SOCIO-ECONOMIC DETERMINANTS OF SUSTAINABLE WATER SUPPLY IN KAKAMEGA COUNTY

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DECLARATION

This thesis is my original work prepared with no other than the indicated sources and support and has not been presented elsewhere for a degree or any other award.

Signature…… Date……

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CERTIFICATTION

The undersigned certify that they have read and hereby recommend for acceptance of MasindeMuliro University of Science and Technology of a proposal entitled "***Effect of Socio Economic Factors on Sustainable Water Supply in Kakamega County.***"

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ABSTRACT

The Government of Kenya has been implementing the water sector reforms since the enactment of the Water Act 2002 to improve sector efficiency and accelerate water service provision. In Kakamega County, 43 per cent of the water produced is unaccounted for due to illegal connections and water wastage. Therefore, the overall objective of this study is to assess the effect of socio-economic factors on sustainable water supply in Kakamega County. Specifically, the study determined the effect of water tariff on sustainable water supply in Kakamega county, to establish the effect of water production costs on sustainable water supply in Kakamega County, to establish the effect of household characteristics on sustainable water supply in Kakamega County and to establish moderating effect of subsidies on the relationship between socio economic factors and sustainable water supply in Kakamega County. The study used mixed research design comprising of correlation research design, longitudinal and descriptive research designs. Secondary data was applied for this study. The researcher analyzed data between 2013-2022. The study targeted 34,206 water connections in Kakamega County. Secondary data was used for this study which was collected from Kakamega County Water and Sanitation Company (KACWASCO), Water Services Regulatory Board (WASREB), World Bank and Kenya National Bureau of Statistics (KNBS). The study computed both descriptive (mean and standard deviation) and inferential statistics (simple linear regression analysis, multiple regression analysis and hierarchical regression analysis). The study found that Water Tariffs, Water Production Cost and Household Characteristics had a significant positive effect on Sustainable Water Supply ($p<0.05$). The study further found that Water consumption Subsidy had a positive moderating significant relationship between socio economic determinants and Sustainable Water Supply ($p<0.05$). The study concluded that an increase in water tariff, water production cost and household characteristics would result to significant increase in sustainable water supply in Kakamega County. The study recommends that water companies should improve the tariff base for sustainability. Water firms should manage cash inflow and outflows for water sustainability. The number of households or water users should be assessed to ensure sustainability. The study suggests that water firms should accommodate all people by providing subsidies where applicable. The findings of this research are crucial to various stakeholders in this sector including the nation's monetary and fiscal policy makers, the house owners and other scholars.

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ABBREVIATIONS AND ACRONYMES

EWFD	European Union Water Framework Directive
EU	European Union
GDP	Gross Domestic Product
GoK	Government of Kenya
IBT	Increasing Block Tariff
IREC	Institutional Research Ethics Committee
KACRWASCO	Kakamega County Rural Water and Sanitation Company
KACWASCO	Kakamega County Water and Sanitation Company
KNBS	Kenya National Bureau of Statistics
MMUST	Masinde Muliro University of Science and Technology
NACOSTI	National Commission for Science, Technology and Innovation
O&M	Operations and Maintenance
OLS	Ordinary Least Squares
UN	United Nations
UNICEF	United Nations International Children's Emergency Fund
USD	United States Dollar
SDGs	Sustainable Development Goals
SPSS	Statistical Package for Social Science Program
VIF	Variance inflation factors
WASREB	Water Services Regulatory Board
WSP	Water Service Providers

OPERATIONAL DEFINITION OF TERMS

Household Characteristics- It is refers to the number of individuals occupying a given house, the household income patterns and household status whereby it has an impact on water usage.

Subsidies- This refers to reward actions that promote water security and mitigate the impacts of policies, which are unfavorable for underprivileged groups.

Sustainable water supply- This refers to actual water supplied by the water utility in comparison to water demand in a given area for a specified time.

Water costs- This refers to charges that are incurred in the process of providing water such as water installation costs, operation and maintenance costs, water treatment costs and labor costs involved.

Water prices- This refers to the charges set for water provision whereby the cost aspect is considered in the entity.

Water supply- This refers to the provision of water by public utilities based on total domestic water demand per head and total population.

Water tariff- This refers to a price assigned to water supplied by a public utility through a piped network to its customers and it aims at treating consumers equitably.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In the world today many nations have struggled with the problem of water sustainability which is as a result of socio-economic factors. Worldwide, there has been continued focus on sustainable access to quality, quantity and affordable water (Schwartz, Tutusaus, & Savelli, 2017). This is emphasized in the Sustainable Development Goals (SDGs) thus SDG 6 regarding clean water and sanitation, the African Agenda 2063 that explains the integrated water resource management, the constitution of Kenya 2010 article 43 that crowns the right to clean and safe water. Whereas this has been the case, sustainable water supply has equally been a concern. In water service provision, sustainability depends on water prices, water cost and water tariffs (Pinto & Marques, 2016). It is impossible to attain either of the aspects of sustainability in the absence of an optimal water pricing mechanism (Rosegrant & Cline, 2018).

At the global level, the United Nations (UN) identified water pricing for cost recovery as a major component in the economic pillar of sustainability as operationalized by the European Union Water Framework Directive (EWFD) (Bernard, 2013). It was also a major target for reforms during the global move to commercialize water service provision in the 1990s (Rusca & Schwartz, 2017). Whereas this has been the case, sustainable water supply has equally been a concern especially in the wake of huge commercial losses. According to the World Bank (2016) developing countries lose about 45 million cubic meters with an economic value of USD 3 billion. This calls for

developing countries to investigate the matter and come up with mechanisms that will reduce these losses if not eliminating them.

An uninterrupted and sufficient water supply is crucial for the long-term progress and welfare of humanity. Nevertheless, the uncertainties surrounding the sustainability of water resources are causing worries, particularly due to the existing limited availability of freshwater (Oki, 2016, Ferguson et al., 2018). Rising populations, more advanced economies, and shifting consumer preferences are driving a 1% yearly increase in the demand for the world's freshwater supplies (UN, 2020). Water is acknowledged as an essential component for achieving the numerous Sustainable Development Goals (SDGs) in the 2030 Agenda for Sustainable Development. As stated in SDG 6, the availability of safe drinking water and sanitation services is a top priority. Achieving water accessibility by 2030 would need sustainable ways to extract and distribute freshwater, as well as a marked improvement in water-use efficiency across all industries (Desa UN, 2016).

It is possible to decouple a country's economic growth from its water use by gradually improving water-use efficiency. According to UN-Water (UN, 2021), there was a 9% increase in worldwide water-use efficiency between 2015 and 2018, with industrial services reaching 32 USD/m3 and home services reaching 112 USD/m3. One of the most obvious but politically contentious ways to encourage water sustainability is through water pricing, one of various approaches (Rogers et al., 2002). One way to improve water-use efficiency and encourage sustainability is through water pricing reforms (Dinar, 2000). Because people's access to water varies over time, the efficiency of water usage is not constant and declines as supplies grow. Changing people's views of water as a private good makes it easier to implement full-cost pricing, which in turn depends on what drives water users (Toan et al., 2016). In the last few decades, water

tariff reform has been initiated by a number of industrialized nations, notably the US and EU member states. Water tariff reform in underdeveloped nations is a complex and arduous undertaking (Toan et al., 2016).

Tariff setting is considered to be a highly sensitive process because of the requirement to balance between cost recovery and access to water (Mitlin &Walnycki, 2019). That notwithstanding, the importance of water pricing in ensuring sustainability cannot be overemphasized because it is the only means of earning own revenue in water service provision (Rosegrant & Cline, 2002). This is because it is through the water tariff that operation and maintenance costs, loan repayments, new investment and asset renewal are financed (Rosegrant & Cline, 2018). Among the key objectives of water pricing is attainment of sustainability through revenue sufficiency and revenue stability (Rosegrant& Cline, 2018).

The price of water should reflect the complete cost, encompassing the total supply cost, opportunity cost, and environmental externalities (Wang et al., 2020). The complete supply cost encompasses both the expenses associated with operating and maintaining the system, as well as the initial investment cost. Few countries have effectively used full cost water pricing or entire water supply cost pricing, even though the idea has been included in certain water plans (Parris, 2010). According to Toan (2016), the amount that users pay for water in most nations hardly covers a fraction of the whole cost. The difficulty in calculating opportunity costs as well as environmental costs and benefits is a contributing factor. The water supply system's day-to-day operations are covered by the Operations and Maintenance (O&M) program, which includes things like labor charges, repair costs, and electricity consumption for pumping. A company's "capital cost" includes not only the price tag for new assets but also the price tag for repairing and updating older infrastructure.

According to demand theory, when the price of a commodity rises, the demand for that good decreases (Julius & Kalunda, 2021). In a competitive market, the price of water is set by the combination of demand and supply, which accurately reflects the marginal costs of using water. This price will incentivize customers to buy the optimal amount of water. The fundamental rationale is that increased water prices result in decreased use (Murrar & Tamim, 2021), a logical outcome when water is seen as a purely economic commodity. Nevertheless, according to Reynaud (2016), water does not conform to the characteristics of a typical commercial commodity, as it is indispensable for most purposes and cannot be easily substituted. The majority of economists studying domestic water acknowledge that domestic water consumption is often price-inelastic, meaning that the decrease in demand is proportionally smaller than the increase in price. The concept of price elasticity of water can be expressed as $Q = KPe$, where Q represents the quantity demanded, K and e are constants, and e is the elasticity of demand, which is a negative value.

The pricing of water serves as a means for a Water Service Provider (WSP) to generate money. Optimal pricing aims to promote efficiency by providing appropriate signals to water consumers and also supporting the expansion of water access (Massarutto, 2020). The focus of academic debate has primarily been on pricing strategies to enhance affordability and expand access to water and sanitation services (WSPs). However, there has been a lack of attention towards other crucial issues, including the financial sustainability of WSPs (Murrar & Tamim, 2021).

The challenge that countries encountered in achieving complete cost recovery was addressed by the introduction of the concept of sustainable cost recovery. The long-

term viability of water resources and the provision of water services are the goals of this idea. Eventually, it was adopted and put into practice (Wu, 2011). The key features of sustainable cost recovery encompass the utilization of suitable pricing and taxation mechanisms to fund operation and maintenance as well as capital expenses. Additionally, targeted public subsidies are employed to stimulate investment, while affordable pricing strategies are implemented to ensure the long-term financial viability of water services (Camdessus, 2003).

Sustainable pricing aims to offer a middle ground for water supply, particularly in developing nations, in contrast to full cost price. Subsidies can serve as assistance methods to promote water sustainability. Subsidies play a crucial role in ensuring a sustainable water supply in numerous countries. Typically, governments in developing nations must allocate significant funds towards subsidies in order to ensure water security, leading to the provision of water at reduced prices. Long-term sustainability cannot be maintained with excessive subsidies. Hence, it is imperative to employ suitable or targeted subsidies to support the implementation of water sustainability (Murrar & Tamim, 2021).

Precise subsidies are incentives that are tailored to specific regions and are designed to influence changes in water usage behavior. In addition, quota control is a widely used policy to decrease water consumption, which is implemented through administrative management. Water quota is the measure of water consumed per unit of product or unit of land during a specific time period. It serves as a direct method to restrict water supply and decrease water usage (Camdessus, 2003).

Implementing quota management can effectively regulate the overall water usage, allowing for greater flexibility in adjusting water pricing without altering the total water fee. Thus, in order to maximize the impact of water pricing on the efficient allocation

and use of water, it is necessary to integrate water pricing with a range of comprehensive measures, such as subsidies and quota control management (Julius & Kalunda, 2021).

An investigation was conducted on the water fees imposed by 45 water service providers in 23 African nations between 2006 and 2007. The investigation revealed that a mere 36 percent of the utilities assessed are covering their whole operations and maintenance (O&M) expenses. Furthermore, just 9 percent are able to cover both their O&M costs and a portion of their capital costs, even in the highest tariff blocks where consumption is rather high (Omondi, 2017).

The increasing block tariff (IBT) is the predominant tariff system in Africa, as stated by Julius and Kalunda (2021). According to WASREB (2022), African utilities generally succeed in recovering operation and maintenance (O&M) costs through the highest block rates. However, they struggle to accomplish cost recovery through the first-block tariffs, which are intended to offer affordable water to low-volume consumers, who are frequently impoverished.

Overall, the extent of access to enhanced water services in Africa remains rather limited. In 2011, the percentage of urban areas with access to drinking water was 85%, while the percentage for rural areas was 51%. As for sanitation, 42% of urban areas had access to proper sanitation facilities, compared to only 24% in rural areas. Water underpricing is prevalent throughout Africa. In countries like Côte d'Ivoire, Madagascar, and Senegal, under-pricing of utilities has resulted in a significant loss of income, with less than 40 percent of the required funds being captured. This has imposed an economic burden equivalent to approximately 0.7-0.9 percent of GDP (Arouna, 2019). Under-pricing has additionally played a role in the current scenario,

with approximately 30 percent of water services infrastructure assets in Africa requiring rehabilitation on average. In Kenya, the practice of under-pricing water results in the water sector losing at least USD 1.8 billion annually, which is equivalent to 0.3 percent of the country's GDP (Arouna, 2019).

According to Marson and Savin (2015), sustainability in the water sector depends on achieving both optimal pricing and efficiency. The lack of consideration for cost in water pricing in Kenya was identified as one of the main obstacles that impeded economic progress (GoK, 2019). Sustainability, in the context of water supply, refers to the ability to maintain the perceived benefits of investment projects even after the active implementation period has ended (Lockwood & Smits, 2011). The Water Services Regulatory Board (2023) has stated that many counties in Kenya are still facing significant challenges with water losses. Specifically, 16 counties have had water losses above 50% of their total production. The Gusii water and sanitation firm had a 77% loss in the production of water in both Kisii and Nyamira counties. This translates into a substantial financial loss. Given this pattern, water service providers in Kenya may face challenges in fully covering all costs and may not be financially viable in the long term. This will weaken the gradual implementation of the right to water as protected in the Kenyan constitution. The majority of these losses are mostly attributed to business and governance issues, such as corruption and criminal practices, rather than technological factors.

Kakamega County Water and Sanitation Company recorded a 36% of water wastage through leakages and illegal connections on average per month (IMPACT report 2023), which would translate to Ksh. 182,250,000 per year. This calls for attention by the concerned authorities to come up with solutions to this problem. Consequently, the

approved development budget for the sector increased by a factor of seven over the past eight years, going from Ksh 4.4 Billion in the 2014/2015 financial year to Ksh 32.1 Billion in the 2022/2023 financial year. Nevertheless, Kakamega municipality has stated that 43 percent of the 8,000 cubic meters of water it provides on a daily basis cannot be accounted for due to unauthorized connections, production, government support, and wasteful usage.

1.2 Statement of the Problem

The Ministry of Water in Kenya has been carrying out water sector changes since the Water Act of 2002 was passed. The goal of these reforms is to enhance the efficiency and overall performance of the sector. Additionally, a new decentralized institutional structure has been established to expedite the provision of water services. Kakamega town has recorded a water loss rate of 43 percent, equivalent to 8,000 cubic meters per day, attributed to unauthorized connections and wasteful usage of water (WASREB, 2022). Water sustainability cuts across water availability, water quality, efficient water use and integrated water resources management. In Kakamega County, there have been cases of water rationing due to non-sustainable water supply (KACWASCO). Furthermore, the high failure rate of water service providers has contributed to non-sustainable water supply. It is worrisome that close to a decade and half none of the water service providers in Kenya has attained and sustained full cost recovery on water. Available data show that the national average water price per cubic meter in 2021/2022 financial year was Kshs 79 while the average per unit operation and maintenance cost was Kshs 83 (WASREB, 2021). Charging a price lower than the input costs however, impacts negatively on financial sustainability. Furthermore, underpricing water concept

makes the water sector to forgo at least USD 1.8 billion a year in revenues which reflects 0.3 percent of GDP.

Julius and Kalunda (2021) conducted a study on the impact of water pricing on sustainability among water service providers in Kenya. Numerous studies have evaluated the issue of sustainable water supply. According to the study's results, water pricing in Kenya does not significantly affect the financial sustainability of WSPs. The component of water supply was not examined in the study. Murrar, *et al*. (2017) undertook a study to investigate the impact of water price on financial sustainability for the Palestinian WSPs and found that pricing was of insignificant influence on sustainability, the study failed to address water tariff effect. Regarding water costs Murrar, Tamim, *et al*. (2017) found water costs insignificant on water viability for the Palestinian WSPs. The study failed to address other socio-economic determinants of water supply. Although Kakamega County has large population of 1,867,579 as per the 2019 census that need enough water supply there is need to improve water provision. Therefore, this study sought to establish the effect of socio-economic factors on sustainable water supply in Kakamega County.

1.3 Research Objectives

1.3.1 General Objective

The general objective of this study was to establish the socio-economic determinants of sustainable water supply in Kakamega County.

1.3.2 Specific Objectives

The specific objectives were:

i) To determine the effect of water tariff on sustainable water supply in Kakamega county.

ii) To establish the effect of water production costs on sustainable water supply in Kakamega County.

iii) To establish the effect of household characteristics on sustainable water supply in Kakamega County.

iv) To establish moderating effect of water consumption subsidies on the relationship between socio-economic factors and sustainable water supply in Kakamega County.

1.4 Research Hypothesis

i) Water tariff has no significant effect of on sustainable water supply in Kakamega County.

ii) Water production costs have no significant effect of on sustainable water supply in Kakamega County.

iii) Household characteristics have no significant effect on sustainable water supply in Kakamega County.

iv) Water consumption subsidies have no significant moderating effect on the relationship between socio-economic factors and sustainable water supply in Kakamega County.

1.5 Significance of the study

The results of this study may be crucial to Kakamega county households and Kenya at large, on matters of water sustainability supply. Water sustainability examinable through water availability in terms of demand at a specific period in time against what

was supplied in actual terms by the water service provider. It will help them understand the socio-economic factors of water tariffs, water production costs and household characteristics as well as water consumption subsidies on sustainability.

The outcome may be of significance to the Government and other regulators on water provision. It may help the regulators to get insights on the key factors to target and avail water sustainability.

The study may be beneficial to households who are users of the water resource. Access to sustainable water may be of aid to water users. Therefore, this study would shed light on approaches to sustainable water supply. Finally, the study may be used by future researchers and academicians on water sustainability and supply. The study also recommends new areas for further study that influence water sustainability.

1.6 Scope of the Study

The study was carried out in Kakamega County. Kakamega County is the second largest in population after Nairobi hence need for water sustainability thus water availability, water quality, efficient water use and integrated water resources management. With a population of 1,867,579, Kakamega County water and Sanitation company (2023) reported that only 53% of the population within its service coverage area had access to clean and safe drinking water giving indication that 47% of residents lack access to quality water. The study conducted a time series data of 10 years thus 2014-2023 a period, a period within which Kakamega County Water Supply and Urban Sewerage Strategic Plan (2015-2020) allude to be of great concern on water sustainability. The target population entails the residents of Kakamega county household based on 12 sub counties of Mumias East, Mumias West, Matungu, Navakholo, Lurambi, Shinyalu, Ikolomani, Likuyani, Malava, Khwisero and Butere. The study was limited to socio

economic factors conceptualized through water tariffs, water production costs, and household characteristic and water consumption subsidies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter the researcher carried out a theoretical review on various theories explaining the socio-economic factors under investigation. The section also provided empirical review where the researcher also reviewed past studies in similar field and a conclusion on literature review.

2.2 Theoretical Framework

The theoretical framework reviewed the theories that have been advanced by scholars that relate with the topic under study. A theory is a set of assumptions proposed to explain a certain phenomenal. In this case, the researcher reviewed economic theories related to the independent variables under study to try and explain socioeconomic factors and water sustainability gaps in Kenya.

2.2.1 Public utility Theory

This theory was formulated by Hotelling (1938). This study was anchored on the public utility pricing theory that bases on perfect competitive market for pricing of water supply. The theory holds that in order to maximize general welfare, public utilities should charge prices at the marginal cost of delivering the service. In instances where a utility is faced with decreasing average costs, total revenue earned is less than total costs and for optimality to be attained the government is required to finance the deficit (Coase, 1946). According to the theory, all fixed costs including water infrastructure development should be financed if possible by the government through subsidies (Frischmann & Hogendorn, 2015). The theory has however, been critiqued on grounds

that public utilities do not operate under perfect competition with majority considered monopolies such as water supply and are subjected to government regulation (Frischmann & Hogendorn, 2015). Secondly, the factor inputs used by a majority of these entities are indivisible and not transferable across customers (Wiseman, 1957). In the case of decreasing average costs, the requirement for government funding through taxes destabilizes the economic welfare (Frischmann & Hogendorn, 2015). Given the limitations, Coase (1946) introduced the aspect of multi-part pricing system in which every consumer pays a portion of the fixed costs in addition to the variable costs commensurate to their consumption. By so doing, Coase (1946), brought in a balance between the desire to charge full cost for services delivered while eliminating the requirement for government subsidies. The full costs leads to the element of water costs. The multi-party system of pricing is the commonly adopted system across many countries for pricing of government services including water services. This theory was critical to this study because it defines water pricing tariff, water production costs and shows its linkage with subsidies. It is the main theory for the study.

2.2.2 Transaction cost theory

Transaction cost theory, introduced by Ronald Coase in 1937, seeks to elucidate the characteristics and rationale for the presence of enterprises in the market. Coase argues that firms persist due to their ability to minimize transaction costs, which refer to the expenses related to conducting business operations. Organizing production within a corporation can save the expenses associated with coordinating it through the market, according to the notion. Using this method, the expenses associated with parties' contract negotiations, monitoring, and enforcement can be reduced (Coase, 1937).

Transaction cost theory posits that individuals are driven by rationality and self-interest, with the primary goal of maximizing their earnings. Additionally, it presupposes that markets are imperfect and that there are expenses related to conducting transactions, such as costs involved with searching, negotiating, and enforcing agreements. Firms have the ability to lower these costs by internalizing transactions and decreasing the necessity for negotiation and enforcement (Williamson, 1975).

One of the main arguments against transaction cost theory is that it ignores the role that social relationships play in transactions and how trust and cooperation can reduce transaction costs. However, not all businesses run efficiently, and the theory assumes that their very existence is due to market failures (Klein, Crawford & Alchian, 1978).

Nevertheless, the theory has been extensively employed in the analysis of diverse economic and business phenomena. Additionally, it has been utilized in the examination of water production expenses, water pricing, and financial assistance. Water firms may experience a range of transaction expenses during the process of supplying water, including costs associated with installation. Transaction cost theory posits that these expenses can impact the provision of services.

2.2.3 The Contingency Theory

The contingency theory, developed by Fred Edward Fielder in 1964, posits that there is no universally optimal approach to project management. Instead, the success of projects is determined by the alignment between the management style and the specific characteristics of the work and tasks involved. In addition, according to the notion, a project's success depends on how effectively it adjusts to its surroundings. An organization's performance, according to contingency theory, hinges on how well its

internal workings mesh with its external setting. The success of this concept hinges on the complex interaction of various factors, according to this theory.

Therefore, it has emerged as one of the most reliable and enduring theoretical frameworks employed in the field of management. It is the responsibility of the management to devise strategies for offering subsidies as a precautionary step to ensure water availability and promote effective water usage (Arouna, 2019). The Contingency hypothesis posits that optimal effectiveness in organizations is contingent upon adapting organizational relationships to suit varied settings, while considering diverse water management issues such as water tariffs and subsidies. Water service providers would find the contingency theory highly important for ensuring a sustainable water supply (Marson & Savin, 2015). Water delivery systems that are sustainable must possess the ability to adapt and be flexible in order to effectively address and accommodate changes in environmental, social, and economic circumstances. Contingency theory posits that management processes should adapt and develop in response to new knowledge, technology progress, and feedback from stakeholders. This may involve implementing innovative water conservation technology, modifying water distribution techniques during periods of drought, or updating regulations in light of population expansion (Cheruiyot, 2019).

Contingency theory promotes the comprehension of the interconnections within these systems and the contemplation of the possible repercussions of managerial choices. An instance of sustainable water management could entail the harmonized endeavors of various stakeholders to equitably distribute water resources between agricultural irrigation and urban water delivery (Arouna, 2019).The significance of engaging stakeholders in decision-making processes regarding water management is emphasized by contingency theory. This encompasses several stakeholders such as local

communities, government agencies, non-governmental organizations (NGOs), private sector companies, and research institutions. Engaging stakeholders facilitates the identification of various viewpoints, worries, and priorities, which can then be used to develop management methods that are more suitable and efficient in the given environment (Zetland & Gasson, 2012).

Contingency theory suggests that it is important to incorporate resilience into water management methods due to the uncertainties and risks related to water supply, including climate change impacts and fluctuations in water availability. This entails predicting possible disturbances, formulating backup strategies, and executing procedures to alleviate risks and guarantee the uninterrupted provision of water under different circumstances (Omollo, et al, 2020).

2.3 Conceptual Review

The conceptual review was guided by the variables, water tariff, water production costs, household characteristics and subsidies. It explains the variables and how they were measured.

2.3.1 Water tariff

Tariff setting is considered to be a highly sensitive process because of the requirement to balance between cost recovery and access to water (Mitlin &Walnycki, 2019). Water tariffs and sustainable water management are intricately linked, as tariffs play a significant role in promoting efficient water use, funding infrastructure investments, and ensuring the long-term sustainability of water resources. Water tariffs enable utilities to recover the costs of producing, treating, and distributing water (Marson & Savin, 2015). This includes operation and maintenance expenses, capital investments

in infrastructure upgrades and expansions, energy costs, and administrative overheads. Sustainable water management requires adequate funding to maintain and improve water supply systems over time. It is through the water tariff that operation and maintenance costs, loan repayments, new investment and asset renewal are financed (Rosegrant & Cline, 2018). Tarif is used on billing customers and hence for this study was measured by cost per cubic meter.

2.3.2 Water Production costs

Sustainability is greatly affected by the expenditures related to the water sector. Users' payments for water in most nations hardly scrape the surface (Toan, 2016). The difficulty in calculating opportunity costs as well as environmental costs and benefits is a contributing factor. Powering pumps, supervising employees, and paying for repairs are all part of the day-to-day operations of the water delivery system, which are covered by the Operations and Maintenance program (Reynaud, 2016).

The term "capital cost" encompasses expenses related to both the replacement of existing infrastructure and the costs associated with new investments. In Kenya, the practice of under-pricing water results in the water sector losing at least USD 1.8 billion annually, which is equivalent to 0.3 percent of the country's GDP (Arouna, 2019). Water Services Regulatory Board (2023) reported that water losses continued being a challenge to many counties in Kenya with 16 counties having more 50% water losses of what they have produced. Kisii and Nyamira counties recorded 77% loss of what was produced, concluding that if this is converted into monetary terms depicts a significant loss of revenue. Water production costs was measured by expenditure over depreciation.

2.3.3 Household Characteristics

According to Arouna (2019) a house set up has certain characteristics which imply that they add up to sustainable water supply. Omollo *et al* (2020) found that household characteristics have a role in sustainable water supply. This comprises of the income, status and size of the house. Larger households typically consume more water due to increased demand for cooking, cleaning, bathing, and laundry. Sustainable water management involves promoting efficient water use practices, such as installing water-efficient fixtures and appliances, to reduce per capita water consumption. Household income influences water consumption behaviors, with higher-income households often using more water for landscaping, swimming pools and luxury amenities. Sustainable practices include promoting affordability through equitable tariff structures and encouraging water-saving investments regardless of income (Rosegrant & Cline, 2018).

Household knowledge of water conservation practices and environmental awareness impact behavior. Sustainable water management includes education campaigns to promote behaviors like fixing leaks, using efficient irrigation methods and reducing unnecessary water wastage (Rusca & Schwartz, 2017). Household characteristic will be measured by persons per household, income patterns and status.

2.3.4 Subsidies

Subsidies are an economic tool designed to incentivize the consumption or production of products and services. They involve the discrepancy between the actual cost and the amount spent to ensure effective consumption or production (Cheruiyot, 2019). Rios et al. (2018) argue that subsidies are intended to enhance the affordability of water for customers, but this can have a detrimental effect on corporate earnings. The worldwide demand for water resources is increasing at an annual pace of 1%, propelled by

population increase, economic advancement, and changing consumption habits (UN, 2020). Subsidies play a crucial role in ensuring a sustainable water supply in numerous countries. Typically, governments in developing nations must provide significant subsidies to ensure water security, leading to the availability of low-cost water. Long-term sustainability cannot be achieved with excessive subsidies. Hence, it is imperative to employ suitable or targeted subsidies to support the implementation of water sustainability (Murrar & Tamim, 2021). The study was tempered by water consumption subsidies, which were calculated by multiplying the cost per unit delivered by the quantity consumed.

2.3.5 Sustainability in Water Supply

Managing an activity effectively is key to sustainability. According to Lockwood and Smits (2011), sustainability in water supply means that the advantages of investment projects are maintained even after the active phase of implementation ends. Between 2015 and 2018, the world's water-use efficiency rose by 9%, reaching 32 USD/m3 for industrial and 112 USD/m3 for home services, according to UN Water (UN, 2021). Kakamega County Water and Sanitation Company recorded a 36% of water wastage through leakages and illegal connections on average per month (Impact report, 2023), which would translates to Ksh. 182,250,000 per year. Kakamega town has reported that 43 per cent of the 8,000 cubic meters of water it supplies daily is unaccounted for due to illegal connections, production costs, subsidies and water wastage. Sustainability of water supply was measured by water supplied verses water demanded in a particular period.

2.4 Empirical Review

The empirical study is guided by the variables, water tariff, water production costs, household characteristics and subsidies. Water tariff refers to the pricing structure or rate schedule that water utilities or providers charge consumers for the provision of water services. It is a critical component of water governance and management, influencing both the financial sustainability of water utilities and consumer behavior towards water conservation and efficiency (Julius & Kalundahe, 2021) Water production costs encompass various expenses incurred in extracting, treating, and distributing water to consumers. Household characteristics refer to various demographic, economic, social, and behavioral attributes that define a household's composition, lifestyle, and consumption patterns. These characteristics play a significant role in influencing resource use, including water consumption, waste generation, energy use, and overall environmental impact (Murrar & Tamim, 2017). Water subsidies are financial support mechanisms provided by governments or utilities to reduce the cost of water services for certain groups or purposes. These subsidies aim to promote access to clean and safe water, particularly for low-income households, while also supporting sustainable water management goals (Bel, 2020).

2.4.1 Water tariff and Sustainable Water Supply

Ortuzar et al (2023) conducted a study on the macroeconomic effects of water distribution during droughts in the global supply chains of China, taking into account multiple regions. The main objective was to ascertain how water tariff regimes affect water supply. The study assessed the worldwide macroeconomic impacts of localized droughts using a multi-regional input-output model and a non-linear programming optimization model. Water tariff policies are beneficial in making water supply

accessible, according to the study. The study's results show that developing nations and the region directly impacted by economic repercussions are significantly impacted by the choice of policy-regime. Drought has a negative impact on agriculture's bottom line, but measures to increase output and decrease trade can help. On the flip side, worldwide economic losses could ensue from a persistent reduction in water supply across all economic sectors in the drought-stricken region. This work is pertinent to the present investigation since it provides useful background on the effects of water tariffs on long-term water supply sustainability.

Vucijak, Pasic and Bijelonja, (2018) in assessing utility operational and sustainable water supply in Western Balkans, it was established that water tariff should be accompanied by other policies for effectiveness. The study recommended that, a tariff increase for utility's financial sustainability should not be the first strategy, instead, it should be accompanied by implementation of efficiency measures including cost justification, infrastructure maintenance to reduce non-revenue water and optimal staffing levels (Vucijak *et al*., 2018). This informs the study as water tariff has an influence on sustainable water supply. The prices determine the usage and supply ability thus forces of demand and supply.

Julius and Kalundahe (2021) looked at how water tariffs affect Kenyan water service companies' ability to provide water. The study used an explanatory sequential mixed design and was based on pragmatism, a theory of research. Analysis of the data was done using both descriptive statistics like standard deviation and mean, and inferential statistics like ordinary least squares (OLS) regression. According to the results of the study, Water Service Providers (WSPs) in Kenya are not significantly affected financially by the water pricing. According to the findings, water companies should verify the adequacy of the current pricing methodology in achieving its four main goals:

fair access, efficiency, simplicity, and full cost recovery. They should also reassess the methodology to protect water service providers from changes in input costs and to ensure its ability to handle other external disruptions. This study focuses on the analysis of water tariffs and cost components.

Murrar and Tamim (2017) undertook a study to investigate the impact of water price on water supply for the Palestinian and found that the higher the price of water the lower the working capital, implying financial sustainability. The results established shows that water supply is subject to tariff hence informing the study on sustainability of water supply.

Bel, (2020) conducted a project-based study in Zambia to determine the water supply of household water treatment and storage project. The study adopted a mixed research design. The study established the existence of a positive relationship between tariff and water project sustainability. This informs the study on basis of water tariff in line with sustainability of water supply.

2.4.2 Water Production costs and Sustainable Water Supply

While assessing the impact of full cost recovery on water services across European households, Reynaud (2016) found that the influence of water production costs on water supply is informed to a great extent by the price elasticity of demand for the particular countries. The results from the study which covered nine European countries including Austria, Bulgaria, Czech Republic, Estonia, France, Greece, Italy, Portugal and Spain showed that the influence of water production costs increases to full cost level was watered down by consumption adjustment hence leading to nonattainment of the required results (Reynaud, 2016). From the foregoing, scholars have taken interest in exploring the relationship between water production costs and water supply of WSPs.

There have, however, been contradictory findings by the various studies whereby three different schools of thought on the influence of water costs on water supply emerge from the literature reviewed including school of, positive influence (Murrar, Awad, *et al*., 2017; Murrar, &Tamim, 2017; Zetland & Gasson, 2012), school of no influence (Vucijak et al., 2018; Rusca & Schwartz, 2017; García-Rubio et al., 2015); and the school of thought that the influence is depended on other factors like price elasticity (Reynaud, 2016).

Tifow (2013) examined rural water supply sustainability in Kenya, specifically looking at rural water projects funded by UNICEF in the Lake Victoria North and South Water Services Board Regions. In particular, the study examined the impact on sustainability and sustainability outcomes of community involvement, technology choice, water management committee abilities, and post-implementation support. This study contributes to our comprehension of the elements that lead to the failure of community-based water systems, with the aim of enhancing the sustainability of rural water supplies. Additionally, it assists the sector in developing training models and packages to educate communities and trainers at an intermediate level. The training packages aim to enhance the long-term sustainability of rural water supply by providing support to stakeholders, including personnel of the Ministry of Environment, Water, and Natural Resources. The study's findings contribute to the existing knowledge on strategies for enhancing the sustainability of rural water supply, hence influencing policy and practice in this field.

2.4.3 Household Characteristics and Sustainable Water Supply

Arouna (2019) conducted an analysis of families' water consumption based on the availability of water. The study specifically estimated the amount of water used by

homes during both the rainy and dry seasons, when water is respectively abundant and limited. The amount of water used in households rises in proportion to the number of people living in them. Both home size and composition have an impact on water usage. Furthermore, research has shown that household size is the primary factor influencing water consumption (Arouna, 2019). In the context of household data analysis, household size is the number of individuals residing in the household, while household composition is the gender of the family chief and the ratio of children to adults.

Omollo et al. (2020) found out what makes people in Kibera, a slum in Nairobi County, Kenya, use more or less water. Finding out what makes the Kibera informal slum in Nairobi County use water so much was the driving force for this research. The purpose of this research was to analyze the water demand in the Kibera informal settlement in Nairobi County as a function of price, home size, gender, family head's income, education level, age, and profession. The study employed an explanatory research approach incorporating a demand-responsive model and a Stone-Geary model. The study found that the variables impacting water demand accounted for 120.3% of the total variation in water demand within the slum. The availability of water is highly correlated with the size of the household. The report recommends that the Nairobi county government set prices for water that reflect the demand in informal settlements. It is also critical that the county government do more to support the informal settlement's businesses. People would be able to earn more money and be able to afford more water if this happened.

Cheruiyot (2019) investigated the utilization, allocation, and community-driven governance strategies regarding water resources in the Nyangores Sub catchment of

Bomet County, Kenya. The goals of this research were to find out how much water people use at home, what variables affect that amount and where it goes, and how effective the water management plans that are in place in the Nyangores sub-catchment are. Three hundred homes from the Silibwet, Bomet, and Sigor divisions were surveyed for the study, and descriptive statistics were used to analyze the results. Major factors influencing domestic water demand, according to the results, include household income, household size, and distance from homesteads to water sources. The fast increase in human population has put a strain on already-scarce water supplies, the quality of which has declined significantly as a result of increased agricultural and livestock production. Presently, unregulated water sources provide the majority of the 9,745 m3 per day needed for water use.

2.4.3 Subsidies, Socio Economic Factors and Sustainable Water Supply

Subsidies, which are a kind of economic stimulus, are defined as the gap between the market price of a thing or service and the amount actually spent on it in order to maximize its use or production. Generally speaking, the implementation of targeted subsidies for both consumption and production (Cheruiyot, 2019).

In China, Wu (2011) sought to establish the effectiveness of water subsidies in ensuring cost recovery in Chengdu, a city in South-west China. The study adopted descriptive study design. The study reported that there is a positive correlation between water subsidies and financial sustainability. The water tariff informs the study in explaining sustainability of water supply.

Similar results were obtained by Zetland and Gasson (2012) who sought to examine the relationship between water consumption subsidies, sustainability, efficiency and equity.

The study conducted a survey research design, a positive relationship between water price and cost recovery by WSPs was established. On contrary, other studies have established that the positive influence of water pricing on WSP financial sustainability is only felt if used in conjunction with appropriate efficiency measures. This informs the study since water subsidies is an area of interest for the study.

According to Rios *et al*, (2018) who conducted a multi-national study covering Ghana, Spain, Brazil, Bolivia and France. The study employed a causal design and panel data model. The study found that water subsidies should be applied in conjunction with other policies including efficiency, public participation and subsidies in order to ensure that the motivation is not increasing return on investment only.

A study undertaken by Rusca and Schwartz (2017) established the influence of water subsidies on sustainable water supply in Maputo and Lilongwe, they established the influence of water subsidies on water supply as positive and significant. The implementation of full cost recovery pricing negatively affected affordability for water and thus recommended consideration for water supply to incorporate subsidies and other transfers (Rusca & Schwartz, 2017). This informs the study as water subsidies have a significant input on water supply sustainability.

2.5 Research Gap

Table 2.1 Knowledge Gap

Author(s)	Study	Methodology	Results	Gap

Julius &Kalundahe (2021)	The influence of water pricing on water supply among water service providers in Kenya	pragmatism research philosophy and explanatory sequential mixed design. The target population constituted seven senior managers from each of the 88 registered small to very large Water Service Providers	The findings of the study indicate that water pricing does not have a statistically significant influence on financial sustainability of WSPs in Kenya.	The study was based on water pricing and not socio economic determinants as a whole
Murrar &Tamim (2017)	The impact of water price on water supply for the Palestinian Water Service Providers	Factor analysis, correlations, and regression techniques	The higher the price of water the lower the working capital, implying financial sustainability	Study was conducted on water prices only failing to outline the tariffs, costs and households
Mutavi (2016)	The effect of corporate culture on performance of public water companies and sewerage in Makueni and Machakos Counties, Kenya	The target population was 188 which comprised all levels of employees working with the four water and sewerage companies. Using the stratified sampling, a sample size of 136 (72%) employees was selected and used in the study. Data was collected using a structured questionnaire which was distributed to the 136 respondents. The statistical Package for Social Science program (SPSS) was utilized	Companies that did not perform well such as Machakos tended to be autocratic and less participatory. Employees in these companies did not adhere to their organizational norms and did not believe that it was important to do so. Lastly poor performance was common among companies that did not adhere to their organizational artifacts.	Limited to corporate culture and performance of public water companies and not socio economic factors and waters supply

		to analyze the data collected and presented by use of pie charts, bar graphs and tables.		
Briand, Viroleau &Markantonis (2021)	The macroeconomic effects of water scarcity in South	Water computable general equilibrium Model	The long-term impact of water scarcity varies from one sector to another, with the most negatively impacted sectors being those related to water loss of GDP up to -2.48%. Due to the increase of water scarcity, the unemployment rate is expected to be 0.1% higher in 2020 which represents a loss of 18,000 jobs compared to the baseline year. The 17% increase in water scarcity is also expected to have a negative impact on household welfare: by 2030, household consumption may decrease by -0.26%. Some policies can mitigate the negative impacts of water scarcity, the most promising one being to promote water saving.	Based on water scarcity and not socio-economic factors and water supply
Omollo, Odhiambo&Ng'eno (2020)	The determinants of water demand in Kibera informal settlement in Nairobi county, Kenya	The study adopted a demand-responsive model and Stone-Geary model based on the explanatory research design. The target population was 15,000 individuals living in the Kibera informal settlement. Stratified and simple random	Regression results (R2 =0.1203) indicated that the determinants of water demand accounted for 120.3% of the total variation in water demand in the informal settlement. Variables such as age; household size; income; price; gender; education and	Factored determinants of water demand and not socio-economic factors and water supply

		sampling techniques were used to select respondents from the strata. From the target population of 15,000 a sample size of 390 respondents was selected. Data was collected using both a questionnaire and the interview guide and thereafter analysed using descriptive and inferential statistics.	occupation had significant relationship with water demand. Gender and income had positive and significant relationship with water demand while price, age, education, occupation and household size had negative and significant relationship with the demand for water.	
Arouna (2019)	Households' water use and water availability	The study adopted a demand-responsive model Stratified and simple random sampling techniques were used to select respondents from the strata.	Household characteristics had positive and significant relationship on water demand.	Factored determinants of water demand and not socio-economic factors and water supply
Cheruiyot (2019)	Household water demand, distribution and community management strategies in Nyangores Sub catchment, Bomet county, Kenya	The study employed descriptive statistics based on survey responses from a total of 300 households picked from Silibwet, Bomet and Sigor divisions.	Results indicate that income, household characteristics and distance from homesteads to water sources are major determinants of domestic water demand.	The study based on water distribution than socio economic factors
Reynaud (2016)	The impact of full cost recovery on water services	Mixed research design Stratified and simple random sampling techniques	The study found that the influence of water costs on water supply was informed to a great extent by the	The study relied on full cost recovery

	across European households	were used to select respondents from the strata. Data analyzed using descriptive and inferential statistics.	price elasticity of demand for the particular countries	on water services and not socio economic factors
Tifow (2013)	Factors influencing sustainability of rural water supplies in Kenya, a case of UNICEF supported rural water projects in Lake Victoria South and Lake Victoria North Water Services Board Regions	Causal research design Random sampling technique Data analyzed using descriptive and inferential statistics.	The study found that community participation, choice of technology, skills of water management committees and post implementation support had a significant effect on sustainability of water supply	The study failed to address water tariff, water production costs, household size and water consumption subsidy
Wu (2011)	The effectiveness of water subsidies in ensuring cost recovery in Chengdu, a city in South-west China	The study adopted descriptive study design Stratified and simple random sampling techniques were used to select respondents from the strata. Data analyzed using descriptive and inferential statistics.	The study reported that there is a positive correlation between water subsidies and financial sustainability.	The study relied water subsidy in general as the current study addresses consumption subsidy
Rios *et al*, (2018)	Amulti-national study on sustainable water supply covering	Mixed designs OLS model Stratified and simple random sampling techniques were used to select	Water subsidies had positive and significant relationship on water demand.	The study relied water subsidy in general

	Ghana, Spain, Brazil, Bolivia and France.	respondents from the strata. Inferential statistics. Regression and correlation analysis		as the current study addresses consumption subsidy
Rusca & Schwartz (2017)	The influence of water subsidies on sustainable water supply in Maputo and Lilongwe	The study adopted descriptive study design Stratified and simple random sampling techniques were used to select respondents from the strata. Data analyzed using descriptive and inferential statistics.	The implementation of full cost recovery pricing negatively affected affordability for water and thus recommended consideration for water supply to incorporate subsidies and other transfers	The study relied on full cost recovery pricing and not water consumption subsidy

2.6 Conceptual Framework

The study outlines the dependent, independent and moderating variables. The independent constitutes the socio economic factors. The first socio economic factor adopted in this paper is water tariff, which is measured by cost per cubic meter. Water production costs measured by expenditure over depreciation. Household characteristic is measured by persons per household, income patterns and status. The dependent variables; Sustainability of water supply measured by total demand vis a vis total supply for a given period. This was moderated by water consumption subsidies measured by the cost per unit delivered multiplied by the quantity consumed.

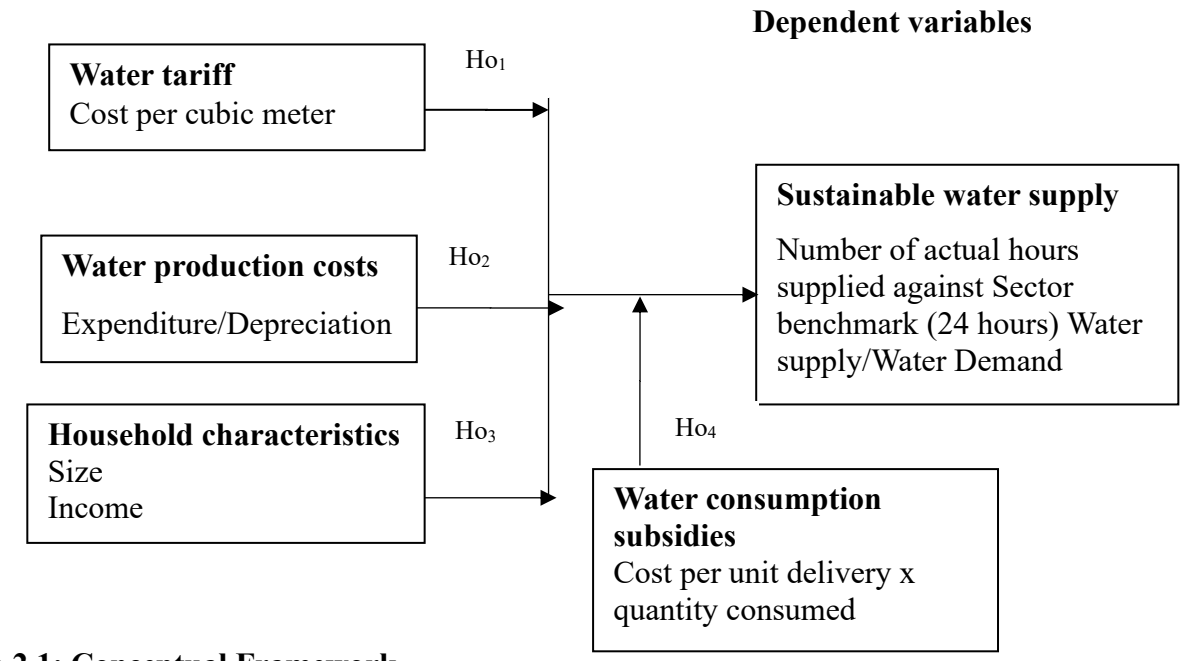

Figure 2.1: Conceptual Framework
Source: Julius &Kalundahe (2021)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The research methodology employed in this study is detailed in this chapter. It will encompass the following: the research area, the research design, the population of the study, the sample size, the sampling procedures, the data collection instrument, data analysis, and research ethics.

3.2 Study Area

This study was based in Kakamega County which is in the Western Kenya bordering Bungoma, Busia, Vihiga and Tranzoia Counties. Kakamega County is the second largest in population after Nairobi hence need for water sustainability. It has 12 sub counties of Lugari, Mumias East, Mumias West, Matungu, Navakholo. Lurambi, Shinyalu, Ikolomani, Likuyani, Malava, Khwisero and Butere.

3.3 Research design

This study utilized a mixed research design. These research designs encompass correlation research design, longitudinal research design, and descriptive study. Correlational designs involve a systematic investigation of the relationships or connections between variables, rather than emphasizing direct cause-and-effect relationships. The correlational approach revealed the connection between research variables by considering their positive or negative importance, whereas the longitudinal

design examined the patterns in time series data from 2014 to 2023. The descriptive design elucidated the relationship between the variables. A descriptive study is any research study that collects information without altering or affecting the surroundings. The descriptive study focused on analyzing and discussing descriptive statistics. It delineates the attributes of a certain individual or a collective.

3.4 Target Population

The target population consisted of houses in Kakamega, Kenya. According to the 2019 census, Kakamega County had a total population of 1,867,579 individuals, comprising 897,133 male, 970,406 females, and 40 intersex individuals. The Kenyan Census Population Report of 2019 indicates that there are a total of 433,207 homes in the area. On average, each household consists of 4.3 individuals. Furthermore, the population density is recorded at 618 people per square kilometer. The report examines the water connections in Kakamega Urban, specifically noting that there were 31,201 connections according to the Kakamega County Water Sanitation Company in 2023. Based on the research of Kakamega County Water and Sanitation Company (2023), it is shown that only 53% of the population has access to clean and safe drinking water. This suggests that 47% of the citizens do not have access to high-quality water.

3.5 Data collection

Secondary data was used for this study which was collected from Kakamega County Water and Sanitation Company (KACWASCO), Water Services Regulatory Board (WASREB), World Bank and Kenya National Bureau of Statistics (KNBS). Data for water tariff, water prices, water costs, household size, water subsidies and water supply

constituted of annual average figures for the period under study. The study conducted a time series data of 10 years thus 2014-2023, a period within which Kakamega County Water Supply and Urban Sewerage Strategic Plan (2015-2020) allude to be of great concern on water sustainability. Annual data pertaining the variables was collected from companies' performance reports, published reports and websites. Attached in Appendix II is the data extraction tool adopted for this study.

3.6 Data Analysis

This section delves into the statistical model or analysis employed for data analysis, encompassing the measurement of variables. The data that was gathered was inputted into an Excel spreadsheet, carefully examined for any abnormal outcomes, and subsequently imported into STATA software for analysis. Analyzed data employed both descriptive and inferential statistics. The descriptive statistics were computed utilizing the measures of central tendency (mean), variability (standard deviation), asymmetry (skewness), and peakedness (kurtosis).

The inferential investigation involved three statistical methodologies: simple linear regression, multiple linear regression, and hierarchical regression. The aim of this study was to investigate the relationship between specific socio-economic factors and the presence of a reliable and long-lasting water source (Mugenda & Mugenda, 2013). Diagnostic tests were conducted before doing inferential analysis.

Regression equation

Without moderating variable;

$$\text{Sustainable water supply}_{it} = \alpha + \beta_1 Wt_{it} + \beta_2 Wp_{it} + \beta_3 Wh_{it} + \varepsilon_{it}$$

With moderating variable;

$$\text{Sustainable water supply}_{it} = \alpha + \beta_1 Wt_{it} + \beta_2 Wp_{it} + \beta_3 Wh_{it} + \beta_1 WtS_{it} + \beta_2 WpS_{it} + \beta_3 WhS_{it} + \varepsilon_{it}$$

Where:

Sustainable water supply $_{it}$ for 2014 - 2023

α = Determines the level of fitted lines

$\beta_1, \beta_2, \beta_3$ and β_4 = Regression coefficient

Wt_{it} = Measures of Water tariffs for 2014 - 2023

Wp_{it}= Measures of Water production costs for 2014 - 2023

Hs_{it}= Measures of Household size for 2014 - 2023

S= Subsidies

$EmWt_{it}$= Measures of Water tariffs multiplied by Subsidies for 2014 - 2023

$EmWc_{it}$= Measures of Water production costs multiplied by Subsidies for 2014 – 2023

$EmHs_{it}$= Measures of Household size multiplied by Subsidies for 2014 – 2023

ε_{it} = Error term

3.7 Diagnostic Tests

The Classical Linear Regression Model's assumptions are guaranteed to be upheld by the tests. Violation puts the study at danger of producing parameter estimates that are biased, inconsistent, and inefficient. The study employed diagnostic tests such normality, multicollinearity, and stationarity both before and after estimate.

3.7.1 Stationarity

Guraji (2003) argues that biased conclusions could emerge from data estimations that fail to account for the non-stationary character of the data. It is necessary to determine the panel data's stationarity since it contains both cross-sectional and time series information; otherwise, the study would have been biased in its assumptions about the

stationary nature of the time series variables. Stationarity was assessed using the Augmented Dickey Fuller test. The variables that are impacted are differentiated in the presence of a unit root.

3.7.2 Multicollinearity

According to Cooper and Schindler (2008), it is necessary to conduct tests for multicollinearity in order to prevent the occurrence of indeterminate regression coefficients and endless standard errors, which can impact the acceptance or rejection of the null hypothesis. The presence of extreme multicollinearity might result in incorrect inferences and ultimately lead to erroneous conclusions. The study assessed the presence of multicollinearity by using a threshold of greater than 0.9 (indicating multicollinearity) or less than 0.9 (indicating absence of multicollinearity). Variables exhibiting a significant degree of collinearity were removed.

3.7.3 Normality

Normality is assessed in order to determine the distribution of variables in a research study. The presence of non-normal distribution of variables can result in inaccurate judgments. This thesis employed the Bera and Jarque (1981) criteria to assess normalcy. The null hypothesis for this test assumed a normal distribution, while the alternative hypothesis assumed a non-normal distribution. The test's significance level was established at 0.05. A p value less than 0.05 signifies that the null hypothesis should be rejected, indicating that the data does not conform to a normal distribution.

3.7.4 Housman test

The Housman test (2000) was conducted to determine the optimal model for the regression analysis. Fixed effects and random effects are the two primary methods employed for analyzing panel data. While random effects models are better suited for evaluating the overall effect of a variable across multiple groups, fixed effects models are good for determining the average influence of a variable inside a particular group.

Whether to employ a random effects or a fixed effects model was decided by performing a Housman test with the null hypothesis that the preferred model is random effects. Any time the test's estimated value exceeds 0.05, a fixed effect model is used.

3.8 Ethical consideration

Researchers have an obligation to their profession, clients, and participants and should maintain elevated ethical standards to ensure that both the integrity and the credibility of their work and the information they provide are not compromised. The study strictly adhered to ethical considerations. Likewise, immoral behaviors like as deceit and invention were abstained from. The study obtained research permits from NACOSTI and MMUST IREC, which were utilized for data gathering.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents summary of findings, conclusions and recommendations. Suggestions for further study are also provided. The overall objective of this study was to analyze the socio-economic determinants of sustainable water supply in Kakamega County. Specifically, the study examined the effect of water tariff, water production costs and household characteristics on sustainable water supply in Kakamega County. It further established the moderating effect of water consumption subsidies on the relationship between socio-economic factors and sustainable water supply in Kakamega County.

4.2 Normality Test

Normality is assessed in order to determine the distribution of variables in a research study. The presence of non-normal distribution of variables can result in inaccurate judgments. This thesis utilized the Bera and Jarque (1981) criterion to evaluate normality. A p value less than 0.05 signifies the rejection of the null hypothesis, indicating that the data does not conform to a normal distribution.

Table 4.1: Normality Test

Variable	Skewness	Kurtosis	Jarque Bera adj chi2(2)	Prob>chi2
Water tariff	0.9899	3.5251	14.68	0.1010
Water production cost	0.4339	2.4115	3.1208	0.1428
Household characteristics	0.4339	2.4115	3.1208	0.1465
Water consumption subsidy	0.4508	3.1408	2.915	0.2326
Sustainable water supply	1.2323	2.6537	1.175	0.5559

Source: Research data (2024)

The Monte Carlo rule states that a normal figure has a skewness value of less than 2 and a kurtosis value of less than 6. None of the observations indicated non-normal data, as the maximum skewness value was 1.2323, indicating a fairly normal distribution. Additionally, the highest kurtosis value was 3.5251, which did not surpass 6. For Jarque-Bera test the probability values were greater than 0.05 hence data being normal (Chatterjee & Hadi, 2015). Therefore the data was normal distribution.

4.5.1 Multicollinearity

Variance inflation factors (VIF) and tolerance values were utilized to elucidate the concept of Multicollinearity. Multicollinearity occurs when two or more independent variables are correlated with one other (Cooper & Schindler, 2011). In this scenario, a Variance Inflation Factor (VIF) below 10 and a tolerance value below 1 indicate the lack of multicollinearity.

Table 4.2: Multi-Collinearity

Variable	Tolerance	VIF
Water tariff	0.210	4.762
Water production cost	0.321	3.115
Household characteristics	0.250	4.000
Water consumption subsidy	0.172	5.814
Sustainable water supply	0.124	8.065

Source: Research data (2024)

The variance inflation factors (VIF) obtained from the coefficient table are all less than 10. The water tariff is 4.762, the water production cost is 3.115, the household characteristics are 4.000, the water consumption subsidy is 5.814, and the sustainable water supply is 8.065. These values indicate that there is no issue of multi-collinearity. Since the tolerance values from the coefficient table are all less than 1, there is no issue of multi-collinearity. Ortuzar, Serrano & Xabadia (2023) determined that a Variance Inflation Factor (VIF) value below 10 indicates the absence of multi-collinearity. This finding was made during their assessment of the impact of socio-economic variables on sustainable water supply.

4.5.2 Heteroscedasticity Test

Heteroscedasticity occurs when the variance of the error term, which is typically assumed to be constant, varies. This suggests that the ordinary least squares model is ineffective because it underestimates the variation of standard errors, leading to

misleading conclusions. The Walid test was employed to examine heteroscedasticity in this study.

Table 4.3: Test for Heteroscedasticity Results.

Walid Test	Walid test Statistic
Chi2	7.12
P-value	0.001

Source: Research data (2024)

The results of the heteroscedasticity test in Table 3 show that the Walid test result was statistically significant, with a Chi-square value of 7.12 and a p-value of 0.001, which is less than the significance level of 0.05. The investigation refuted the null hypothesis and demonstrated the absence of heteroskedasticity.

4.6 Panel Unit Root Test

Unit root tests were performed to determine the stationery state and determine the presence of spurious effects. The tests conducted were Levin Lin and Chu, Phillips-Perron, and Impeseran. These tests were chosen for their ability to effectively detect and analyze spurious effects in stationary processes. The results are displayed in Table 4.

Table 4.4: Unit Root Test

Variable	Levin, Lin & Chu Stat	Phillips Perron	Impeseran
Water tariff	12.5244**	2.2175**	15.4074**
Sig*	(0.0012)	(0.023)	(0.001)
Water production cost	17.4442**	5.0534**	41.2700**
Sig*	(0.020)	(0.012)	(0.0033)
Household characteristics	14.4442**	5.0534**	3.2723**
Sig*	(0.021)	(0.010	(0.027)
Water consumption subsidy	10.5795**	3.0571**	5.7056**
Sig*	(0.0049)	(0.0089)	(0.005)
Sustainable water supply	21.5892**	5.8132**	1.4181**
Sig*	(0.001)	(0.000	(0.008)

Source: Research data (2024)

A panel data that was not balanced resulted in several unit root tests. The p-value in parenthesis in Table 4 indicates the rejection of the null hypothesis at a significance level of 1% and 5%, denoted by ** and *, respectively. All of the P values were below 0.05, indicating the absence of a unit root. Consequently, the data was suitable for analysis. All three unit root tests, namely Levin Lin and Chu, Phillips-Perron, and Impeseran, confirmed that the data was stationary.

4.7 Correlation Analysis

Table 5 shows the relationship among independent variables thus water tariff, water production cost, household characteristics, to dependent variable, thus sustainable water supply and moderating variable basically water consumption subsidy. Pearson correlation was therefore conducted.

Table 4.5: Correlation Analysis

VARIABLES	Water tariff	Water production cost	Household characteristics	Water consumption subsidy	Sustainable water supply
Water tariff	1.0000				
Water production cost	0.3287* 0.0023	1.0000			
Household characteristics	0.3208 * 0.0029	0.4000** 0.0000	1.0000		
Water consumption subsidy	0.3208* 0.0029	0.2704* 0.0129	0.2704* 0.0129	1.0000	
Sustainable water supply	0.2985* 0.0058	0.2103 * 0.0180	0.3103* 0.0080	0.2080* 0.0426	1.0000

Source: Research data (2024)

The data did not exhibit a significant correlation across variables, since there was no indication of multi-collinearity, with correlation coefficients below 0.9. Furthermore, a statistically significant and positive correlation was observed between the Water tariff and Sustainable water supply, as evidenced by a p-value of 0.0058. The correlation between the cost of water production and the availability of sustainable water supply was found to be statistically significant, with a p-value of 0.0180. This indicates a positive and substantial association between the two variables. However, household characteristics showed a substantial p-value of 0.008, indicating a positive and significant relationship. In contrast, the p-value for water consumption subsidy was 0.0426, suggesting a positive and significant relationship as well. This finding is

consistent with the research conducted by Ortuzar, Serrano, and Xabadia (2023), which examined the effects of water tariff allocation on the macroeconomy in the context of droughts in China's global supply networks.

4.8 Regression Results

Linear regression analysis was conducted to establish the relationship between social economic determinants, water consumption subsidy and sustainable water supply study variables.

Table 4.6: Hausman Test

	Sustainable Water supply
Chi-sq statistic	9.321
Prob	0.0210

Source: Research data (2024)

The fixed effects analysis reveals that the F-statistic is statistically significant (p - value 0.0210 < 0.05), given it was less than 0.05 the fixed model was hence adopted. Fixed effects models provide unit-specific intercepts, allowing for the estimation of how each unit's sustainable water supply performance deviates from the overall average, holding constant all time-invariant factors. This can offer valuable insights into the heterogeneity of water sustainability across different units. Sustainable water supply often involves studying trends and changes over time. Cheruiyot (2019) applied a fixed model when analyzing the household water demand, distribution and community management strategies in Nyangores Sub catchment, Bomet county, Kenya. Fixed effects models are well-suited for longitudinal analysis as they capture within-unit

variation over time, enabling researchers to assess how sustainable water supply practices evolve within each unit.

4.8.2 Effects of Water Tariff on Sustainable Water Supply

The objective of the investigation was to verify the null hypothesis Ho1: that the Sustainable Water Supply in Kakamega County is not significantly influenced by the water tariff. The results are presented in Table 7.

Table 4.7: Regression Fixed Effects of Water Tariff on Sustainable Water Supply

. xtreg Demand to Population_			**Demand to Population _**			**fe**
Fixed-effects (within) regression			Number of obs = 120			
Group variable: FIRM			Number of groups = 12			
R-sq:			Obs per group:			
within = 0.1572			min = 7			
between = 0.1667			avg = 7.0			
overall = 0.0050			max = 7			
			F(1,120) = 8.52			
corr(u_i, Xb) = -0.2061			Prob > F = 0.0047			
Demand to Population	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**
Cost Per Cubic M	.23	.04	-2.92	0.005	-.20	-.04
_cons	.45	.04	18.78	0.000	.58	.72
F test that all u_i=0: F(11, 120) = 8.87			**Prob > F = 0.0047**			

Source: Research data (2024)

The fixed effect model revealed that the Water tariff explained 15.72% ($R^2 = 0.1572$, $p < 0.05$) of the variability in Sustainable Water Supply in Kakamega County. The regression model is displayed below.

$Y = 0.45 + 0.23A$

Where Y = sustainable water supply and A = water tariff

The study rejected the null hypothesis that Water tariff has no significant effect of on sustainable water supply in Kakamega County and concluded that the effect of Water tariff on sustainable water supply was statistically significant ($p < 0.05$). This implies that increase in water tariff would results to increase in sustainable water supply in Kakamega County because WSPs will be able to cover more costs as a result of improved revenue. Increase in water tariff would also affect the consumer behaviors such as unwillingness to pay more for water services.

To curb unwillingness, it would be ideal to launch public awareness campaigns highlighting the importance of paying water bills for maintaining water supply infrastructure, ensuring quality, and promoting sustainable water management. Provide education on water conservation practices and the community benefits of reliable water services funded by tariff payments. Policies to improve metering accuracy and billing transparency to build trust among customers. Ensure timely and accurate billing cycles and provide accessible customer service for billing inquiries and disputes. Furthermore waters service providers can enforce penalties for non-payment of water bills, while ensuring mechanisms for fair dispute resolution.

This finding agrees with Vucijak, Pasic and Bijelonja, (2018) who assessed utility operational and sustainable water supply in Western Balkans, it was established that water tariff should be accompanied by other policies for effectiveness. It further agrees with Ortuzar *et al* (2023) who established the macroeconomic impacts of water

allocation under droughts in the global supply chains of multiregional context in China and found water tariffs significant on sustainable water supply. Contrary to the findings of Julius and Kalundahe (2021), this study indicates that the water tariff does not exert a statistically significant impact on the financial sustainability of Water Service Providers (WSPs) in Kenya. Water tariff is geared towards tariff structure affordability measures so as to make consumers afford water. When water tariff is imposed it lowers the cost for water purchases hence sustainable water provision. This leads to water being more affordable among users. The integrated water resource management and public private partnerships are further availed to ensure sustainability is attained.

4.8.3 Effect of Water Production Cost on Sustainable Water Supply

The study sought to determine influence of Water Production Cost on Sustainable Water Supply in Kakamega County. The null hypothesis Ho_2: Water Production Cost has no significant effect of on sustainable water supply in Kakamega County. Table 8 contains the findings.

Table 4.8: Regression Fixed Effects of Water Production Cost on Sustainable Water Supply

. xtreg Demand to Population_			**Demand to Population _**			**fe**
Fixed-effects (within) regression			Number of obs = 120			
Group variable: FIRM			Number of groups = 12			
R-sq:			Obs per group:			
within = 0.281			min = 7			
between = 0.377			avg = 7.0			
overall = 0.223			max = 7			
			F(1,120) = 22.52			
corr(u_i, Xb) = 0.1694			Prob > F = 0.0000			
Demand to Population	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**
Water Production cost	-.23	.03	-4.75	0.000	-.19	-.08
_cons	.79	.03	23.17	0.000	.63	.75
F test that all u_i=0: F(11, 120) = 7.63			**Prob > F = 0.0000**			

Source: Research data (2024)

The result obtained from fixed effect model indicated that water production cost basically maintenance and repair, water treatment, infrastructure and operations, energy costs, chemicals and supply costs accounted for 28.1% (R^2 =0.281, $p < 0.05$) of the variation in Sustainable Water Supply in Kakamega County. The regression model is as shown below

Y = 0.79 - 0.23B

Where Y = sustainable water supply and B = water production cost

The relationship was significant ($p < 0.05$) and thus the null hypothesis that Water Production Cost has no significant effect of on sustainable water supply in Kakamega County was rejected. This implies that increase in water production cost would affect sustainable water supply in Kakamega County negatively. This finding agrees with Julius and Kalundahe (2021) who established the influence of water production cost on water supply among water service providers in Kenya. It further agrees with Tifow (2013) who found water production costs as significant on sustainability of rural water supplies in Kenya. It however disagrees with Reynaud (2016) who found that the influence of water production costs on water supply was insignificant.

Water service providers incur water costs which at the end of the day add charges on consumers on water accessibility. Water charges increases to cater for costs of production. Unfavorable water production cost policies such as cost recovery mechanisms, full cost pricing, cost allocation, risk management and resilience planning makes water sustainability a challenge. This would make WSPs turn to upward review of water tariffs which may be met by resistance from consumers due to unwillingness to pay more for water services.

4.8.4 Effect of Household Characteristic on Sustainable Water Supply in Kakamega County

The study sought to determine the effect of household characteristic on Sustainable Water Supply in Kakamega County. The null hypothesis Ho_3: Water Production Cost has no significant effect of on sustainable water supply in Kakamega County. Table 9 contains the findings.

Table 4.9: Regression Fixed Effects Household Characteristic on Sustainable Water Supply

. xtreg Demand to Population_			**Demand to Population _**			**fe**
Fixed-effects (within) regression			Number of obs = 120			
Group variable: FIRM			Number of groups = 12			
R-sq:			Obs per group:			
within = 0.404			min = 7			
between = 0.483			avg = 7.0			
overall = 0.371			max = 7			
			F(1,120) = 46.12			
corr(u_i, Xb) = 0.2228			Prob > F = 0.0000			
Demand to Population	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**
Household Characteristic	.43	.018	-6.79	0.000	-.15	-.01
_cons	.92	.03	24.96	0.000	.69	.81
F test that all u_i=0: F(11, 120) = 7.65			**Prob > F = 0.0000**			

Source: Research data (2024)

The fixed model results showed household characteristic basically household size and income levels was 40.4% ($R^2 = 0.404$, $p < 0.05$) of the variation in sustainable water supply in Kakamega County. The regression equation is shown below.

$Y = 0.92 + 0.43C$,

Where Y = sustainable water supply and C = household characteristics

The study therefore rejected the null hypothesis since $p < 0.05$ and concluded that the effect of household characteristic on sustainable water supply was statistically significant. This finding agrees with Murrar and Tamim (2017) who undertook a study to investigate the impact of water price on water supply for the Palestinian and found

household characteristic as significant. A study in Kibera Kenya by Omollo, *et al* (2020) found size of households significantly affects water supply. It also agreed with Cheruiyot (2019) study that analyzed the household impact on community water sustainability in Nyangores Sub catchment, Bomet county, Kenya. Arouna (2019) conducted a study on families' water usage, specifically examining how water availability affects water consumption. The study estimated domestic water usage throughout both wet and dry seasons, when water is respectively abundant and limited.

Basically household characteristics on basis of income, number of households, age and level of education impacts on water sustainability. The number of households and level of income would determine water demand rate. Level of education and age would guide on efficient water usage. This guides on usage rate and even wastage levels that accounts to consumption levels. Therefore, water conservation education and outreach becomes a concern that come with household characteristics. Water metering and pricing is based on household features. Similarly leaking water or wastages arise on basis of household behavior. Illegal water connections negatively impact on sustainability, for they cause losses to WSPs. In the long run water providers will not be able to cater for operation costs, capital expenditures and full cost recovery thus impacting on water sustainability to the residents of Kakamega county.

4.8.5 Multiple Regression

The study sought to obtain the multiple effect of socio-economic determinants on sustainable water supply in Kakamega County, Kenya.

Table 4.10: Multiple Regression

Source	SS.	df.	MS			
				Number of obs =	120	
				F(3, 120) =	127.69	
Model	.58	3	.19	Prob > F =	0.0000	
Residual	.12	80	.002	R-squared =	0.757	
				Adj R-squared =	0.721	
Total	.70	83	.001	Root =	.0389	
corr(u_i, Xb) = 0.2228			Prob > F	= 0.0000		
Demand to Population	**Coef.**	**Std. Err.**	**T**	**P>|t|**	**[95% Conf.**	**Interval]**
Water tariff	.23	.03	14.39	0.000	.39	.51
Water Production Cost	-.313	.03	-2.72	0.008	-.18	-.02
Household characteristic	-.273	.02	-9.86	0.000	-.20	-.13
_cons	.38	.04	10.89	0.000	.32	.46
F test that all u_i=0: F(11, 120) = 7.65			**Prob > F = 0.0000**			

Source: Research data (2024)

Model one entails sustainable water supply on basis of water demanded verses water supplied and socio economic determinants. The model of independent and dependent variable produced an R of 0.757 implying that 75.7% of sustainable water supply which is associated with socio-economic factors and the remaining is accounted for by other factors. The study results showed ($p<0.05$) hence socio-economic determinants had significant effect on sustainable water supply. The regression equation is as follows:

$$Y = 0.38 + 0.23X_1 – 0.31X_2 – 0.27X_3$$

Where Y = sustainable water supply and = X_1, X_2 and X_3 are water tariff, water production cost and household characteristics respectively.

This implies that water tariff and household characteristics thus number of households affects sustainable water supply positively and significantly based on the positive signs while water production cost affects sustainable water supply negatively but significantly. It further implies that water tariff and household characteristics enhances sustainable water supply while water production cost lowers sustainable water supply.

This finding agrees with Banerjee, McFarland, Singh and Quick (2007) who conducted a project-based study in Zambia to determine the water supply of household water treatment and storage project the study found socio economic factors basically tariffs, water costs and household characteristics as significant on water sustainability. It further agrees with Omollo, Odhiambo and Ng'eno (2020) who found water tariff, water costs and household characteristics significant on water sustainability in Kibera informal settlement in Nairobi county, Kenya. This disagreed with Briand, Viroleau and Markantonis (2021) who found macroeconomic effects of no impact on water scarcity.

4.8.6 Moderating effect of Water consumption subsidy on the Relationship between Socio Economic Determinants and Sustainable Water Supply

The study sought to obtain the moderating effect of water consumption subsidy on the relationship between socio economic determinants and sustainable water supply. The null hypothesis Ho_4: Water consumption subsidy has no significant moderating effect on the relationship between socio economic determinants and sustainable water supply. Hierarchical regression analysis was performed to determine whether Water consumption subsidy had a moderation role on socio economic determinants and sustainable water supply. Three models were obtained to summarize the regression results.

Table 11: Model 1-Independent and Dependent Variables

Source	SS.	df.	MS	
				Number of obs = 120
				F(3, 120) = 127.69

Model	.58	3	.19	Prob > F = 0.0000		
Residual	.12	80	.002	R-squared = 0.720		
				Adj R-squared = 0.710		
Total	.70	83	.001	Root = .0389		
Demand to Population	**Coef.**	**Std. Err.**	**t**	**P>|t|**	**[95% Conf.**	**Interval]**
Water tariff	.548	.031	14.39	0.000	.386	.510
Water Production Cost	.568	.025	2.72	0.008	.118	.018
Household characteristic	.264	.017	9.86	0.000	197	.131
_cons	.491	.036	10.89	0.000	.319	.462

Source: Research data (2024)

Model one entails Sustainable Water Supply and the socio-economic determinants. The model of independent and dependent variable produced an R square of 0.720 implying that 72% of sustainable water supply which is associated with socio-economic factors and the remaining is accounted for by other factors. This contribution is significant ($p < 0.05$) implying that socio economic determinants is a significant predictor of Sustainable Water Supply. The regression equation is as follows:

Sustainable Water Supply =0.49+0.55WT+0.57WPC+0.26HC. This finding agrees with Tifow (2013) who conducted a study on the factors influencing sustainability of rural water supplies in Kenya as the study found subsidized water as significant. This further agrees with Julius and Kalundahe (2021) who stated that water pricing based on water costs, water tariffs and size of house members significantly determined water sustainability among water service providers in Kenya. The existence of tariffs makes water cost lower making water sustainable to users. The policies on lifeline tariffs, subsidized infrastructure investments, rural and remote area subsidies and social

assistance program policies provided by government and water service providers makes water sustainable.

Table 12: Model 2-Independent, Moderating and Dependent Variables

Source	SS.	df.	MS			
				Number of obs = 120		
				F(3, 120) = 100.25		
Model	.56	4	.15	Prob > F = 0.0000		
Residual	.11	79	.001	R-squared = 0.746		
				Adj R-squared = 0.728		
Total	.70	83	.001	Root = .0381		
Demand to Population	**Coef.**	**Std. Err.**	**T**	**P>|t|**	**[95% Conf.**	**Interval]**
Water tariff	.51	.036	11.57	0.00	.34	.48
Water Production Cost	.15	.026	-2.10	0.04	-.10	-.003
Household characteristic	.32	.016	-10.16	0.00	-.20	-.134
Water Cons	.21	.007	-2.03	0.05	-.03	-.0002
Subsidy						
_cons	.53	.086	6.37	0.00	.38	.72

Source: Research data (2024)

Model two entails sustainable water supply, the socio-economic determinants and water consumption subsidy. The model of independent, moderating and dependent variable produced an R square of 0.746 implying that 74.6% of sustainable water supply which is associated with water consumption subsidy and the remaining is accounted for by other factors. The introduction of additive water consumption subsidy moved R^2 from 0.7201 to 0.746. This study agrees with Omollo, Odhiambo and Ng'eno (2020) who established the determinants of water demand in Kibera informal settlement in Nairobi County, Kenya and crowned water subsidy as quite significant. Additionally supports the findings of Rios et al. (2018) regarding their research on sustainable water supply

in Ghana, Spain, Brazil, Bolivia, and France. The second regression model is as shown below.

Sustainable Water Supply=0.53+0.51WT+0.15WPC+0.32HC+0.21WCS.

Table 13: Model 3-Independent, Moderating, Interaction and Dependent Variables

Source	**SS.**	**df.**	**MS**			
				Number of obs =	120	
				F(3, 120) =	57.19	
Model	.59	7	.012	Prob > F =	0.0000	
Residual	-.319	76	.001	R-squared =	0.7501	
				Adj R-squared =	0.716	
Total	.70	83	.001	Root =	.0383	
Demand to Population	**Coef.**	**Std. Err.**	**T**	**P>|t|**	**[95% Conf.**	**Interval]**
Water tariff	.16	.366	0.18	0.86	-.65	.78
Water Production Cost	-.22	.32	-0.63	0.53	-.83	.43
Household characteristic	-.32	.21	-1.28	0.09	-.70	.15
Water Cons Subsidy	-.17	.050	-1.74	0.34	-.19	.013
Subsidy_WaterT	.15	.04	0.95	0.66	-.04	.11
Subsidy_WPC	.13	.03	0.44	0.61	-.05	.08
Subsidy_HC	.21	.02	0.51	0.01	-.03	.06
_cons	2.37	.49	2.59	0.02	.29	2.3

Model	**R2**	**P**	**R2 change**
1:	0.7201	0.000	
2:	0.7459	0.000	0.258
3:	0.7501	0.000	0.042

Source: Research data (2024)

Model three entails sustainable water supply, the socio-economic determinants, water consumption subsidy and the association between socio economic determinants and water consumption subsidy. The third regression model is as shown below.

This model produced an R square of 0.7501 implying that 75.01% of the variation is as a result of water consumption subsidy. The incorporation of (IV*MV) thus interaction terms moved R squared from 0.7459 to 0.7501. The change was of P=0.042 hence significant. This increase implies that Water Consumption Subsidy e interaction had a moderating effect to on the relationship between socio economic determinants and Sustainable Water Supply in Kakamega County.

Sustainable Water Supply= 2.37 +0.16WT +-0.22WPC +-0.31HC+-0.17WCS +0.15WCSWT+0.13WCSWPC+0.2115377WCSHC. This finding agrees with In their study, Arouna (2019) examined how families' water usage changes with different water availability conditions. They specifically estimated domestic water use during the rainy season and the dry season, when water is abundant and limited, respectively. It further agrees with Rusca and Schwartz (2017) who established the influence of water subsidies on sustainable water supply in Maputo and Lilongwe, they established the influence of water subsidies on water supply as positive and significant.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides summary of findings, conclusions and recommendations strictly based on sustainable water supply, socio economic determinants and water consumption subsidy in Kakamega County.

5.2 Summary of the Findings

The general objective was to determine the effect of socio-economic determinants on Sustainable Water Supply in Kakamega County. The data for the findings of this study was collected from secondary sources from published water sector impact reports.

5.2.1 Water Tariffs and Sustainable Water Supply

The first objective of the study was to determine the effect of Water Tariffs on Sustainable Water Supply in Kakamega county. Panel data Pearson correlation results showed a positive significant relationship between water tariffs on sustainable water supply ($p < 0.05$). Water tariffs had a significant positive effect on sustainable water supply. The study rejected H_{O1}.

5.2.2 Water Production Cost and Sustainable Water Supply

The second objective of the study was to determine the effect of water production cost on sustainable water supply in Kakamega county. Panel data Pearson correlation results showed a negative significant relationship between water production cost on sustainable water supply in Kakamega county ($p < 0.05$). Water production costs had a significant effect on sustainable water supply in Kakamega County. The study rejected H_{O2}.

5.2.3 Household Characteristic and Sustainable Water Supply

The third objective of the study was to determine the effect of household characteristics on sustainable water supply in Kakamega County. Panel data Pearson correlation results show a significant relationship between household characteristics on sustainable water supply in Kakamega County, ($p<0.05$). Household characteristics had a significant positive effect on sustainable water supply. The study rejected H_{O3}.

5.2.4 Moderating effect of Water consumption Subsidy on the Relationship between Socio Economic Determinants and Sustainable Water Supply

The fourth objective of the study was to determine the moderating effect of water consumption subsidy on the relationship between socio economic determinants and sustainable water supply. Panel data Pearson correlation results show that water consumption subsidy had a negative significant relationship between socio economic determinants and sustainable water supply p ($p<0.05$). The study rejected H_{O4}.

5.3 Conclusion

The study concludes that an increase in water tariff would result to significant increase in sustainable water supply in Kakamega County. Therefore, water tariff has positive significant effect on sustainable water supply.

Further, an increase in water production cost would have a significant negative effect sustainable water supply in Kakamega County. Therefore, water production costs have significantly affected sustainable water supply in Kakamega County.

The study revealed that an increase in household characteristics result to significant increase in sustainable water supply in Kakamega County. Therefore, household characteristics has significantly influenced sustainable water supply in Kakamega County.

Finally, the research concluded that a rise in the subsidy for water use results in a substantial enhancement in the correlation between socio-economic parameters and the provision of sustainable water in Kakamega County. Hence, the provision of a subsidy for water use plays a crucial role in moderating the major impact of socio-economic determinants on the sustainability of water supply in Kakamega County.

5.4 Recommendation

The findings guided the following recommendations:

It was revealed that water tariff to be significant on sustainable water supply hence water companies should improve the tariff base for sustainability. The study recommends policy framework on water tariffs thus transparency and equity especially on tariff structure affordability measures, cost recovery, integrated water resource management and public private partnerships. The policy gaps on affordability and vulnerability should be addressed by establishing needy status of consumers. This would help in ensuring there is sustainable water supply.

It was established that water production costs to be significant on sustainable water supply hence firms should manage cash inflow and outflows for water sustainability. The study recommends drastic water production cost policies such as cost reduction through leak detection and repair programs to avoid water wastage and employ energy efficient technologies.

It was determined that household characteristics to be significant on sustainable water supply hence number of households or water users should be checked to ensure sustainability. Policies on household characteristics recommended include, water conservation education and outreach, water metering and pricing, water audits and efficiency assessments as well as community-based water management. Water audits report water wastages by households, however through audits opportunities for improvement, such as upgrading infrastructure, optimizing operational practices, or implementing water-saving technologies should be utilized.

It was explained that water subsidies leverage water sustainability hence water firms should accommodate all people by providing subsidies where applicable. The study recommends policies such as lifeline tariffs, subsidized infrastructure investments, rural and remote area subsidies and social connection program policies.

5.5 Suggestion for Further Studies

There are several water provision agencies in Kenya. This study factored Kakamega county, hence a study in other counties would be ideal. This study examined a few socio-economic determinates of water sustainability others such as GDP should be examined for further studies. Equally other moderators and intervening variables such as firm size and age of the firm can be used in further studies.

The study recommends further study on water subsidy as an independent variable examining lifeline tariffs, targeted subsidies, cross-subsidization and subsidized infrastructure investments.

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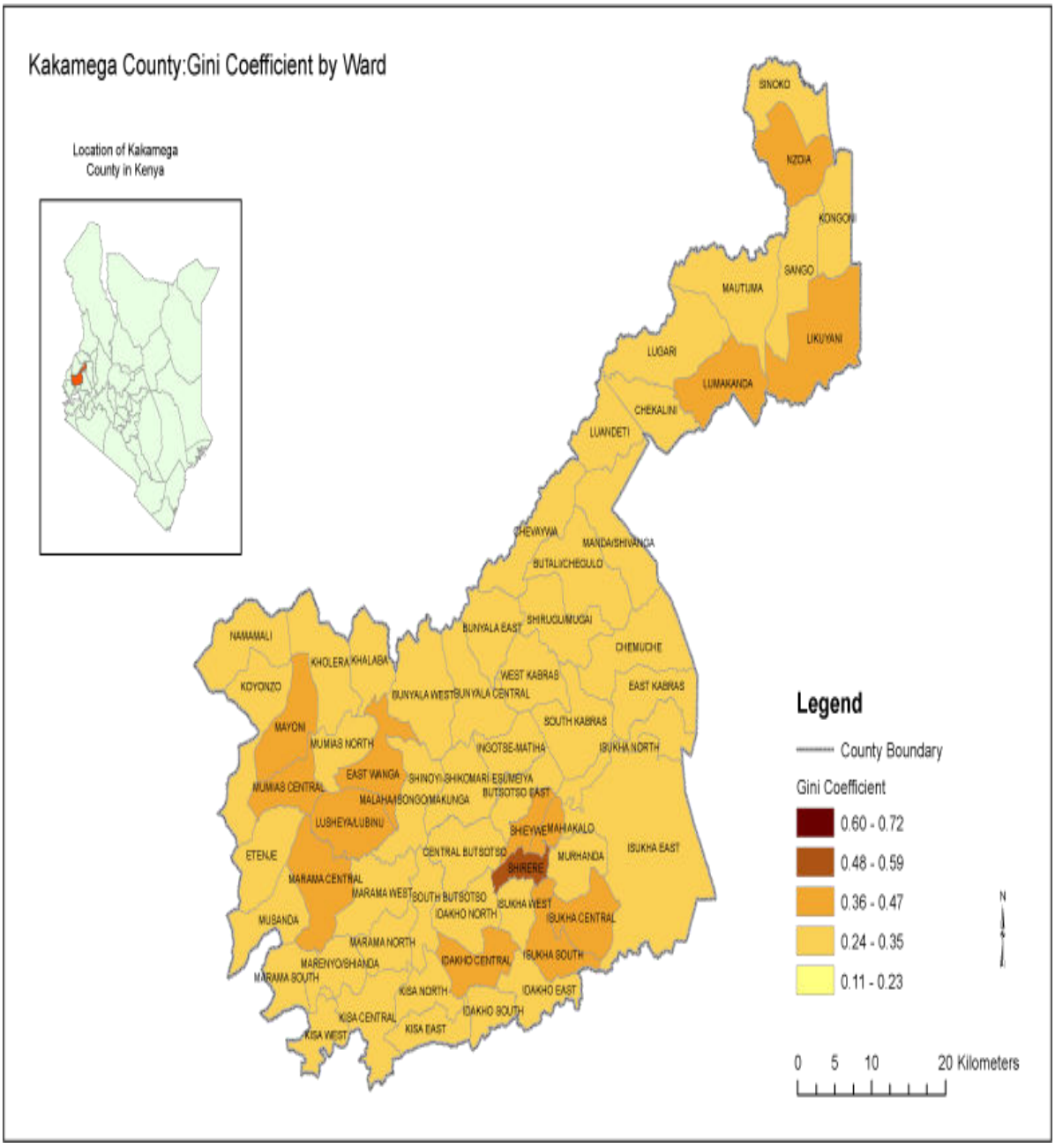
APPENDICES

APPENDIX I: Map of Kakamega County



Source (Kakamega County Website, 2023)

APPENDIX III: Secondary Data Collection Tool

Variable measure	2011-2012	2012-2013	2013-2014	2014-2015	2016-2017	2017-2018	2018-2019	2019-2020	2020-2021	2021-2022

Cost per Cubic meter	18	28	23	18	22	21	21	22	22	17
Water Expenditure	77	68	44	44	43	44	40	51	59	34
Depreciation	2470	2964	2171	2070	3580	3078	3746	2356	2107	3858
Number of water Connections	22925	26754	35239	35,628	37151	31204	49317	38636	43760	37647
Number of households	296470	239964	288171	298070	335580	346078	370046	237056	254107	367858
Amount of subsidies	1925	2754	4239	3,628	3715	12024	4317	3636	4760	3647
Total domestic water demand per head	1.38	1.38	1.39	1.38	1.16	1.15	1.10	1.73	1.64	1.15
Total population	408992	331478	401781	411131	389444	397785	406308	410453	415807	421227

Water Services Regulatory board published reports (2024)

APPENDIX IV: NACOSTI License

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