requirements.

Buyanja's poor performance was attributed to the frequent break down of its pump which according to the system operator was caused by the unstable voltage of the electricity grid that ended burning up their motor and transformer. The system's heavy expenditure in replacement and repair of the mentioned items affected their financial wellbeing while an extended period without operating affected the system's effective usage. Although there was an attempt to place the blame on a third party, Buyanja management were found to be poorly maintaining their infrastructure. For example the door to the source area where the pump is located was found to have been broken for over 3 months, their reservoir tanks had their plaster cracked and peeling off and all the fences broken. The researcher could not rule out vandalism as the cause of the burning of the pump motor with this form of extreme negligence exhibited by the management.

Poor performance in Kabirizi could be attributed to the abundance of alternative water sources (50% of the respondents were using alternative water sources), which affected its effective usage and financial wellbeing. In Kihiihi, the poor performance of the operator and the board was the cause of the scheme's poor performance. The operations of the public kiosks were erratic with the attendants opening and closing whenever they want which greatly reduced supply hours of the system and according to one of the board members, under reporting of the actual water sales by the operator could not be ruled out. The board also contributed to this poor performance by not meeting as regularly as they are required. As a matter of fact during the 2008 calendar year, they met only 4 times instead of the 12 meetings required. This irregular meeting indicate the operator was not adequately supervised which could have led to his poor performance that resulted in reduced functionality, effective usage and financial wellbeing.

4.4.10 System's Capacity to Fulfill Environmental Requirements

A system is said to be environmentally sustainable if it does not adversely impact on its upstream environment and it does not show effects of environmental degradation within its source catchment Lundin (1999). The system's possibility to negatively impact on its upstream environment which was to be measured by the fraction of the system's safe yield that is left untapped was excluded from the analysis because all the sixteen systems were found to be under utilising their installed capacities and therefore could not degrade the environment. Signs of environmental degradation within the system's catchment were measured by the seasonal stability of source quality and source yield. The system's capacity to fulfil environmental requirement was computed by getting the mean of yield stability and quality stability is presented in Table 15.

Table 15: Systems Capacity to Fulfil Environmental Requirements

	Capacity to fulfill environmental requirements		
Name of the scheme	Yield stability	Quality stability	Mean
Kihiihi	18.2	50.0	34.1
Ryakarimira	93.9	12.0	53.0
Muhanga	91.2	26.0	58.6
Kabirizi	90.6	31.0	60.8
Kisiizi	97.0	28.0	62.5
Mirama	100.0	35.0	67.5
Buyanja	91.4	54.0	72.7
Bugongi	100.0	47.0	73.5
Rwenshama	100.0	47.6	73.8
Karukara	91.2	60.0	75.6
Mitoma	100.0	53.0	76.5
Kambuga	100.0	59.0	79.5
Kashenshero	100.0	59.0	79.5
Kebisoni	96.9	71.0	82.8
Rwashamaire	100.0	66.0	83.0
Rubaare	100.0	100.0	100.0

From Table 15, Rubaare, at 100%, was the most environmentally sustainable system while Kihiihi was the least environmentally sustainable system at 34.1%. This implies that Kihiihi system can only meet 34.1% of the environmental requirements. Kihiihi's poor performance was due to the seasonal variation in the source yield and quality which was attributed to upstream activities and the soil structure around the spring. According to an engineer with the Ministry of Water and Environment, the soils around the spring are sandy and therefore very porous which makes it easy for the runoff water to infiltrate and therefore contaminate and seasonally vary the spring yield. The borehole water in Rubaare on the other hand are found deep below an impermeable bed rock which makes it impossible for the runoff water to infiltrate, contaminate and vary the yield seasonally.

4.4.11 Overall Sustainability of Water Supply Systems

The system's overall sustainability was obtained by computing the mean score of the system's capacity to fulfill service quality and the capacity to fulfill the environmental requirement. The findings are summarized in table 16 which shows that the least sustainable system was Kihiihi (43%) %) followed by Kabirizi (56%) and that the most sustainable system was Rubaare (85%) followed by Rwashamaire (77%) and that with the exception of Rubaare, sustainability in all systems is below the national requirement of at least 80%.

Kihiihi's overall performance was very poor because it could only achieve 53% of the service quality requirements and 34% of the environmental requirements. The cause for low performance on service quality requirement was largely due to fewer hours of opening kiosks which resulted in only 5.3 hours of service per day in steady of the required 24 hours and the low number of board meetings (4 in steady of 12) meetings in a year while, as explained above, the cause of its poor performance in relation to the environmental requirements were the soil structure and upstream activities.

Table 16: Overall Sustainability of Water Supply Systems

Name of the system	Sustainability (%) - Capacity to fulfill requirements for:		
	Service quality	The environment	Both service quality and environment (Mean)
Kihiihi	53	34	43
Kabirizi	51	61	56
Ryakarimira	65	53	59
Kisiizi	56	62	59
Buyanja	47	73	60
Muhanga	63	59	61
Mirama	63	68	65
Kambuga	56	80	68
Karukara	60	76	68
Bugongi	66	74	70
Rwenshama	70	74	72
Kashenshero	69	80	74
Kebisoni	68	83	75
Mitoma	75	77	76
Rwashamaire	70	83	77
Rubaare	69	100	85

4.5 Correlation and Regression Analyses

Correlation and regression analyses were conducted to establish whether there was any relationship between the independent and dependent variables, the magnitude and direction of the relationships and to establish the relationship model and test four of the five hypotheses. The independent samples T-test and ANOVA were conducted to test the remaining hypothesis.

4.5.1 Correlation Analysis

This study utilized Pearson product moment correlation analysis for three purposes, firstly to examine the presence of multi-co linearity, second to explore relationship between the variables, and third to test hypotheses.

Table 17: Correlation Matrix of Sustainability and Factors that Affect Sustainability

	1	2	3	4	5	6	7	8	9	10	**11**	12	13	**14**	**15**
1. Scheme age	1														
2. Population Growth	.129 (**)	1													
3. Conflicts	.251 (**)	-.014	1												
4. Affordability	-.234 (**)	-.760 (**)	-.012	1											
5. Use of alternative source use	.244 (**)	.109 (*)	.231 (**)	-.269 (**)	1										
6.Functionality	-.454 (**)	-.213 (**)	-.082	.085 (*)	-.206 (**)	1									
7. Effective use	-.211 (**)	-.169 (**)	-.132 (**)	.103 (*)	-.196 (**)	.264 (**)	1								
8. Perceived Quality	.044	-.202 (**)	-.061	.116 (**)	-.050	-.048	-.077	1							
9. Financial Wellbeing	-.144 (**)	-.112 (**)	-.062	-.005	-.048	.105 (*)	.358 (**)	.090 (*)	1						
10. State of Infrastructure	-.734 (**)	-.140 (**)	-.246 (**)	.184 (**)	-.220 (**)	.200 (**)	.227 (**)	.117 (**)	.353 (**)	1					
11. Capacity to fulfill service quality	-.495 (**)	-.302 (**)	-.190 (**)	.161 (**)	-.250 (**)	.600 (**)	.623 (**)	.381 (**)	.647 (**)	.591 (**)	1				
12. Quantity Stability	-.185 (**)	-.121 (**)	-.039	.064	-.112 (**)	.324 (**)	.150 (**)	.160 (**)	.036	.192 (**)	.314 (**)	1			
13.Quality Stability	-.356 (**)	-.072	-.125 (**)	.117 (**)	-.091 (*)	.348 (**)	.174 (**)	-.130 (**)	.183 (**)	.130 (**)	.263 (**)	.056	1		
14. Capacity to fulfill Environmental Requirements	-.354 (**)	-.137 (**)	-.102 (*)	.117 (**)	-.144 (**)	.454 (**)	.222 (**)	.045	.130 (**)	.228 (**)	.397 (**)	.813 (**)	.625 (**)	1	
15. Sustainability	-.466 (**)	-.222 (**)	-.152 (**)	.153 (**)	-.208 (**)	.585 (**)	.411 (**)	.180 (**)	.347 (**)	.404 (**)	.692 (**)	.759 (**)	.592 (**)	.938 (**)	1

N =539, ** Correlation is significant at the 0.01 level; * Correlation is significant at the 0.05 level (2-tailed).

Examination of correlation matrix displayed in table 17 suggested that with the exception of two pairs (water quantity stability /capacity to fulfill environmental and capacity to fulfill environmental requirements/overall sustainability) multi-co linearity was not a problem as no correlation coefficient exceeded the limit of 0.8 as recommended by Hair et al (1995).

Table 17 further shows that the system age was found to be negatively correlated, with the systems' sustainability (r = -0.466, p <0.01) and with all the sustainability dimensions apart from perceived water quality where the relationship was insignificant and positive (r = 0.044, p>0.05).

Social political dynamics of conflicts and population growth were found to be individually negatively correlated with sustainability and its dimensions. This negative relationship with conflicts was only significant with respect to effective usage (r =-0.132, P<0.01), state of the infrastructure (r=-0.246, p<0.01), and quality stability (r=-0.125, p<0.01). Population growth had a significant negative relationship with all the dimensions except with quality stability where the relationship was insignificant.

Affordability had a positive significant relationship with effective usage (r = 0.185, p<0.01) and the capacity of the system to fulfil service quality but had an insignificant relationship with the other dimensions and the overall sustainability.

Use of alternative water sources was negatively correlated with sustainability and its dimensions individually. However, the relationship was insignificant with regard to perceived quality and financial wellbeing of the system but significant with the rest of the dimensions.

4.5.2 Testing of the Hypotheses

Five hypotheses were stated and therefore tested. These are:

1. H_{1a}: The age of an urban water supply system affects its sustainability.
2. H_{2a}: Technology influences sustainability of urban water supply systems.
3. H_{3a}: Social-political dynamics has a significant impact on sustainability of urban water supply systems.
4. H_{4a}: There is a significant positive relationship between affordability and sustainability of urban water supply systems.
5. H_{5a}: Use of alternative water sources affects sustainability of urban water supply systems.

Correlation analysis was used to test hypotheses 1, 3, 4 and 5 while the independent samples T-test and ANOVA were conducted for hypothesis number two.

4.5.2.1 Testing of the Hypotheses Using Correlation Analysis

From the correlation matrix, table 17, it was concluded as follows:

1. The relationship between system age and sustainability was significant and negative ($r = -0.466$, $p<0.01$). The alternate hypothesis **(H_{1a}: The age of an urban water supply system affects its sustainability.)** was upheld.
2. The alternate hypothesis **(H_{3a}: Social-political dynamics has a significant impact on sustainability of urban water supply systems)** was upheld since for both conflict and population growth p is less than 0.01.
3. The alternate hypothesis **(H_{4a}: There is a significant positive relationship between affordability and sustainability of urban water supply systems)** was upheld since $r=0.153$ and p is <0.01.

4. The alternate hypothesis **(H_{5a}: Use of alternative water sources affects sustainability of urban water supply systems)** upheld since the p is less than 0.01.

4.5.2.1 Testing of the Hypothesis Using the Independent Samples T-test and ANOVA

To test the alternate hypothesis 2, it was split into two to reflect the water and power source options as below:

H_{2a1}: Water source type influences sustainability of urban water supply systems.

H_{2a2}: Power source type influences sustainability of urban water supply systems.

The independent samples t-test was used to test H_{2o1} and ANOVA used to test H_{2o2} since as explained in section 4.4.5, water source refers to springs and borehole while power source options are gravity, national electricity grid and solar. The results of comparison of sustainability of spring based and borehole based water supply systems together with the Levene test which the researcher used to verify the equality of variances assumption of the independent samples t –test are shown in table 18.

Table 18: Comparison of Sustainability of Spring Based and Borehole Based Water Supply Systems.

	Mean score (%) by Type of water source		Levene's Test for Equality of Variances		t-test for Equality of Means	
	Spring	Borehole	F	Sig.	T	Sig. (2- tailed)
Capacity to fulfill service quality	62.8	61.5	78.9	.000	1.046	.298
Ecological sustainability	68.5	82.2	.001	.972	-7.518	.000
Overall Sustainability	65.6	71.9	2.18	.141	-5.238	.000
N	439	100				

Basing on the results which are shown in table 18, the researcher concluded as follows:

- Spring based systems have a higher capacity to fulfil service quality than the borehole based systems but that the difference between the means is not significant ($t=1.046$, $p>0.05$) and therefore the type of source does not influence the capacity of a system to fulfil its service quality requirement.
- Borehole based systems have a higher capacity to fulfil environmental requirements than the spring based systems and that the difference between the means are significant ($t = -7.518$, $p<0.01$) and therefore, the type of water source influences the system's capacity to fulfil environmental requirements.
- Borehole based systems have a higher overall sustainability than the spring based systems and that the difference between the means is significant ($t = -4.985$, $p<0.01$) and therefore the type of water source influences the system's overall sustainability.

Hypothesis H_{2a1}: Water source type influences sustainability of urban water supply systems, is therefore substantiated.

Hypothesis H_{2o2} was tested using a one way ANOVA and the results of which are presented in table 19 which compares sustainability of systems using gravity, grid and solar power sources and the results are presented in table 19 which shows that on average,

- Grid systems have a higher capacity to fulfil service quality, followed by solar systems and finally by gravity systems and that the difference between the means is significant ($F=9.304$, $p<0.01$) and therefore the power source influences the capacity of a system to fulfil its service quality requirement.
- Grid systems have a higher capacity to fulfil environmental requirements, followed by gravity systems and finally by solar systems and that the difference between the means is

significant (F=122.715, p<0.01) and therefore the power source influences the capacity of a system to fulfil environmental requirements.

- Grid systems have a higher overall sustainability, followed by gravity systems and finally by solar systems and that the difference between the means is significant (F=81.291, p<0.01) and therefore the power source influences the system's overall sustainability.

Table 19: Comparison of Sustainability of Systems Using Gravity, Grid and Solar Power Sources

Dependent Variable	Power source	N	Mean (%)	Std. Deviation	Analysis of variance (ANOVA)			
						Df	F	Sig
Capacity to fulfill service quality	Gravity	303	61.5	6.32	Between groups	2	9.304	.000
	Grid	139	65.1	11.49				
	Solar	97	62.5	7.96	Within groups	536		
	Total	539	62.6	8.36	Total	538		
Ecological sustainability	Gravity	303	71.3	12.58	Between groups	2	122.715	.000
	Grid	139	82.9	12.58				
	Solar	97	53.1	20.87	Within groups	536		
	Total	539	71.0	17.38		538		
Sustainability	Gravity	303	66.4	7.95	Between groups	2	81.291	.000
	Grid	139	74.1	9.96				
	Solar	97	57.8	13.51	Within groups	536		
	Total	539	66.8	11.04	Total	638		

In order to test exactly which power sources had significant differences in mean scores of sustainability, the researcher used Scheffe test for multiple comparison. The results, as shown in table 20 show that with the exception of gravity and solar systems which has an insignificant difference in means with respect to the systems' capacity to fulfil service quality requirements, the rest have significant differences between their means.

Table 20: Multiple Comparisons for Sustainability and Types of Power Source (Scheffe Test)

Dependent Variable	(I) Source of power	(J) Source of power	Sig.
Capacity to fulfill service quality	Gravity	Grid	.000
		Solar	.603
	Grid	Gravity	.000
		Solar	.051
	Solar	Gravity	.603
		Grid	.051
Ecological sustainability	Gravity	Grid	.000
		Solar	.000
	Grid	Gravity	.000
		Solar	.000
	Solar	Gravity	.000
		Grid	.000
Sustainability	Gravity	Grid	.000
		Solar	.000
	Grid	Gravity	.000
		Solar	.000
	Solar	Gravity	.000
		Grid	.000

From the above discussion, hypothesis H_{2a2}: Power source type influences sustainability of urban water supply systems is substantiated.

4.5.3 Regression Analysis

Multiple regression analysis was carried out to develop a model for predicting the system's capacity to fulfil service quality using age of a system, social political dynamics (conflicts and population growth), affordability and use of alternative water sources as independent variables. The results in Table 21 show that age of the system, conflicts, population growth (social political dynamics), affordability and use of alternative water sources explain 31.3% of the variance in the system's capacity to fulfil service quality requirement. The F-statistic (F = 50.098, p<0.01) demonstrates that the regression model is significant at 99% level of confidence. The coefficients show that the constant, scheme age, population growth and use of alternative water sources are important predictors of the capacity to fulfil service quality.

Table 21: Multiple Regression Table – The Relationship between Factors Affecting Sustainability and Capacity to Fulfill Service Quality

	Un-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	74.643	1.503		49.664	.000
Scheme age	-1.118	.100	-.424	-11.168	.000
Population growth	-.049	.008	-.237	-6.534	.000
Conflicts	-.017	.010	-.091	-1.646	.100
Affordability	-.009	.012	-.040	-.715	.475
Use of alternative water sources	-.022	.008	-.111	-2.917	.004
R	.565				
R-Square	.32				
Adjusted R-Square	.313				
F	50.098				.000
N	539				

Multiple regression analysis was again carried out to develop a model for predicting the system's capacity to fulfil environmental requirements using age of a system, social political dynamics (conflicts and population growth), affordability and use of alternative water sources as the independent variables. Table 22 shows that age of the system, conflicts, population growth (social political dynamics), affordability and use of alternative water sources explain 13.3% of the variance in the system's capacity to fulfil environmental requirements. The F-statistic (F = 16.993, p<0.01) demonstrates that the regression model is significant at 99% level of confidence. The coefficients show, the constant, scheme age, and population growth are the only important predictors of the capacity to fulfil environmental requirements.

Table 22: Multiple Regression Table – The Relationship between Factors Affecting Sustainability and Capacity to Fulfill Environmental Requirements

	Un-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	84.283	3.515		23.981	.000
Scheme age	-1.788	.234	-.327	-7.643	.000
Population growth	-.039	.018	-.089	-2.180	.030
Conflicts	.009	.025	.024	.378	.706
Affordability	.020	.029	.045	.712	.477
Use of alternative water sources	-.020	.018	-.048	-1.115	.265
R	.371				
R-Square	.137				
Adjusted R-Square	.129				
F	16.993				.000
N	539				

In a similar manner, multiple regression analysis was again carried out to develop a model for predicting the system's overall sustainability using age of a system, social political dynamics (conflicts and population growth), affordability and use of alternative water sources as the independent variables. Table 23 shows that age of the system, conflicts, population growth (social political dynamics), affordability and use of alternative water sources explain 24.2% of the variance in the system's overall sustainability. The F-statistic ($F = 35.96$, $p<0.01$) demonstrates that the regression model is significant at 99% level of confidence. The coefficients show that, the constant, scheme age, population growth and use of alternative water sources are the only important predictors of the overall sustainability.

Table 23: Multiple Regression Table – The Relationship between Factors Affecting Sustainability and Overall Sustainability

	Un-standardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	79.463	2.079		38.224	.000
Scheme age	-1.453	.138	-.418	-10.498	.000
Population growth	-.044	.010	-.160	-4.205	.000
Conflicts	-.004	.015	-.016	-.276	.783
Affordability	.006	.017	.020	.344	.731
Use of alternative water sources	-.021	.011	-.079	-1.997	.046
R	.502				
R-Square	.252				
Adjusted R-Square	.242				
F	35.96				.000
N	539				

CHAPTER FIVE

SUMMARY, DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

In this chapter, a summary of the study, discussion of the main findings, conclusions, recommendations and areas that need further research are given.

5.1 Summary of the Study

This study examined factors that affect sustainability of urban water supply systems in South Western Uganda. It followed realisation in the MWE (2006, 2007, and 2008) reports that despite increased funding, access to safe water had stagnated at 63% for the previous three years largely because of partial functionality and total collapse of some systems that made originally served areas to fall back to un-served.

To guide the study, the researcher hypothesised as follows:

1. The age of an urban water supply system affects its sustainability.
2. Technology influences sustainability of urban water supply systems.
3. Social-political dynamics have a significant impact on sustainability of urban water supply systems.
4. There is a significant positive relationship between affordability and sustainability of urban water supply systems.
5. Use of alternative water sources affects sustainability of urban water supply systems.

In this cross-sectional correlational field study, data on five independent variables of the system age, technology, social-political dynamics, affordability and use of alternative water sources, and the dependent variable (sustainability) were collected from 16 water supply systems through documentary review, observation and interviewing at least 30 respondents from each of the water supply systems. The respondents comprised of water system operators, water board members and representatives from the households and institutional consumers.

Frequency distributions for the demographic data and a Pearson correlation matrix were obtained; an independent samples t-test and a one way ANOVA were conducted. Basing on the results, the study upheld the alternate hypotheses and concluded as follows:

1. The age of an urban water supply system negatively affects its sustainability.
2. Technology influences sustainability of urban water supply systems. On average, a borehole based system is likely to be more sustainable than a spring based system. With regard to type of power source, a grid powered system had the highest chances of being sustainable, followed by gravity flow systems and lastly solar powered systems.
3. Social-political dynamics have a significant negative impact on sustainability of urban water supply systems. Conflicts as well as population growth have a negative impact on sustainability of water systems.
4. There is a positive, statistically significant relationship between affordability and sustainability of urban water supply systems.
5. Use of alternative water sources affects sustainability of urban water supply systems.

From the above findings, the conceptual frame work (figure 2) can apply without modification.

5.2 Discussion of the Main Findings

The results of this study were consistent with each of the hypotheses and suggest that the conceptual framework which was summarised in figure 1 can be reasonably applied to urban water supply systems. The study confirmed that the identified factors (age of the system, social-political dynamics of the given area (conflicts and population growth), technology (water source and power source), affordability and use of alternative water sources) affect sustainability of urban water supply systems.

Previous researches, such as those conducted by Alexia (2006) and NEWAH (2006), established that as a water supply system ages, its performance on sustainability indicators reduces. Its reduction in sustainability is triggered by increased component break downs which results in increased unaccounted for water, increased expenditures, reduced supply hours, poor water quality and reduced revenue collections. The strong negative correlation coefficient between age and system's capacity to fulfil service quality (r=-0.495), capacity to fulfil environmental requirement (r=-0.354) and the system's overall sustainability (r=-.466) reported in this study confirmed these earlier findings. The earlier findings are further confirmed by the strong negative Pearson correlation coefficient between age and functionality (r=-.454), effective usage (r=-0.211), financial wellbeing (-0.144), infrastructure state (r=-0.734), quantity stability (r=-0.185) and quality stability (r=-0.356). In this study, however, the correlation between age and perceived water quality is weak and insignificant (p = 0.044) contrary to expectation. This could be attributed to the fact that most of the schemes were relatively young; (the majority (87.5%) were within the first half of their design life span of 20 years) and therefore could have not deteriorated to the level to affect the water quality.

Some previous studies, undertaken within the rural settings, established that technology chosen has a bearing on sustainability. Tiwaitu (2007) and Bariira (2001) reported total collapse and abandonment of boreholes because of hardness and objectionable tastes, Bariira (2001) established that boreholes were more likely to be shunned than springs because hand pumps on the boreholes were more strenuous to use and sometimes lacked spare parts and skills in their repairs. Kesavan, et al (2008) and Alexia (2006) reported that simple technologies (low cost easier to maintain, simple to use and readily available spares) such as gravity flow systems are more sustainable in comparison to the more complex pumping systems. The findings of this study, to some extent, were consistent with these earlier findings. On average, borehole based systems were more likely to be sustainable than spring based systems and Grid systems have a higher overall sustainability, followed by gravity systems and finally by solar systems which confirms that technology chosen affects sustainability.

However, with respect to which technology is more sustainable, the study findings were inconsistent with the previous studies. The inconsistence is attributed to the fact that the previous studies were largely focusing on point sources where the source of water is the major component of the system where as this study focused on piped systems where the source ceases to be the major component of the system but the other components such as pipes, tanks etc play crucial roles in the system.

Gravity flow, spring source systems were found less sustainable contrary to expectation. This was attributed to the fact these systems are considered simple and therefore taken for granted. Beneficiaries expect them to continuously flow without maintenance. Indeed beneficiaries in this type of system were not appreciating the need for paying for the service. More to that springs are close to the surface and therefore prone to effects of environmental degradation, seasonal variation in both quality and quantity. On the other hand, boreholes are deep and less prone to environmental degradation and seasonal variation in their quality and quantity. The poor performance of solar powered systems is attributed to the rampant thefts. All the solar powered systems under the study had at one time lost a number of solar panels to thefts. Replacement of these relatively expensive panels depletes the system's savings thus affecting the system's financial well being while the time taken to replace reduces on the functionality, effective usage and therefore sustainability.

The relationship between social political dynamics (conflicts and population growth) and sustainability reported in the present study are similar to those reported in research conducted by Guio-Torres (2007), Khatri and Vairavamoorthy (2007), and Hummel and Lux (2007). For example, (Khatri & Vairavamoorthy, 2007); reported underutilisation and therefore reduced sales due declining population, while Hummel and Lux (2007) in their study which was based in Germany, reported, changes in lifestyles, water consumption and therefore water sales due to migration that resulted in changes in population characteristics (distribution, density, age) and SWTWS (2006) reported illegal connections, vandalism and unpaid bills resulting from conflicts. All of which are consistent to the negative significant correlations between sustainability and conflicts (r= -.152) and population growth (r=-0.222) reported in this study.

In a similar manner, the relationship between affordability and sustainability reported in the present study are similar to those reported in research conducted by Alexia (2006), (Khatri & Vairavamoorthy (2007). Both studies reported reduced usage due to affordability problems.

Koestler (2008) reported success in sustaining hand pumps in Katakwi and Amuria districts which he attributed to lack of alternative sources which leads to high motivation to maintain. Similarly Mengesha et al (2002) reported reduced system effective usage due to use of alternative sources. Consistent with expectations, this study established that water supply system sustainability reduces where you have alternative water sources. This is because the intended beneficiaries run to the alternatives whenever there is any excuse such as conflict, breakdown etc. Where there are no alternative water sources, extra efforts are put in place to ensure the system is operating as soon as possible.

5.3 Conclusions

Sustainability of urban water supply systems in South Western Uganda is an issue that requires urgent attention. With the exception of only one system; all systems fell short of the national target of 80%. This study established that the tools that are being used to measure sustainability are inadequate. Measuring functionality by looking at whether the system is providing water at the time of spot checking - as is being done in rural areas, or by looking at the number of supply hours – as being done in urban areas, leaves a lot of vital information. The study further established that some of the vital data such as seasonal variation in source yield are not being collected.

The age of an urban water supply system negatively affects its sustainability. As a water supply system ages, the percentage of new comers also increases, water related conflicts increases, the infrastructure deteriorates, thereby reducing functionality, effective usage, financial wellbeing and finally the sustainability of the system.

The technology options adopted in the design of an urban water supply system influences its sustainability s. On average, a borehole based system is likely to be more sustainable than a spring based system. With regard to type of power source, a grid powered system had the highest chances of being sustainable, followed by gravity flow systems and lastly solar powered systems.

The social-political dynamics of a given area have a significant negative impact on sustainability of an urban water supply system based in the area. Conflicts such as those related to tariff setting, unfair tap stand distribution and water resource ownership result use of alternative sources, vandalism and none-payment of the bills. These result in reduced functionality, reduced effective usage, reduced financial wellbeing, poor state of the infrastructure and therefore reduced sustainability. The increased population growth (a higher percentage of the population who missed out on capacity building programs) has a negative impact on sustainability of water systems.

There is a positive, statistically significant relationship between affordability and sustainability of urban water supply systems. When the beneficiaries perceive their system to be affordable, the use and pay for the service which enhances the financial wellbeing of the system and therefore sustainability of the system. When they consider the system not affordable on the other hand, the beneficiaries switch to alternatives thereby reducing the system's financial wellbeing and therefore sustainability.

The use of alternative water sources negatively affects sustainability of urban water supply systems. Use of alternative water sources result in reduced system utilization, reduced revenue and therefore reduced financial wellbeing and sustainability of the system. System break downs, reduced affordability, increased walking distance, waiting time and poor water quality are the drivers to the use of alternative water sources.

5.4 Recommendations

The researcher was not able to obtain data on stability of water quantity but relied on users' perception of stability as nobody has been monitoring the seasonal variation of water source yield.

Given the current phenomena of global warming and its effects, the researcher strongly recommends that the seasonal monitoring of water source yields should be undertaken together with the commendable seasonal monitoring of water quality that is being undertaken.

The Government should consider using a more comprehensive tool of measuring sustainability of water supply systems such as the one used in this study. This is because the current system where one looks at a small component of functionality and effective usage is inadequate as it leaves out other vital aspects. For example all the systems under the study would have been considered 100% functional (all of them were supplying some water for 24 hours per day) and yet as the study has shown their level of sustainability has been found wanting.

Capacity building programs should be strengthened to include conflict resolution and should be continuously implemented during the entire life of the system specifically targeting the new comers and refreshing the old timers. Project implementers should always be on the look out for possible sources of conflicts so that they are addressed as soon as they arise. The already identified causes of conflicts (unfair tariff, unfair tap stand distribution and water resource ownership) should always be addressed during the project cycle by continuously involving the beneficiaries in setting and revising the tariff, distribution of public tap stands and in discussing the equitable sharing of the water resources.

Designers should always address the triggers of use of alternative water sources (system break downs, reduced affordability, increased walking distance, waiting time and poor water quality) and areas with abundance of alternative sources should be given systems basing on improving those sources and the management of these systems should use similar structures and tariff.

5.5 Areas for Further Research

Since this study was conducted in 16 out of over 250 urban water supply systems and it concentrated on one of the 8 regions of Uganda, further studies should be conducted involving more towns and other regions to validate the findings of this study so that they shade more light on how the identified factors affect sustainability countywide. Given the severe underutilisation of installed capacities, the researcher recommends a study on water consumption pattern with a view of revising the per person rate of 20 litres per day used in water supply designs

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APPENDIX 1:

DOCUMENTATARY REVIEW STRUCTURED FORM

INTRODUCTION

This documentary review structured form was designed to study factors affecting sustainability of urban water supply systems in South Western Uganda. It was designed to help the researcher collect information from the available information on the study water supply systems. The form was used to collect information from the system design reports, scheme operators' reports, the SWUWS quarterly and annual reports as well as the SWTWS project's end of implementation reports. The form is structured in three sections covering age and technology, financial wellbeing as well as the environmental requirements. The data collected was used to validate the data collected using the other method and to calculate effective usage, the financial wellbeing and stability of the water source quality. Data was entered by filling in the space provided or by ticking the appropriate option from the given options.

SECTION 1: AGE AND TECHNOLOGICAL OPTIONS OF THE SYSTEM

1 Name of the water supply system: ---

2 Month and Year when the system started operations: --

3 Number of water sources for the system --------------------

4 Main source of water

Spring	Borehole	Hand dug well	Surface water	None

5 Second source:

Spring	Borehole	Hand dug	Surface water	None

6 Third source:

Spring	Borehole	Hand dug	Surface water	None

7 Main source of power:

Gravity	Grid	Solar	Diesel/Petrol	None

8 Secondary source of power?

Gravity	Grid	Solar	Diesel/Petrol	None

SECTION 2: FINANCIAL WELL BEING

Please fill the information in the table below and in the space provided.

Financial Information on the Scheme Collected over the Years.

Year	Collections (UGX)				Tariff (UGX/L)	Sales (Litres)	Expenditure (UGX)	Remarks
	Public	Private	Institutions	Total				
2003								
2004								
2005								
2006								
2007								
2008								

9 Average monthly consumption (UGX) ---------------------

10 Average monthly collections (UGX) ---------------------

11 Average 2008 collection efficiency (%) ---------------------

12 Average monthly expenditure (UGX) ---------------------

13 Total savings to date (UGX) ---------------------

SECTION 3: ENVIRONMENTAL REQUIREMENT

Water Quality Information on the Scheme Collected over the Years.

Year	**Quarter**	**Turbidity**	**Col counts**	**Yield**	**Remarks**
	Q1				
	Q2				
	Q3				
2008	Q4				

APPENDIX 2

OBSERVATION CHECKLIST

INTRODUCTION

This observation checklist is designed to aid the researcher in rating the state of repair of the physical infrastructure. A component of the infrastructure that is well maintained should be given a score of 5 (very good) while the component that is in a sorry state should be given the score of 1 (Very bad) by ticking the appropriate space below the rating. Please tick the appropriate cell corresponding to you rating of the infrastructure.

Name of the system: ---

Rating of State of Repair of the Physical Infrastructures.

INFRASTRUCTURE	COMPONENTS OF THE INFRASTRUCTURE	RATING				
		5 Very Good	4 Good	3 Fair	2 Bad	1 Very bad
Source	Fence					
	Pipes fittings & shutters					
	Protection area					
	General cleanliness					
Tank	Fence					
	Pipes fittings & shutters					
	Structural fitness					
	General cleanliness					
Office	Fence					
	Pipes fittings & shutters					
	Structural fitness					
	General cleanliness					
Kiosks	Fence					
	Pipes fittings & shutters					
	Structural fitness					
	General cleanliness					

APPENDIX 3

QUESTIONNAIRE

THE LETTER USED TO INTRODUCE THE QUESTIONNAIRE TO THE RESPONDENTS

Dear Participant,

This questionnaire is designed to study factors affecting sustainability of your water supply system. The information you give us will help us understand why some water supply systems are sustainable while others are not. Because you are the one who can give us the correct picture of how you water system is performing, I request you to respond to the questions frankly and honestly.

Your response will be kept strictly confidential. Only the research team will have access to the information you give. In order to ensure the utmost privacy, I have provided an identification number for each participant. This number will be used by the research team only for follow up procedures. The numbers, names, or the completed questionnaires will not be made available to anyone else. A summary of the results will be sent to you after the data are analyzed.

Thank you very much for your time and cooperation.

Sincerely,

Eng. Herbert Nuwamanya.
RESEARCHER

THE QUESTIONNAIRE FOR COLLECTING DATA ON FACTORS AFFECTING SUSTAINABILITY OF URBAN WATER SUPPLY SYSTEMS IN SOUTH WESTERN UGANDA.

Please provide, or tick the box that has, the most appropriate answer for following the questions:

SECTION A: GENERAL INFORMATION ABOUT THE RESPONDENT

No	**QUESTION**	**ANSWER**				
		1	**2**	**3**	**4**	**5**
1	What is your age in years?	Under 20	20-35	36-50	51-65	Over 65
2	What is your gender?	Female	Male			
3	What is your highest completed level of education?	None	Primary	Ordinary level	Advanced Level	College & above
4	What is your occupation?	Peasant	Commercial Farmer	Business	Salary Earner	Casual Labourer

SECTION B: AGE AND TECHNOLOGICAL OPTIONS OF THE SYSTEM

5 When did this system start operations? (Month & Year) --------------------

6 What is/are its sources of water?

Spring	Borehole	Hand dug	Surface water	Rain water

7 What is the main source of power for the system?

Gravity	Grid	Solar	Diesel/Petrol	None

8 What is the secondary source of power?

Gravity	Grid	Solar	Diesel/Petrol	None

SECTION C: SOCIAL-POLITICAL DYNAMICS

9 Do you know of any conflict related to your source of water?

Yes	No

10 What type of conflict do you have?

Community	Religious	Political	Other	None

11 Kindly explain this conflict ---

----

12 Do you experience any vandalism?

Yes	No

13 If yes, why do you think you have vandalism? ---

14 Who is vandalising the system? --

15 Have you experienced any thefts?

yes	No

16 If yes, what items were stolen? --

17 In the course of doing your jobs have you ever taken a decision against your will?

yes	No

18 If yes, please explain ---

19 Who forced you take the decision?

Community	Politician	Board member	Chief	other

Please explain if your choice is other ---

20 What decision was it?

Tariff setting	Extension	Reconnection	Payment	Other

Please explain if your answer is other ---

21 How many people are in this household/ institution?

Females	Males	Adults	Minors

22 Of these how many were in this household/ institution when this system started operating? ----

----

23 Which of the following describe the general population growth in your town/ RGC?

Rapid growth	Steady growth	No growth	Steady decline	Rapid decline

24 Why do you think that the population growth in your town/ RGC is as described above?

SECTION E: AFFORDABILITY

What is your monthly expenditure on rent, power (electricity, paraffin etc), telephone, water, education, and household consumables (such as food, soap, salt, sugar)?

UGX	0	1 to 10,000	10,001 to 20,000	20,001 to 30,000	30,001 to 40,000	40,001 to 50,000	Above 50,000
Rent							
Power (electricity, paraffin, dry cells, firewood etc)							
Telephone							
Water							
Entertainment (alcohol, etc)							
Education							
Household consumables							

25 What is your total monthly household income in Uganda shillings? --------------------

Below 30,000	30,001 To 60,000	60,001 to 90,000	90,001 to 120,000	120,001 to 150,000	150,001 to 180,000	180,001 to 210,000	Above 210,000

26 In your opinion is this water affordable?

yes	No

27 Why do you think so? ---

SECTION F: USE OF ALTERNATIVE WATER SOURCES

28 Do you have any alternative source of water nearby (within 1.5km?

yes	No

29 If yes what type of source is it?

Spring	Borehole	Hand dug well	River/stream	Lake/pond

30 How far (km) is it from your household? -----------------------

31 Do you ever use the alternative sources of water?

yes	No

32 If yes, how often do you use alternatives?

often	Rarely	Never

33 Why do you use alternative source?

Better quality	Nearer	Shorter waiting time	Better quality	When main system breaks down	Cannot afford the main system

34 For what purposes do you use the alternative?

Drinking	Washing	Cooking	Others

SECTION G: SUSTAINABILITY

System Functionality

35 Is the water supply system functioning now?

Yes	No

36 If no, for how long have you been without water?

Days	Weeks	Months	>6 months

37 Why hasn't the problem been rectified?

Lack Funds	Lack Expertise	Lack Spares	Other	I don't know

Please explain if your answer is other---

38 On average how many hours do you supply water to the community daily? -----------------

39 How often does your system break down?

often	Rarely	Never

40 What is the longest period of time that the system has taken to be restored? ------------

41 What is the average period that it has taken you to restore the system? ------------

42 How often do you hold board meetings?

Never	Ad hock	Monthly	Quarterly	Annually

43 Where do you keep minutes of these meetings?

Office	Home	Do not keep

44 Which of these records do you keep?

Minutes book	Receipts	Accounts register

45 Are you audited?

yes	No

46 How often do you get audits

Never	Ad hock	Annually	Bi-Annually

47 Who audits you? ---

Financial well being

48 How much do you collect from water sales every month? ----------

49 How much do you spend per month? ----------------------

50 How much do you save per month? ------------------------

51 What is your total savings to date? -----------------

Environmental/ecological requirement

52 How is your source of water in terms of adequacy?

53 Is it stable in terms of quantity?

yes	No

54 Is it stable in terms of quality?

yes	No

55 What percentage of the source yield is being tapped? -------------

Water Quality

56 How does your water affect food, utensils, washing? ---

----

57 How does it taste? ---

----

58 How does it smell? --

----

59 How would you rank suitability of your water for the indicated purposes? (Answer by ticking the appropriate box).

Purpose	1 Very Poor	2 Poor	3 Fair	4 Good	5 Very good
Washing					
Cooking					
Drinking					

APPENDIX 4

LETTER OF INTRODUCTION FOR THE RESEARCHER TO COLLECT DATA FROM THE FIELD

UGANDA MANAGEMENT INSTITUTE

Telephones: 256-41-4259722 /4223748 /4346620
256-31-2265138 /39 /40
256-75-2259722
Telefax: 256-41-4259581 /314
E-mail: admin@umi.ac.ug

Plot 44-52, Jinja Road
P.O. Box 20131
Kampala, Uganda
Website: http://www.umi.ac.ug

Your Ref:

Our Ref: **G/35**

17 March 2009

TO WHOM IT MAY CONCERN

MASTERS IN MANAGEMENT STUDIES DEGREE RESEARCH

Mr. Nuwamanya Herbert is a student of the Masters Degree in Management Studies of Uganda Management Institute 16th Intake 2008/2009 specializing in Project Planning and Management, Registration number: **08/MMSPPM/16/068.**

The purpose of this letter is to formally request you to allow this participant to access any information in your custody/organisation, which is relevant to his research.

His Research Topic is: ***"Factors Affecting the Sustainability of Urban Water Supply Systems in South Western Uganda".***

John Kittobbe
AG. HEAD, HIGHER DEGREES DEPARTMENT/PROGRAMME MANAGER, MASTERS DEGREES IN MANAGEMENT STUDIES

APPENDIX 5

LETTER OF APPROVAL OF THE RESEARCH PROPOSAL

UGANDA MANAGEMENT INSTITUTE

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E-mail: admin@umi.ac.ug

Plot 44-52, Jinja Road
P.O. Box 20131
Kampala, Uganda
Website: http://www.umi.ac.ug

Your Ref:

Our Ref: G/35

17 March 2009

Mr. Nuwamanya Herbert
07/MMSPPM/16/068

Dear Ms. Nuwamanya,

FIELD RESEARCH

Following a successful defense of your proposal before a panel of Masters Defense Committee and the inclusion of suggested comments, I wish to recommend you to proceed for fieldwork.

Please note that the previous chapters 1, 2 and 3 will need to be continuously improved and updated as you progress in your research work.

Wishing you the best in the field.

Yours sincerely,

John Kittobbe
AG. HEAD, HIGHER DEGREES DEPARTMENT/
PROGRAMME MANAGER MMS