

WATER SCARCITY MITIGATION STRATEGIES AND SUSTAINABLE LIVELIHOODS IN MARSABIT COUNTY, KENYA

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ABSTRACT

This study identified water scarcity mitigation strategies and their impact on the sustainable livelihoods of the rural population, as a case study of Saku constituency in Marsabit County. The objectives of the research were to determine the operational mitigation measures for sustainable water availability, affordability, and quality, to establish the set of structural and management systems implemented to limit the adverse impact of water scarcity and their effect on sustainable livelihoods, and to evaluate supply strategic mitigation plans that were implemented to extend the region's ability to meet water demands to improve living standards. This study embraced the descriptive cross-sectional design, where data gathering was done once. Stratified sampling was utilized as the sampling technique since the target population was not homogeneous. The number of responders was 600, who were members of the CDF Committee in Saku constituency, County Assembly members, subcommittee members, chiefs, sub-chiefs, representatives of CBOs, and community members. Data collection was done both through primary sources and secondary sources. Primary data were obtained from a questionnaire that was prepared by the researcher. The data were then analyzed using SPSS. Anonymity, informed consent, confidentiality, and objectivity were observed to enhance the ethical standards of research. The regression model proved to have a high level of explanation since the R-value was 0.731, showing a significant correlation between water scarcity mitigation strategies and sustainable livelihoods in Saku Constituency, Marsabit County. The value of R^2 was 0.534, which shows that 53.4% of the variation in sustainable livelihoods can be attributed to operational mitigation measures, structural systems of management, and supply strategic mitigation plans. The ANOVA results ($F = 89.412, p = 0.000$) showed that the model was statistically significant, implying that the interaction of all water scarcity mitigation strategies significantly affects the outcome of sustainable livelihoods. Further, regression findings revealed that operational mitigation measures ($\beta = 0.318, p = 0.000$), structural systems of management ($\beta = 0.271, p = 0.000$), and strategic mitigation plans for supplies ($\beta = 0.249, p = 0.000$) have a significant positive impact on sustainable livelihoods since the P-value is less than 0.05. It is therefore conclusive that the water scarcity mitigation strategies significantly affect sustainable livelihoods in Saku Constituency, Marsabit County. In order for the county government and other relevant stakeholders to improve sustainable livelihoods in the area, efforts should be made to improve operational mitigation measures, strengthen structural systems of management, and come up with effective supply strategic mitigation plans.

Key Words: Operational Mitigation, Structural Systems, Supply Strategic, Livelihoods Sustainability

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INTRODUCTION

Unrestricted water consumption has escalated globally at a rate exceeding twice that of population growth, resulting in the inability to deliver reliable water services in numerous locations. Pressure from demographic factors, rates of economic development, urbanization, and pollution is putting more pressure than ever before on a resource that is renewable but finite. According to the UNDP (2006) report, humans need water for health and dignity, and water beyond their domestic use is important for keeping the ecological processes running, which help maintain production systems necessary for their livelihoods. The implication of this is that water touches all facets of people's lives, and when there is no access to water in domestic use and in production, there are lower levels of livelihoods due to poor health, poverty, and insecurity (Barry 2007).

According to Huang, Yuan, and Liu (2021), water scarcity refers to a limited availability of clean drinking water and chances of supporting basic hygiene in households, educational institutions, and health centres. According to a report issued by the UN (2018), in the current trends in the world concerning water shortage, there is an urgent need to formulate an action plan to mitigate the problem to prevent a massive war (Mulwa, Li, and Fangninou, 2021). Water is considered the constituent part of the development of a nation; thus, to improve the standards of life of the global population, the overall action plan must be determined to create the effective management of this asset (Zarei, Karami, and Keshavarz, 2020). Wheeler and Beatley (2014) argue that the rising population in the Middle East has put a great strain on the water resources. Unsustainable growth patterns are one of the causes that have led to the Middle East nations' decreased water supply (Rockstrom & Falkenmark, 2015). The world's water situation is getting worse due to the production methods now in use, particularly in the agricultural sector.

In Africa, excessive use of water resources is driven by rising population, heavy hydropower, climate unpredictability, political instabilities along trans-frontiers, poor water governance, and massive ecological losses in freshwater systems. The population growth rate in Sub-Saharan Africa is causing chronic poverty and thereby weakening the already poor infrastructure, which is further causing an uncertain climatic future. (Huho et al, 2010). The river basins in Africa are of a high trans-boundary nature, which is overexploited through over agricultural cultivation, mining of minerals and hydropower generation. The possibility to turn rainforest into agricultural or savannah is another issue. Its supply is unpredictable in the short and long term due to its unpredictable availability both in time and space. A river basin can survive a long period of drought, and neighboring river basin can experience massive floods (Hayson, 2006).

The water scarcity affects every sphere of life and threatens the sustainability of the natural resource basis (Larsen, Hoffmann, Lusti, Truffer and Maurer, 2016). The environment needs a sustainable approach to water resources through a multidisciplinary approach to maintain ecosystems and the economic and socio-cultural well-being of populations under the conditions of water scarcity. Furthermore, it is important to increase water productivity (quantity of output per unit of water) in all sectors in order to develop effective water scarcity reduction measures. Nigeria is the seventh most populated country in the world and is currently facing a problem of water scarcity in some of its states thus causing infrastructure related problems and concerns over long sustainability. Water shortage is a very difficult task because the Nigerian population is over 152 million, and of them only less than 30 percent have access to the amount of drinking water. Water scarcity increases poverty, causes social misery, and impedes the growth. According to the reports of Integrated Regional Information Networks, 62 percent of the Nigerian population has access to increased water sources (Eni, Digba & Moses, 2015).

The growth of the urban community and the fast urbanization of the rural territories of Kenya are pushing up the domestic water demand, including industrial and agricultural one (Wakhungu, 2019). Still, it would be wrong to overlook the problems tied to the water industry such as population pressure, water scarcity, climate change, and water quality. One key concern for reaching the 2030 Agenda is water scarcity. Because of this, effluent is being released into river systems, due to a higher quantity of wastewater generation and the absence

of proper treatment facilities and operating systems. As a result, downstream ecosystems get harmed, and there are health hazards for people. Developing countries really need an urgent shift away from current water management techniques toward sustainable approaches, for example water reuse and big-scale water development initiatives. Meanwhile, population growth has created a clear mismatch between water demand and supply across the nation. That situation turns into a water crisis for the populace, making them unable to meet their water needs. In response, policy frameworks are being put in place to improve resource management, but the pressure keeps rising.

Water scarcity affects a bigger population particularly in the vast Arid and Semi-Arid Lands. In the past thirty-five years, at least nine significant episodes of water scarcity have occurred, impacting a growing population (Government of Kenya, 2009). Despite several campaign drives by the ministry, little has been done since water mitigation measures are marred with controversies and objections from various quarters. Kenya has experienced water scarcity in the recent past. The northwest and southeast regions of the country have been severely affected by water shortages due to receiving the least amount of rainfall. This has revealed the country's susceptibility, impacting 23 out of 47 counties. The counties most severely impacted include Turkana, Samburu, Marsabit, Isiolo, Tana River, Mandera, Wajir, Garissa, and Baringo (Mugwe, 2017).

In Marsabit County, water scarcity affects both the households' domestic use but as well as their livelihoods. The outputs of livelihoods is influenced directly or indirectly; even the cost of water as an input might elevate the operational expenses of the livelihood enterprise owing to water scarcity. Marsabit County is bordered by Samburu County to the south, Turkana to the west, Isiolo to the east, and Mandera and Ethiopia to the north. Covering an area of 66,000 square kilometers. The County, situated at an elevation of 1820 - 2000 metres above sea level, has precipitation from April to May and from October to November. A rare geographical feature is a rainforest encircled by semi-arid and arid conditions. It contains two crater lakes: Lake Paradise and Lake Sokorte (Marsabit District Planning Unit, 2004). This is the single source of potable water for the population of Marsabit town and the primary means of replenishing other aquifers in the lowlands. The area is located in the driest region of the country with no permanent water pockets. Low rainfall and high temperature levels rates that exceed annual precipitation do lead a marked moisture deficiency. Rainfall varies correspondingly with different elevations (Marsabit District Planning Unit, 2014). This calls for a concerted effort to mitigate water issues in order to improve water availability. This project aims to develop mitigation techniques for water, thereby enhancing the living standards of the Saku population.

Statement of the Problem

The use of relief aid, destocking livestock and use of water tankers in an attempt to distribute water, and appealing for more financing to respond to the water scarcity, have proven ineffective without a sustainable solution in tackling the perennial water shortage in Kenya (Mugwe, 2017). Livelihoods are dependent on the availability of water for domestic use or otherwise. Households in many of Kenya's rural areas are water - scarce areas, with households relying on self-supply sources for domestic, agricultural and subsistence uses (Huho & Muglavai, 2010).

The scarcity of adequate and secure water for the households, is a big challenge for sustainability of livelihoods in rural areas including Marsabit County. Gholamrezai and Sepahvand (2017) established that scarcity of water for sustainability is the scarcity for agriculture. Additionally, the lack of adequate access to better water supply makes rural households vulnerable and exposed them to a variety of problems, including health, economic, social, and cultural issues. Haysom (2006) found that the success of water projects depends on having distinct roles for different service providers courtesy of proper and efficient mitigation measures. E-Sadek (2011) found out that water shortages lead to a grim future and that integrated mitigation strategies are fundamental in operationalizing, managing, coordinating and the development of water, land and interrelated resources. The study aimed to fill these gaps left by the previous studies by addressing the issue of water

scarcity and the mitigation strategies thereof and how they influence sustainability of livelihoods in Saku Sub County in Marsabit County.

Objectives of the Study

The research was directed by subsequent research objectives;

- To determine how operational mitigation measures influence sustainability of livelihoods in Saku Constituency, Marsabit County.
- To ascertain the level to which structural systems of management influence sustainable livelihoods in Saku Constituency, Marsabit County.
- To determine the extent to which supply strategic mitigation plans influence sustainable livelihoods in Saku Constituency, Marsabit County.

LITERATURE REVIEW

Empirical Review

Operational Mitigation Measures

The research extensively utilizes the research of Carlevaro and Gonzalez (2011), which defined and categorized water sources into three primary types: rainfall, GROUND water (rivers, streams, lakes), and groundwater. The choice of a water source will be determined by the quality and amount of water, development and operational costs, available funding, and proximity to the community it serves (DFID, 2011). All these aspects may adversely or beneficially impact household livelihoods, whereas introducing susceptibilities and threats if specific issues become susceptible

OCHA (2010) points out that the availability of water sources continues to pose significant challenges for communities and families. The obtainability of water presents numerous issues for individuals and communities. In regions lacking water access, mothers and children go numerous kilometers to obtain water. This is observed in the lines near water sources during dry periods. The DFID report (2002) concludes that proximity to a high-quality water supply offers various advantages for human well-being, which are interconnected with all other aspects of livelihoods. According to World Bank (2006), the labor released by relieving the water burden on people could be very beneficial in case it was channeled in other more effective and productive activities to improve the living standard of the people.

Poor quality of water, expectations in society, and overworking are major long-term consequences on the output (UN Water, 2005). With the increasing water shortage, the personal hygiene and sanitation needs receive a low priority since they require moving heavier loads far to come by. Lack of water leads to poor health and hygiene, poor education, and poor living conditions of the rural population, who find it hard to use the water to clean their homes as livelihoods are entirely dependent on the scarce water (UNDP, 2006).

The combination of new social and environmental conditions confines the rural inhabitants to their limited residences, offering scant opportunities for improved education and work. The disruption of familial structures and diminished social standing adversely affect productivity (Ritcher *et al.*, 2010). The literature does not however provide the measures to be taken in order to avert the water scarcity problem. It deals more with the effects of lack of sustainable water availability and does not show what effects water mitigation strategies have on sustainable livelihoods of the local population. This research intends to operationalize water scarcity by improving affordable quality water and lessen the time for acquiring water. This research will concentrate on the user's level as the lowest tier of analysis. This stage encompasses enhancing user awareness, implementing water price, and utilizing rationing technologies, all of which will collectively enhance efficiency.

Structural and Systems of Management on water scarcity

As per UNDP-World Bank (2008) Water and Sanitation decade briefings, achieving long-term benefits from water delivery efforts requires much more than just building facilities. The use of suitable technology, the role of government in service delivery, and the significance of community involvement in all facets of service delivery would be the main topics of discussion. The poll also showed that although governments don't engage in or express interest in capacity building, they do presume that communities run their facilities on their own. This compels localities to enhance their conventional methods of sustaining water systems. An important necessity exists to delineate and specify the functions of project conception, execution, cost reduction, and preservation.

Water projects are necessitated by their management in order to be operational and be sustained. Properly coordinated projects usually outlive their goals. In his analysis of water undertakings in Tanzania, Haysom (2006) concludes that the role of the buyers and the regulators with regards to service provision should be defined.

According to E-Sadek (2011), continued water deficits will lead to catastrophic future in case the current trend continues. Governance is required in the management of water since it involves integrated water resource management which ensures the harmonization of the management and development of water and land resources. It tries to streamline social and economic wellbeing in a fair means, ecological sustainability and a combination of technology, social and political spheres.

Water Mitigation Strategies

Water shortage mitigation measures should also be outlined in preemptive programs that will reduce vulnerability and impact (Wilhite et al. 2014). As per HDR (2006), the UN Committee on Economic, Social and Cultural Rights has also avowed water as a human right to which every human being is entitled to adequate, safe, acceptable, physically reachable, and inexpensive water to use at home and in personal consumption. These are the five key questions which form the foundation of water security, and are often desecrated. The discussion shows that poor families are less predisposed to source water of various enhanced sources.

Strategic mitigation measures include significant systemic changes and can include: new water management methods, advanced technological management of water supplies, the development of small water storage, watershed management and improvement, building of groundwater and surface water storage, linking small reservoirs to larger ones, community based management plans of natural resources, new land management techniques and building public awareness of water scarcity. The research will focus on exploring the water mitigation practices and their impacts on livelihoods of people.

Impact of water scarcity on livelihoods

Water shortage has been recognized as a significant obstacle to sustainable living in many regions of the world, according to the Comprehensive Assessment of Water Management in Agriculture (CA, 2007). Seckler et al. (1998) identify two major types of water scarcity, namely, physical scarcity and economic scarcity. When there is not enough water available to fulfil all needs, including environmental flows, physical scarcity arises. Low water allocations, declining groundwater supplies, and severe environmental degradation are signs of physical water shortage. This can lead to human loss, increase of mortality rate of livestock and wildlife, destruction of wildlife and low quality of water.

Economic water shortage is a situation that results from insufficient investment in water resources or inadequate human capacity to meet water demands. Economic signs of water scarcity include underdevelopment of infrastructure, leading to the problems of people in accessing sufficient water to use at their homes. Even without the infrastructure, the allocation of water can be asymmetric. The economic results are lower income and decrease in the number of livestock due to death, high food prices, unemployment,

migration and disaster relief programs. The economic scarcity characterizes a vast part of sub-Saharan Africa; therefore, the water development would greatly reduce poverty (Tadesse, 2016).

According to Haysom (2006), the water project management encompasses other key elements which are considered tools of making projects more efficient. It is seen as a basic right to recipients to be a voice in programs that impacts their lives. Involvement can be in many procedures like the core definition of water demand, entry of technology and the location of the technology, provision of labor and local materials, a financial input to project spending, the type of management to be used and the decision on water tariffs.

There are many factors that lead to water scarcity and they are interrelated (Abrams, 2009). Scarcity is a situation where demand is greater than the supply available either because of poor organization and inadequate hydraulic infrastructure or simply because there is no physical supply of water. Things only get worse with the escalating competition over water needs which makes individuals or organizations exploit the already finite resources, such as aggressive borehole drilling, or water rights trading. Current analysis of water scarcity reveals that decision-makers typically respond to water mitigation with a crisis-management strategy, instituting a national or regional deficiency emergency program to mitigate impacts on livelihoods, rather than formulating comprehensive, long-term action plans that could substantially diminish vulnerabilities to extreme weather events. Planning must progress to incorporate mitigating techniques. It necessitates the formulation of extensive, long-term policies and action plans addressing water scarcity (Haysom, 2006). Water encompasses every aspect of our daily lives. Water is a prerequisite for development and therefore prompting researcher to address acute water shortage in the area of study with a view to seek long term solution to the problem that is now global.

Theoretical Review

Rights Based Approach

In 2002, subsequent to the World Summit on Sustainable Development in South Africa, a UN commission aligned with opponents of water supply privatization asserted that water needs to be regarded as a social and cultural asset rather than predominantly as an economic commodity. Subsequently, ECOSOC, and Social Rights, concurred on the essentiality of water as the foundation of our existence. Water is essential for life and well-being. The human right to water is essential for maintaining health and self-esteem. It is a prerequisite for the actualization of all other human rights (UNESCO, 2004). The maintainable frameworks theory provides a systematic, all-inclusive, inter-sectoral, and action-oriented methodology for comprehending the circumstances of impoverished and disregarded individuals. It facilitates the establishment of connections to policies aimed at poverty alleviation. The implemented approaches have demonstrated efficacy in research, programmatic interventions, and policies aimed at poverty alleviation, food security enhancement, and water scarcity mitigation (Benneth, 2010).

This theory applies to this study since water is incomparable, non-substitutable, and a basic right. Water is also a local commodity. Transportation is not easy and it has always been used in the vicinity of its source. This means that water management policies should be developed by putting into consideration the local issues as well as the overall impacts on the whole basin. They also have to consider how they can collaborate with the local population, the national governments, and in some cases, the international efforts regarding the best use of corporate water.

Securitization Theory

Securitization of water has become one of the leading topics in academia and policy. The Copenhagen School developed the Securitization Theory, which is a skilled and subtle design of general security studies (Williams, 2003). The rhetoric of securitization lays stress on the urgency and interrelatedness of the environmental issues with human security and well-being (Fischhendler, 2015). A paper that was filed with the US Department of Defense in 2003 had claimed that climate change would soon become a challenge to the

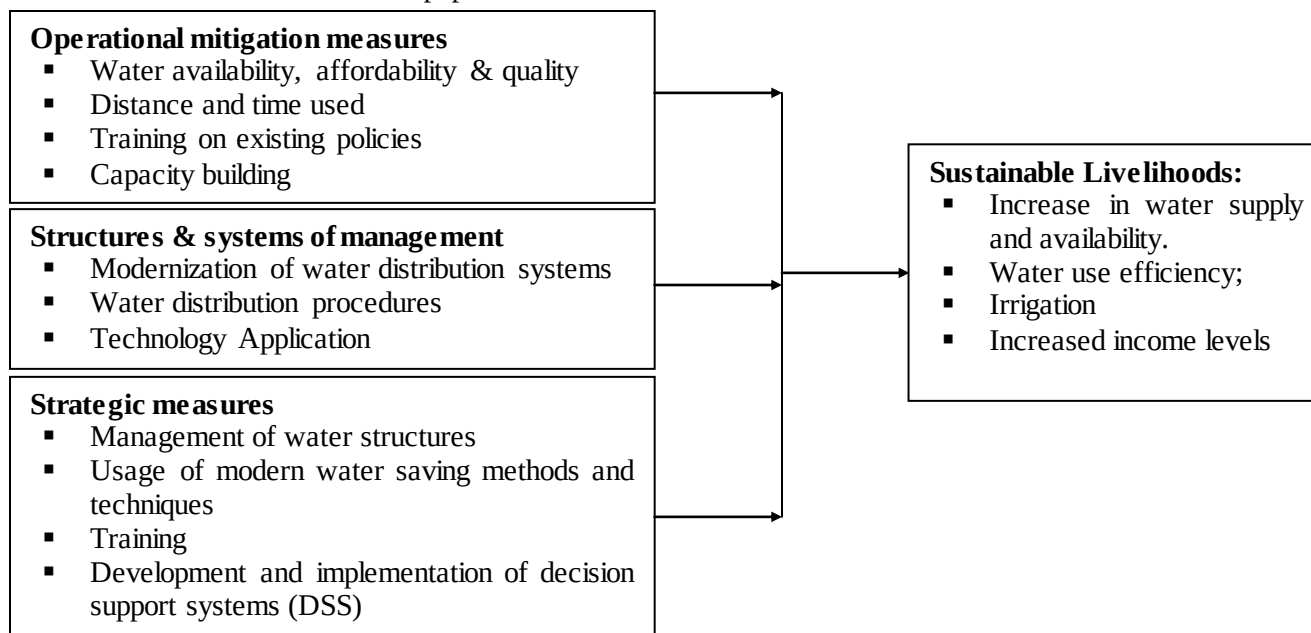
national security of the US (Fischhendler, 2015). This implies that there is a desire to make the environmental issues feature highly on the agenda. In case water is securitized, then senior security agencies can view it as a major threat.

Many environmental activists and politicians insist on the process of securitization of water shortage to the high placed position in the political arena. The increased importance of water shortage to security assurances has increased awareness and the easing of solutions and putting into place significant measures that will curb the possibilities of insecurity. According to Fischhendler (2015), a justification of extraordinary measures to prevent an existential threat is often acceptable when a problem is securitized, hence, more effective mitigation solutions are introduced.

This hypothesis is relevant in this study because the rising water scarcity is an issue that is of major concern in the future. It is not the growing scarcity of water that will be considered, but how countries will work together in managing this resource and ensuring that it is distributed equally. It is possible to foresee three different patterns: first, the market competition among the water sources will become more intense with the conflicts and protectionism; second, the commercialization of water or water contained products will lead to more unstable and frail markets where climate change will affect the use of water resources; and third, the cooperation will lead to the creation of the equitable, efficient, and sustainable utilization of water resources.. Water management necessitates an understanding of traditional economic risks linked to the shortage of an economic commodity, as well as political concerns related to water as a public interest social and ecological asset.

Conceptual Framework

It is a representative diagram drawn to illustrate interrelationships between research variables (Orodho, 2003). The study has identified independent variables as water mitigation strategies and dependent variables as sustainable livelihoods of the rural population.



Independent Variables

Figure 1: Conceptual Framework

Source: Author (2022)

Dependent Variables

METHODOLOGY

The survey embraced a descriptive design. The study population was Saku constituency in Marsabit County with a total population of 62,554 people (Kenya Population and Housing Census, 2019). Since the population was quite high and it was not possible to study all of them, sampling was done. The research targeted all the residents of the Constituency which was 46,502 as per National Population and Housing census of 2019 (KNBS, 2019). Disproportionate stratified sampling was utilized since the population did not institute a homogeneous group. The population was divided into strata consisting of any existing local community-based development committees or organizations as well any Non-Governmental Organization (NGOs) if any. Simple random sampling was employed to select persons from each stratum to ultimately form a total of 240 respondents using Slovin's sample determination formula. $n = N / (1 + Ne^2)$

The research gathered both primary and secondary data which were obtained by a feedback form designed according to the study objectives, comprising both open-ended and closed-ended inquiries utilizing a Likert scale. Questionnaires were utilized to gather both quantitative and qualitative data, administered to the designated respondents.

The collected data was cleaned and coded for ease of identification. The collected data was analyzed with the aid of SPSS both quantitatively and qualitatively. The quantitative analysis involved descriptive statistics (standard and mean) and inferential statistics that included correlation and regression analysis, analysis of variance (ANOVA) and the Fisher's (F) Test. Content analysis was utilized to analyse qualitative data. The analysis results were exhibited through frequency tables, bar graphs and pie charts, while qualitative data was provided via themes and debates. Cross tabulation between the variables of the research was also done to corroborate the quantitative results.

The regression model that was embraced was:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon$$

Where Y = Sustainable Livelihoods; X_1 = Operational mitigation measures; X_2 = Structures & systems of management; X_3 = Strategic measures

β_0 = Constant; β_1 ; β_2 and β_3 = Coefficients and ϵ is the error term

FINDINGS AND DISCUSSION

Response Rate

A total of 240 questionnaires were dispersed to chosen responders from the Water Management Committee, MCAs and sub-committees, chiefs and sub-chiefs, representatives from community-based organizations (CBOs), and Saku Constituency residents. Out of these, 232 were returned with everything correctly filled out, for a response rate of 96.7%.

Descriptive Statistics

Statistics that describe each research variable are provided. The Likert items were measured via a scale from 1 (Strongly Disagree) to 5 (Strongly Agree). Frequency distribution as well as means and standard deviations are provided for each item. Agreement is represented by mean scores above 3.50, whereas disagreement is shown with scores below 2.50.

Operational Mitigation Measures and Sustainable Livelihoods

Objective one aimed at establishing the effects of mitigation actions on livelihood sustainability in Saku Constituency. The part presents results from four extent/frequency questions and seven Likert scale questions. Table 1 presents the distribution and percentages of the responses provided by the respondents.

Table 1: Estimated Daily Distance Covered When Searching for Water

Distance Category	Frequency	Percentage (%)
5 km/Day	47	20.3%
10 km/Day	89	38.4%
15 km/Day	64	27.6%
20 km/Day	32	13.8%
Total	232	100%

Survey Data (2026)

Table 1 reveals that the majority of respondents travelled 10 km per day in search of water (38.4%), followed by 15 km (27.6%), 5 km (20.3%), and 20 km (13.8%). Cumulatively, 79.8% of respondents covered distances of 10 km or more daily to access water, a finding that underscores the severity of water scarcity in Saku Constituency. Abdi and Wako (2021) noted that daily water-fetching distances exceeding 5 km in pastoral communities are associated with significant opportunity costs, including reduced time for productive economic activities, school attendance, and rest. Women and girls disproportionately bear this burden, affecting their participation in income-generating ventures. These travel distances also impose physical health risks and increase vulnerability to insecurity along water-fetching routes, further compounding the livelihoods impact of water scarcity (Ndirangu & Wachira, 2023).

The Table 4.7, indicate that most participants travelled 10 kilometers (38.4%) to find water, followed by 15 kilometers (27.6%), 5 kilometers (20.3%), and 20 kilometers (13.8%). Overall, 79.8% of respondents travelled 10 km or more every day in search of water. This number highlights the intensity of the water scarcity problem facing the Saku constituency. According to Abdi and Wako (2021), the distance that pastoral communities travel each day to gather water exceeds 5 km, resulting in a very high opportunity cost, including less time for economically lucrative activities, attending school, and sleeping. The task falls disproportionately on women, limiting their capacity to engage in income-generating activities. The distance also creates health and security risks to the water fetchers.

Table 2: Extent to Which Water is Available, Affordable, and of Quality in Saku Constituency

Extent	Frequency	Percentage (%)
Not at all	61	26.3%
Low extent	98	42.2%
Moderate extent	54	23.3%
Great extent	19	8.2%
Total	232	100%

Survey Data (2026)

From the outcomes exhibited in Table 2 water availability is a big problem in Saku Constituency. A total of 68.5% of those surveyed confirmed that the water available was affordable and accessible to a low extent (42.2%) and no extent (26.3%) respectively. 8.2% of those surveyed indicated great extent availability and quality of water. This concurs with the findings by Muriithi & Omondi (2023) whereby a shortage of water was established in Marsabit County due to poor rainfall, lack of water storing mechanisms, and high cost of purchasing water from water vendors, which makes the water too expensive for poorer families.

Table 3: Extent of Training Received on Existing Water Policies

Extent	Frequency	Percentage (%)
Not at all	43	18.5%
Low extent	87	37.5%
Moderate extent	71	30.6%
Great extent	31	13.4%
Total	232	100%

As seen in Table 3, there was insufficient training in relation to current water policies among most of the respondents. This is demonstrated by the fact that 56.0% of the respondents had been trained to a great extent. On the other hand, 30.6% of the respondents were moderately trained while only 13.4% had been trained extensively. The observations made above align with those put forward by Otieno and Kariuki (2022). These authors suggested that individuals within communities without sufficient information about water governance policies will find it difficult to contribute towards their execution, monitor their effectiveness, and hold service providers accountable.

Table 4: Extent of Knowledge Received Through Capacity Building

Extent	Frequency	Percentage (%)
Not at all	38	16.4%
Low extent	91	39.2%
Moderate extent	74	31.9%
Great extent	29	12.5%
Total	232	100%

Survey Data (2026)

The results displayed in Table 4.10, showed that 55.6% of those asked reported having had little or no capacity building knowledge, while only 31.9% indicated some capacity building knowledge, and 12.5% a lot of capacity building knowledge. The findings above follow suit from the training deficit presented in Table 4.9, confirming a systematic weakness in community capacity building in the area of water management programs in Saku Constituency. As illustrated by Mwenda and Ngugi (2024), capacity building programs in ASALs in Kenya increased the capability of community members to manage and maintain water facilities, as well as to implement rainwater harvesting and engage in water management committees.

Table 5: Results for Operational Mitigation Measures

Statement	SD n(%)	D n(%)	N n(%)	A n(%)	SA n(%)	Mean	SD
Early warning systems for drought help households prepare for water shortages.	8(3.4)	14(6.0)	21(9.1)	107(46.1)	82(35.3)	4.04	0.921
Community training on water conservation improves water use efficiency.	6(2.6)	18(7.8)	24(10.3)	112(48.3)	72(31.0)	3.97	0.896
Water rationing practices help manage limited water resources effectively.	9(3.9)	22(9.5)	31(13.4)	98(42.2)	72(31.0)	3.87	0.983
Access to emergency water supply during drought periods is reliable.	16(6.9)	38(16.4)	29(12.5)	94(40.5)	55(23.7)	3.58	1.122
Water harvesting techniques (e.g., roof catchment) are widely practised.	11(4.7)	26(11.2)	28(12.1)	101(43.5)	66(28.4)	3.80	1.049
Livestock watering programmes reduce the impact of water scarcity.	7(3.0)	19(8.2)	33(14.2)	108(46.6)	65(28.0)	3.88	0.967
Awareness programmes on water management improve household resilience.	5(2.2)	16(6.9)	27(11.6)	114(49.1)	70(30.2)	3.98	0.884
Average						3.87	0.975

Survey Data (2026)

Table 5 shows fairly favorable views concerning the effectiveness of operational measures, whereby the means per variable range from 3.58 to 4.04, while the average mean for all items is 3.87 (Std. Dev = 0.975).

The early warning system for drought was viewed most positively with a mean rating of 4.04 (Std. Dev = 0.921) with 81.4% agreement with the statement. This is consistent with findings by Katumo et al. (2023), who found that early warnings in pastoralists' households were effective as they helped with water stocking, movement of livestock, and rationing of food. Droughts are recurrent within Saku Constituency; hence, the early warning system serves as an important operational tool here.

Programme related to water management awareness programs were ranked second in terms of mean scores (Mean = 3.98, Std. Dev = 0.884). The percentage of agreement was at 79.3%. This is consistent with studies by Mwenda and Ngugi (2024) which concluded that organized awareness campaigns on water conservation for ASAL areas of Kenya have been seen to increase water saving practices in households by more than 30%. It is important for communities to know the importance of water conservation as well as the procedures involved therein.

The community training concerning water conservation had equally high mean scores (Mean = 3.97, Std. Dev = 0.896), aligning with the assertion by Otieno and Kariuki (2022) that the building of capabilities among water users increases efficiencies in water use while curbing waste. Other operational strategies such as the livestock watering programs (Mean = 3.88, Std. Dev = 0.967) and rationing of water (Mean = 3.87, Std. Dev = 0.983) were accorded the same level of agreement scores.

The item with the least mean score of 3.58 (Std. Dev = 1.122) pertained to having access to emergency water source during drought times, with 64.2% either agree or strongly agree with this statement. Given the relatively high standard deviation and higher level of disagreement (23.3%), one may infer inconsistency on the provision of emergency water sources. This finding is corroborated by studies such as those conducted by Abdi and Wako (2021), where it was found that emergency water transportation services in Marsabit County faced delays mainly because of logistical and financial constraints, which left the vulnerable households with no timely access to water during acute droughts.

Structural Systems of Management and Sustainable Livelihoods

The second objective was to explore the effect of structural management systems on sustainable livelihoods in Saku Constituency. The debate is based on responses to two questions on improving the water distribution system and processes. Seven further Likert statements follow. Tables 6 through 8 present the findings.

Table 6: Extent of Modernization of Water Distribution Systems in Saku Constituency

Extent	Frequency	Percentage (%)
Not at all	72	31.0%
Low extent	96	41.4%
Moderate extent	47	20.3%
Great extent	17	7.3%
Total	232	100%

Survey Data (2026)

As seen in Table 6, the results point to a considerable lack of water distribution modernization in Saku Constituency. Altogether, 72.4% of the respondents agreed that there was low (41.4%) or no modernization (31.0%) at all. The level of great modernization reported only by 7.3% of the respondents. The result aligns with the observations of Kiriimi and Muturi (2023), who noted that infrastructure modernization efforts in the Kenyan ASAL counties were continuously underfunded and inequitably distributed, leaving many rural residents to continue utilizing manually-operated water points and outdated distribution systems. Within the conditions of Saku Constituency characterized by high demand for water and its sources scattered throughout large areas, the lack of modernized technologies, including solar-powered pumping stations, pressure-driven distribution networks, and water level monitors, poses a severe limitation on service efficiency.

Table 7: Extent of Improvement and Implementation of Water Distribution Procedures

Extent	Frequency	Percentage (%)
Not at all	58	25.0%
Low extent	101	43.5%
Moderate extent	52	22.4%
Great extent	21	9.1%
Total	232	100%

Survey Data (2026)

The Table 7 show that most responders specified that there was little development in terms of improvement and implementation of water distribution procedures since 68.5% of the respondents indicated that there was either little extent (43.5%) or no extent (25.0%) of improvement and implementation of the said procedures. On the other hand, only 9.1% of the respondents had experienced great-extent improvements in water distribution procedures. The results clearly support the claims made by Githiri & Waweru (2024) on the issue of reforms within Kenya's water sector whereby reforms including the allocation procedure changes, water point management procedures and inter-agency coordination procedures are only achieved at the county headquarters without any impact in sub-counties and among communities.

Table 8: Results for Structural Systems of Management

Statement	SD n (%)	D n (%)	N n (%)	A n (%)	SA n (%)	Mean	SD
Local water management committees effectively manage water resources.	7(3.0)	21(9.1)	28(12.1)	110(47.4)	66(28.4)	3.89	0.964
Government policies support equitable access to water resources.	12(5.2)	34(14.7)	36(15.5)	97(41.8)	53(22.8)	3.63	1.106
Water infrastructure (boreholes, dams, pipelines) is adequately developed.	19(8.2)	42(18.1)	38(16.4)	88(37.9)	45(19.4)	3.42	1.189
Maintenance of water infrastructure is regularly conducted.	23(9.9)	49(21.1)	34(14.7)	84(36.2)	42(18.1)	3.31	1.237
Coordination among stakeholders improves water resource management.	6(2.6)	17(7.3)	29(12.5)	116(50.0)	64(27.6)	3.93	0.924
Community participation in water management decisions is encouraged.	5(2.2)	19(8.2)	31(13.4)	114(49.1)	63(27.2)	3.91	0.919
Institutional support enhances sustainable use of water resources.	8(3.4)	22(9.5)	30(12.9)	106(45.7)	66(28.4)	3.86	0.989
Average						3.71	1.047

Survey Data (2026)

The findings in Table 8 present a more varied picture compared to operational measures, with item means ranging from 3.31 to 3.93 and an overall average of 3.71 (Std. Dev = 1.047). Stakeholder coordination recorded the highest mean (Mean = 3.93, Std. Dev = 0.924), with 77.6% of respondents agreeing or strongly agreeing. This is consistent with Kirimi and Muturi (2023), who found that multi-stakeholder platforms involving government agencies, NGOs, community leaders, and water users were the most effective governance structures for water resource management in Kenya's arid counties. In Saku Constituency, where

water sources are shared across communities and administrative boundaries, coordination mechanisms are indispensable for avoiding resource conflicts.

Community participation in water management decisions (Mean = 3.91, Std. Dev = 0.919) and local water management committee effectiveness (Mean = 3.89, Std. Dev = 0.964) also recorded strong agreement. These findings support Wanjiku and Ndirangu (2022), who demonstrated that community-owned water management structures in ASALs demonstrated higher sustainability because community members felt a sense of ownership and were more motivated to maintain infrastructure and comply with usage rules.

Institutional support for sustainable water use also received agreement (Mean = 3.86, Std. Dev = 0.989), while government policy support for equitable access received a slightly lower mean (Mean = 3.63, Std. Dev = 1.106). The higher standard deviation suggests divided opinion, with 19.9% of respondents disagreeing or strongly disagreeing. This is reflective of widespread concerns documented by Githiri and Waweru (2024), who argued that while Kenya's national water policies articulate equity principles, implementation deficits at the county and sub-county levels leave many marginalized communities inadequately served.

The two lowest-scoring items were adequacy of water infrastructure development (Mean = 3.42, Std. Dev = 1.189) and regularity of infrastructure maintenance (Mean = 3.31, Std. Dev = 1.237). Infrastructure adequacy attracted the highest proportion of disagreement in this section (26.3%), and maintenance regularity drew 31.0% disagreement. These findings corroborate a 2023 Marsabit County Integrated Development Plan review cited by Abdi and Adan (2023), which identified declining functionality of boreholes and water pans as a critical governance challenge attributable to inadequate maintenance budgets and absence of formal maintenance schedules. The aggregate mean of 3.71 still confirms that structural systems are perceived as moderately influential on livelihood sustainability, but the infrastructure maintenance deficit stands out as a priority concern.

Supply Strategic Mitigation Plans and Sustainable Livelihoods

Objective three involved analyzing the degree to which supply strategic mitigation measures affect sustainable livelihoods in Saku Constituency. This section provides findings from three extent questions on the management of water infrastructure, use of water saving technology, and development of Decision Support Systems (DSS), followed by seven Likert scale statements. Tables 9 provide the findings.

Table 9: Extent of Management of Water Structures in Saku Constituency

Extent	Frequency	Percentage (%)
Not at all	49	21.1%
Low extent	104	44.8%
Moderate extent	59	25.4%
Great extent	20	8.6%
Total	232	100%

Survey Data (2026)

From Table 9, the management of water infrastructure was still poorly done in the Saku constituency, as evidenced by the fact that 65.9% of the respondents felt that the extent of the management was low (44.8%) or there was no management at all (21.1%). The proportion of those who had great extent management was just 8.6%. These results confirm the findings of Abdi and Adan (2023), who found that water infrastructure in Marsabit County including boreholes, water pans, and rainwater harvesting tanks were in poor conditions due to lack of clear mandates on how they should be managed.

Table 10: Extent of Usage of Modern Water-Saving Methods and Techniques

Extent	Frequency	Percentage (%)
Not at all	55	23.7%
Low extent	99	42.7%
Moderate extent	56	24.1%
Great extent	22	9.5%
Total	232	100%

Survey Data (2026)

Table 10 demonstrates that uptake of current water-saving technologies and related approaches in Saku Constituency was rather restricted, with 66.4% of respondents indicating a low (42.7%) or no adoption (23.7%), while only 9.5% indicated a high level of adoption. Ndung'u and Kimani (2022) also noted that the adoption of modern water conservation technologies in Kenya's ASALs, such as drip irrigation, water-efficient crop varieties, and solar-powered pumps, was hampered by high upfront investment costs, limited technical know-how, and thin supply lines for spare parts and maintenance services. These constraints are particularly severe in far-flung areas like Saku, where market links are weak and access to agricultural extension services is limited. Overall, this low adoption rate indicates a missed opportunity to improve water efficiency.

Table 11: Extent of Development and Implementation of Decision Support Systems

Extent	Frequency	Percentage (%)
Not at all	83	35.8%
Low extent	102	44.0%
Moderate extent	34	14.7%
Great extent	13	5.6%
Total	232	100%

Survey Data (2026)

Table 11 indicates the most pronounced deficit across all preliminary extent questions, with 79.8% of respondents indicating that DSS development and implementation occurred to a low extent (44.0%) or not at all (35.8%). Only 5.6% reported great-extent DSS integration. Decision Support Systems encompass digital tools, databases, and analytical platforms that help water managers make evidence-based decisions on resource allocation, demand forecasting, and emergency response. Wako and Boru (2024) emphasized that DSS adoption in Kenya's northern counties remained nascent, constrained by limited digital infrastructure, low technological literacy among water management personnel, and inadequate financial resources for system procurement and maintenance. The near-absence of DSS in Saku Constituency suggests that water management decisions are largely reactive and intuition-driven rather than data-informed, which limits the efficiency and fairness of supply strategic plans.

Table 12: Results for Supply Strategic Mitigation Plans

Statement	SD n(%)	D n(%)	N n(%)	A n(%)	SA n(%)	Mean	SD
Water supply systems are reliable during drought periods.	18(7.8)	44(19.0)	35(15.1)	91(39.2)	44(19.0)	3.42	1.196
Strategic water reserves (e.g., dams, water tanks) reduce scarcity impacts.	9(3.9)	24(10.3)	28(12.1)	109(47.0)	62(26.7)	3.83	1.013
Distribution of water resources is timely and efficient.	21(9.1)	48(20.7)	32(13.8)	88(37.9)	43(18.5)	3.36	1.229
Partnerships with NGOs and agencies improve water supply systems.	7(3.0)	21(9.1)	27(11.6)	108(46.6)	69(29.7)	3.91	0.978
Access to irrigation water supports agricultural productivity.	10(4.3)	28(12.1)	33(14.2)	104(44.8)	57(24.6)	3.73	1.054
Availability of water trucking services helps during acute shortages.	14(6.0)	39(16.8)	36(15.5)	97(41.8)	46(19.8)	3.53	1.129
Infrastructure supports equitable distribution of water resources.	17(7.3)	41(17.7)	37(15.9)	89(38.4)	48(20.7)	3.47	1.196
Average						3.61	1.114

Survey Data (2026)

Table 12 revealed that supply strategic mitigation plans received a composite mean of 3.61 (Std. Dev = 1.114), indicating moderate to positive perceptions. However, greater variability in responses was noted compared to the previous sections, as evidenced by the higher standard deviations. Partnerships with NGOs and government agencies received the highest agreement (Mean = 3.91, Std. Dev = 0.978), with 76.3% of respondents agreeing or strongly agreeing. This aligns with Muriithi and Omondi (2023), who documented that NGO-county government partnerships in Marsabit significantly expanded water supply coverage through co-financing of water pans, solar-powered boreholes, and community water kiosks, thereby enhancing livelihood resilience among pastoralist and agro-pastoralist households.

Strategic water reserves received the second-highest mean (Mean = 3.83, Std. Dev = 1.013), with 73.7% of respondents agreeing or strongly agreeing that dams and water tanks reduce scarcity impacts. Wako and Boru (2024) affirmed that in counties like Marsabit where rainfall is highly unpredictable, strategic water storage through sand dams, sub-surface dams, and elevated water tanks constitutes the most resilient long-term supply intervention, as stored water remains available throughout dry spells.

Access to irrigation water for agriculture was moderately agreed upon (Mean = 3.73, Std. Dev = 1.054), reflecting growing interest in irrigated farming as a supplementary livelihood among Saku community members. Ndung'u and Kimani (2022) reported that smallholder irrigation initiatives in Kenya's ASALs contributed to food security and income diversification, particularly for women-led households transitioning from purely pastoralist livelihoods.

Reliability of water supply during drought periods (Mean = 3.42, Std. Dev = 1.196) and equity of infrastructure distribution (Mean = 3.47, Std. Dev = 1.196) received comparatively lower means, with 26.8% and 25.0% disagreement rates respectively. Timeliness and efficiency of water distribution attracted the highest disagreement (29.8%), yielding the lowest mean in this section (Mean = 3.36, Std. Dev = 1.229). These gaps are consistent with Adan and Galgalo (2021), who highlighted systemic last-mile distribution

failures in Marsabit County, particularly in remote villages where water infrastructure is sparse and seasonal roads limit truck access. The overall composite mean of 3.61 confirms that supply strategic plans are moderately influential on livelihoods, but implementation consistency remains a pressing concern.

Sustainable Livelihoods

Respondents rated their agreement with statements on sustainable livelihoods outcomes at the household level on a five-point Likert scale. Results are presented in Table 12.

Table 12: Results for Sustainable Livelihoods

Statement	SD n(%)	D n(%)	N n(%)	A n(%)	SA n(%)	Mean	SD
Water availability has improved my household's income-generating activities.	10(4.3)	28(12.1)	33(14.2)	103(44.4)	58(25.0)	3.74	1.064
My household is more food secure due to improved water access.	8(3.4)	24(10.3)	29(12.5)	112(48.3)	59(25.4)	3.82	1.011
Access to water has enhanced livestock and agricultural productivity.	7(3.0)	20(8.6)	27(11.6)	114(49.1)	64(27.6)	3.90	0.970
I am able to cope better with drought and water shortages.	9(3.9)	26(11.2)	34(14.7)	107(46.1)	56(24.1)	3.76	1.038
My household has diversified livelihood sources due to water interventions.	13(5.6)	34(14.7)	38(16.4)	99(42.7)	48(20.7)	3.58	1.106
Water management strategies have improved my quality of life.	7(3.0)	22(9.5)	31(13.4)	111(47.8)	61(26.3)	3.85	1.000
My livelihood is sustainable despite recurring water scarcity challenges.	11(4.7)	30(12.9)	37(15.9)	103(44.4)	51(22.0)	3.66	1.073
Average						3.76	1.037

Survey Data (2026)

The perceptions towards sustainable livelihoods outcomes were positive overall, with means varying between 3.58 and 3.90 and composite mean being 3.76 (Std. Dev = 1.037). The top scoring item on the survey was the provision of water that increases livestock and agricultural production (Mean = 3.90, Std. Dev = 0.970) where 76.7% agreed or strongly agreed. This is important considering that pastoralism and agro-pastoralism make up the major livelihood activities in the Saku constituency. In their study, Galgalo and Wako (2023) found that the provision of water within five kilometers of homesteads in Kenya's northern ASAL counties resulted in reduction in livestock mortality rates during drought by 40%, while also enabling the cultivation of kitchen gardens for subsistence farming.

Water management measures, improved quality of life (Mean = 3.85, SD = 1.000), and food security as a result of improved water access (Mean = 3.82, SD = 1.011) all received great support. These findings are consistent with the Sustainable Livelihoods Framework (SLF), which states that access to natural capital, particularly water, serves as a form of backbone for livelihood security (Chambers & Conway, 1992; Shikuku et al., 2022). If families can meet their basic water needs, they may redirect their financial and human capital toward more productive endeavors, higher education enrolment, and routine healthcare, ultimately improving their overall quality of life.

The ability to cope with droughts and water shortages (Mean = 3.76, Std. Dev = 1.038), as well as the improvement in income-generating activities (Mean = 3.74, Std. Dev = 1.064), and livelihood sustainability in the face of recurring scarcity (Mean = 3.66, Std. Dev = 1.073), were all rated from moderate to high agreement. The lowest-scoring component was livelihood diversification as a result of water interventions (mean = 3.58, standard deviation = 1.106), with 20.3% of respondents disagreeing or strongly disagreeing. According to Omolo and Oguge (2023), even though water access is a necessary condition for livelihood diversification, it is insufficient on its own. Additional supportive actions, such as market access, financial services, and technical training, are required so that households can transition from subsistence work to more varied income streams.

Inferential Statistics

Multiple linear regression analysis was done to look at how the three independent variables, operational mitigation measures, structural systems of management, and supply strategic mitigation plans, relate to the dependent variable, sustainable livelihoods in Saku Constituency, Marsabit County. The study moved along model summary, then ANOVA, and afterwards regression coefficients.

Model Summary

Table 13: Model Summary Results

Model	R	R Square	Adjusted R Square
1	0.731	0.534	0.528

Predictors: (Constant), Operational Mitigation Measures, Structural Systems of Management, Supply Strategic Mitigation Plans

The combined independent variables; operational mitigation measures, structural systems of management, and supply strategic mitigation plans showed a high correlation with sustainable livelihoods ($R = 0.731$) as shown in table 4.20 above. The R-Square value of 0.534 for the three predictor variables explains variation in sustainable livelihoods as 53.4%. With an Adjusted R Square value of 0.528, it remains a very strong model after adjusting for the number of predictors in the model. Similar R-Square estimates were reported by Mutua and Waithaka (2023) in studies to investigate the link between multi-dimensional water governance interventions and household livelihood outcomes in Kenyan ASALs. This leaves 46.6% of variance unexplained, which could stem from factors beyond the importance of climate discussed within this study such as climate variability, market forces, political influences and even household characteristics.

Analysis of Variance (ANOVA)

Table 14: ANOVA Results

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	48.263	3	16.088	89.412	0.000
Residual	41.929	228	0.184		
Total	90.192	231			

Dependent Variable: Sustainable Livelihoods

The ANOVA results in Table 14 show the overall regression model is statistically significant. The F-statistic is 89.412 with $p = 0.000$ ($p < 0.05$), so the model is significant at the 95% confidence level. This means the three independent variables; operational mitigation measures, structural systems of management, and supply strategic mitigation plans together have a significant effect on sustainable livelihoods in Saku Constituency. The chance of these results occurring randomly is negligible. These findings match Njeru and Ngugi (2023), who also found that multi-component water mitigation frameworks significantly predict livelihood sustainability in semi-arid Kenyan settings.

Regression Coefficients

Table 15: Results for Regression Coefficients

Model	B	Std. Error	Beta	t	Sig.
(Constant)	0.412	0.174		2.368	0.019
Operational Mitigation Measures	0.318	0.074	0.324	4.297	0.000
Structural Systems of Management	0.271	0.071	0.276	3.817	0.000
Supply Strategic Mitigation Plans	0.249	0.068	0.254	3.662	0.000

Dependent Variable: Sustainable Livelihoods

The regression model yielded the following equation:

$$Y = 0.412 + 0.318X_1 + 0.271X_2 + 0.249X_3 + \varepsilon$$

Where: Y = Sustainable Livelihoods; X_1 = Operational Mitigation Measures; X_2 = Structural Systems of Management; X_3 = Supply Strategic Mitigation Plans; ε = Error term.

The constant value ($\beta = 0.412$, $p = 0.019$) shows a baseline level of livelihood sustainability that stands on its own, apart from the mitigation variables being measured. This might be due to the natural ability of households to adapt, their traditional knowledge systems, and the social networks they have that help them stay strong even without formal help. Operational mitigation measures ($\beta = 0.318$, $p = 0.000$) showed a significant positive impact on sustainable livelihoods with a standardized beta of 0.324. This means that as these measures become more effective by one unit, sustainable livelihoods see an improvement of 0.318 units while keeping other factors unchanged. Katumo et al. (2023) also found similar results showing that actions like early warning systems, training communities about water use, and rationing programs lead directly to better household water security and support for livelihood activities. In Saku Constituency, where droughts often cause severe water

Structural systems of management ($\beta = 0.271$, $p = 0.000$): Management structural systems had the second strongest positive and significant impact on sustainable livelihoods (standardized beta = 0.276). This is a clear indication that the enabling role of institutional structures, governance structures, and coordination processes is crucial for the sustenance of livelihoods. As per Kiri and Muturi (2023), the development of water governance structures provides the enabling environment through which effective operational interventions can take place and sustain over time. In the absence of functional committees, equal policies, and maintenance of infrastructures, even the best operational programs will not withstand over time.

Strategic mitigation plans for supplies ($\beta = 0.249$, $p = 0.000$): Strategic mitigation plans for supplies similarly had a statistically significant positive impact on sustainable livelihoods, with a standardized beta of 0.254. This means that strategic investments in water storage facilities, working with NGOs, and irrigated agriculture significantly enhance livelihoods in Saku Constituency. As per Muriithi and Omondi (2023), strategic investments in water supplies in northern counties of Kenya have led to creation of jobs during the construction phase, increased agricultural productivity through irrigation, and less time spent collecting water, especially by women and children who would be able to pursue productive economic activity. This is because strategic supply plans take more time to implement than the operational and structural aspects of sustainability.

CONCLUSIONS AND RECOMMENDATIONS

The study draws the following conclusions based on the research findings:

Firstly, there is a positive correlation between operational mitigation efforts and sustainable livelihoods in the Saku Constituency. Early warning systems within communities, water conservation education, rationing, and other awareness programs increase the preparedness of households to deal with water shortages. The success of operational efforts depends on the involvement of the community, proper timing, and adequate funding of emergency water services.

Secondly, the system of management structures plays a vital role in promoting sustainable livelihoods, although its success is hampered by poor infrastructure. The coordination of stakeholders, community involvement, and institutional backing provide the framework for governance in Saku Constituency, but the poor condition of water infrastructure and lack of maintenance policies make sustainability difficult to achieve.

Third, strategic mitigation plans are very crucial to the sustainability of livelihoods. Partnerships with NGOs, strategic water storage facilities, and availability of water for irrigation are some of the key routes through which income diversification, food security, and improvement in the quality of living can be achieved. But, distribution inequity, shortage of supply in times of drought, and lack of water trucking hinder the effectiveness of strategic supplies.

This study contributes to the academic literature on water governance and rural livelihoods in several important ways. Theoretically, it provides empirical validation of the Sustainable Livelihoods Framework (SLF) within an arid and semi-arid Kenyan context, demonstrating that access to water as natural capital is significantly and differentially mediated by operational, structural, and strategic dimensions of water governance. The study advances understanding beyond singular analyses of water availability by disaggregating mitigation approaches and quantifying their individual and collective contributions to livelihood outcomes.

Empirically, the study provides primary data from Saku Constituency, a context under-represented in academic literature despite its extreme vulnerability to water scarcity thereby bridging an important geographic and contextual gap. The findings offer replicable methodological frameworks for similar studies in other ASAL counties in Kenya and the broader East African region. Practically, the study generates evidence for county-level policy reform by identifying specific intervention areas particularly emergency water supply reliability, infrastructure maintenance, and equitable distribution that require prioritization to translate policy intentions into household-level livelihood impacts.

Based on the study's findings and conclusions, the following recommendations are proposed:

- Marsabit County Government and national water authorities should institutionalize and expand drought early warning systems across all sub-counties in Saku Constituency, integrating meteorological data with community alert networks and linking these systems to pre-positioned emergency water reserves to enable timely household-level mobilization and minimize livelihood disruption during drought onset.
- The County Government should establish a ring-fenced infrastructure maintenance fund to ensure systematic and preventive upkeep of boreholes, water pans, dams, and pipeline networks in Saku Constituency, while formally training and empowering Community Water Management Committees to undertake first-level maintenance with technical backstopping from county water engineers, and strengthening these committees through formal registration, governance training, and financial management capacity building to safeguard infrastructure investments and enhance their role as institutional anchors for sustainable water resource management.

- Marsabit County should develop a comprehensive last-mile water distribution and storage strategy for Saku Constituency that addresses geographic access barriers through expanded strategic storage infrastructure (such as sand dams, sub-surface dams, and solar-powered elevated tanks in priority locations), establishes equitable and transparent allocation protocols developed through participatory community processes, and explicitly incorporates livelihood diversification components including smallholder irrigation, kitchen gardening support, and linkages to agricultural extension services to maximize the livelihood co-benefits of water supply investments.

Suggestions for Further Research

The future study could examine the gender differences of the effects of water scarcity mitigation measures on the livelihoods of people in the Saku Constituency since fetching of water is one activity that more often affects the livelihoods of women and girls. A longitudinal study that measures the livelihood effects of the implementation of particular measures would be more effective compared to the cross-sectional study design. Comparative studies conducted in various ASAL constituencies within Marsabit County and other neighboring counties such as Isiolo and Turkana would shed light on the context-specificity of the findings.

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