

**INFLUENCE OF SOCIAL, ENVIRONMENTAL AND
TECHNOLOGICAL FACTORS ON MANAGEMENT OF
FAECAL MATTER IN ARID AND SEMI-ARID AREAS: A
CASE OF ISIOLO SUB -COUNTY, KENYA**

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**A Thesis Submitted in Partial Fulfilment of the Requirement for Conferment of the
Degree of Master of Science in Sanitation of Meru University of Science and
Technology**

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DECLARATION

This thesis is my original work and has not been submitted for the award of a degree in any other institution.

EG407/202395/22

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DECLARATION BY SUPERVISORS

This thesis has been submitted for examination with our approval as supervisors

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DEDICATION

I dedicate this thesis to my father Fredrick Muthuri and my mother Monicah Muthuri who have been supportive throughout my academic journey.

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OPERATIONAL DEFINITION OF TERMS

- Accessibility** : Ease with which individuals or communities can access faecal sludge management services and facilities.
- Arid and Semi-arid areas** : Regions characterized by low precipitation levels and limited availability of water resources.
- Containment** : first step in the faecal sludge management service chain, involving the storage of human waste at the point of generation. It includes pit latrines, septic tanks, and other on-site facilities designed to temporarily hold waste before treatment or disposal.
- Cultural Beliefs** : Shared traditional or religious views that affect perceptions and practices around sanitation, hygiene, gender roles, and waste disposal. These beliefs can either hinder or enhance safe faecal matter management.
- Environmental factors** : In the context of this study encompass geographical characteristics such as soil type, topography, and water table, climate conditions, and land use and availability of space, which collectively influence the design, implementation, and sustainability of faecal sludge management strategies.
- Faecal matter** : Refers to the mixture of human excreta, water, and solid wastes that accumulate in pit latrines, septic tanks, or other onsite sanitation systems.
- Faecal matter Management** : In the context of this research refers to the systematic and responsible handling, treatment, and disposal of human waste to safeguard public

health and environmental integrity. It involves ensuring the safe disposal of faecal matter through appropriate sanitation facilities and practices,

Gender Roles : Culturally defined responsibilities assigned to men and women in relation to sanitation. For example, women may be tasked with cleaning toilets, while men may build or fund them.

Handwashing Facilities : Designated infrastructure, often located near latrines, for cleaning hands using soap and water or sanitizer. Their presence is a key indicator of hygiene behavior and is essential in preventing fecal-oral disease transmission.

Household : Refers to pertains to a group of individuals or a single family that share housing, food, or other amenities while residing in the same place

Knowledge in Sanitation : The awareness and understanding of best practices, health risks, and available options related to sanitation and faecal sludge management.

Land Use : The manner in which land is allocated and utilized in a given area, such as residential, commercial, agricultural, or communal. It influences sanitation infrastructure planning, construction feasibility, and waste disposal behavior.

Skilled Labour : Trained professionals or artisans (e.g., masons, sanitation engineers, health promoters) involved in constructing or managing sanitation facilities and FSM services.

- Social factors** : In the context of this study encompasses a range of influences that shape individuals' behaviors, attitudes, and interactions. These factors include: Social factors; Age, gender, and level of education; Awareness of FSM practices; Knowledge on sanitation; Social norm and Culture
- Social norms** : Refers to the shared expectations, values, and behaviors that guide how individuals interact with each other and make decisions within their community
- Technological factors** : Refer to various aspects related to the use of technology and infrastructure in managing faecal matter. These factors encompass elements such as the quality and design of technologies used in sanitation systems, the availability and adequacy of sanitation infrastructure, accessibility of containment systems, management skills related to the operation and maintenance of sanitation technologies, and the availability of local resources.

ABBREVIATIONS, SYMBOLS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
CGI	County Government of Isiolo
CI	Confidence Interval
CLTS	Community-Led Total Sanitation
COD	Chemical Oxygen Demand
EDHS	Ethiopia Demographic Health Survey
FGDs	Focus Group Discussion(s)
FM	Faecal Matter
FMM	Faecal Matter Management
FS	Faecal Sludge
FSM	Faecal Sludge Management
GSO	General Statistics Office
IBM-WASH	Integrated Behavioral Model for Water, Sanitation and Hygiene
JMP	Joint Monitoring Programme (WHO/UNICEF)
KESHIP	Kenya Environmental Sanitation and Hygiene Policy
KNBS	Kenya National Bureau of Statistics
M	Mean
MoH	Ministry of Health (Kenya)
MUST	Meru University of Science and Technology
mWater	Mobile Water Survey Tool
NACOSTI	National Commission for Science, Technology and Innovation
OD	Open Defecation

OR	Odds Ratio
OSS	Onsite Sanitation System
SD	Standard Deviation
SDGs	Sustainable Development Goal(s)
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
TN	Total Nitrogen
UN	United Nations
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization

ABSTRACT

Access to safe and adequate sanitation remains a significant challenge in arid and semi-arid areas. To address this issue, onsite sanitation facilities have gained global acceptance, where financial constraints often hinder the installation of conventional centralized systems. However, studies have observed that faecal matter accumulating in these technologies is usually poorly managed, posing risks to public and environmental health and leading to adverse economic and social effects. The study investigated the influence of social, environmental, and technological factors on the management of faecal matter in Isiolo Sub-County. A convergent mixed methods design was used to obtain quantitative data using structured questionnaires and qualitative data from two focus group discussions. Stratified and proportionate random sampling techniques were used to select households, while purposive sampling was applied for informants. Quantitative data were analyzed using Statistical Package for Social Science (SPSS) version 26.0 for descriptive statistics and logistic regression analysis. Logistic regression was computed in univariable and multivariable analysis to determine the relationship between predictors and dependent variables, and results were presented as an odds ratio with 95% Confidence Interval (CI). Qualitative data were analyzed thematically and presented in narratives. From the findings, the pit latrine was most commonly used at 77.1%, and about 46.5% of the resulting excreta was poorly managed. The study established social factors such as secondary education (AOR = 4.085, $p < .001$); gender roles (AOR = 0.518, $p = 0.028$), knowledge of safe disposal (AOR = 22.50, $p < .001$), and social norms (AOR = 0.347, $p = .001$) to have a significant influence on the management of faecal matter. Environmental factors such as rainfall (AOR= 0.825, $p = 0.0315$), space availability (AOR = 0.89, $p = .036$), and land use (AOR=1.012, $p=0.013$), along with technological aspects like sustainable toilet (AOR= 1.398, $p=0.036$); latrine accessibility (AOR= 0.783, $p=0.05$); local resources (AOR = 1.488, $p = 0.009$) were also statistically associated with effective faecal matter management. The study concludes that social, environmental, and technological interaction influences faecal matter management in arid and semi-arid areas. The study recommends that policy makers and sanitation stakeholders, such as the county Government, promote public education and community awareness, promote resilient and lined sanitation technology, strengthen local capabilities through intra-community skilled labour training, and incorporate land experimentation with usability into infrastructure development. To promote sustainable and inclusive faecal matter management, it is vital that sanitation policies across the affected realms can adapt accordingly to context, particularly in disadvantaged arid and semi-arid lands (ASAL).

CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter consists the following; background of management of Faecal Matter, the problem statement, justification of the study, research questions, study objectives, significance of the study, limitation and delimitations of the study.

1.1 Background of Management of Faecal Matter

Access to safe and adequate sanitation is an essential and fundamental human right and vital for promoting human and environmental health (Bazaanah & Mothapo, 2023). The Sustainable Development Goals (SDGs), target 6.2, advocates for universal access to safely managed sanitation, paying particular attention to the needs of women and those in vulnerable situations and aiming to end open defecation by 2030 (United Nation [UN], 2015; Rajapakse, & Danso, 2023). However, safe sanitation is a challenge in low-resource contexts such as semi-arid and arid lands (ASALs), affecting about 61% of the world's population in rural and peri-urban areas (Mallory *et al.*, 2020). Different stakeholders have made an effort to improve sanitation access, including the promotion of onsite sanitation systems (OSS) like septic tanks, flush toilets, aqua privies, or pit latrines (Simiyu *et al.*, 2021; Manga *et al.*, 2021; Manga *et al.*, 2019), which tend to fail due to poor management of accumulating sludge (Zedwe *et al.*, 2021). Past studies have reported that social, environmental, and technological aspects, among other variables (Harper *et al.*, 2018; Taweesan *et al.*, 2017; Dhadho & Okeyo, 2023), could have an impact on the sanitation practices. When Faecal Matter (FM) accumulates in onsite sanitation systems, it poses significant health risks on the population especially children and women as well as contamination of water, soil and air which was the concern of the study.

About 2.7 billion people globally depend on onsite sanitation, and the population is projected to increase to five billion by 2030 (Vyas & Swami, 2021), with the majority in low-income areas. Countries may have made significant progress in the sanitation ladder in emphasizing latrine construction for faecal containment, but faecal handling, transportation, treatment and reuse remain a challenge (Schoebitz *et al.*, 2017; Weststrate *et al.*, 2019; Afework *et al.*, 2022; Achieng *et al.*, 2023). Improper handling and transportation of faecal matter could lead to human contact with pathogens through unclean hands or flies which are the pathways for disease exposure (Coulibaly *et al.*, 2023). Societal knowledge or beliefs on handling of faecal matter could influence faecal handling and maintenance which this study sought to examine.

A report by the World Health Organization (WHO) and the United Nations Children's Fund [UNICEF](2023) indicated that more than 52 million people in rural areas and 13 million people in urban areas in Pakistan rely on onsite sanitation systems (OSS). A study by Maqbool *et al.* (2022), in Pakistan, reported that over 62% of the OSS are never emptied, and only 16% are buried or replaced with new ones with little evidence of manual or mechanical emptying when full. Failure to empty faecal matter from toilets could pose a significant health risk and environmental hazards due to overflow of faecal matter. Similarly, a study by Koottatep *et al.* (2021) in Thailand, established that about 70% of the FS generated from onsite sanitation systems are unsafely managed, and 52% of the Faecal Matter (FM) was not emptied and ended up to open drains or local sewers, which may lead to significant environmental and public health issues. Additionally, in Vietnam, based on General statistics office (GSO), UNICEF, and United Nations Population Fund (UNFPA) (2021) about 10 -30% of faecal sludge is safely managed. Studies by Koottatep *et al.* (2020)

and Maqbool *et al.* (2022) have emphasized on the urgent need to address sanitation issues throughout the service chain, including correctly managing and disposing of faecal matter generated by onsite sanitation systems.

In Sub-Saharan Africa (SSA), sanitation coverage is improving, with over 80% of the population relying on non-sewered systems (Lerebours *et al.*, 2021). Approximately 62% of SSA's urban and peri-urban population utilize onsite facilities (WHO/UNICEF, 2023), possibly due to rapid population growth and urbanization, characterized by overcrowding, informal settlements, and the relatively low cost of establishing onsite facilities. According to UNICEF (2020), only 2% of sludge from onsite facilities in SSA gets safely managed which presents a critical public health hazard. Additionally, a study by Peal *et al.* (2020) in SSA, established that 49% of the population did not empty Faecal Matter (FM) generated from sanitation facilities, however 18% emptied was not delivered to treatment, highlighting as common practices in cities of Asia and Africa, therefore urgent need to address sanitation behavior.

In Kenya, about 60.9% of the population have access to improved Sanitation, including 51% rural and 63.5% urban population using onsite technologies such as septic tanks and pit latrines (WHO/UNICEF Joint Monitoring Programme [JMP], 2023) an indication of positive trend. However, in Arid and Semi-Arid areas sanitation access is still a challenge. To address sanitation problem, the Ministry of Health of Kenya (MoH) adopted the Kenya Environmental Sanitation and Hygiene Policy (KESHP) 2016-2030, which provides the overarching policy framework for achieving universal and sustainable access to improved sanitation and a clean and healthy environment by 2030 (MoH,2016). The policy provides various strategies, such as the adoption of Community Led Total Sanitation (CLTS), mainly

in ASAL regions, to eradicate open defecation (OD), through constructions of pit latrines (United States Agency for International Development [USAID],2021). However, with high population growth rate in such areas, the utilization of onsite facilities has increased, thus generation of large quantity of Faecal matter . According to Halcrow *et al.* (2016) the pragmatic steps to improve Faecal Matter Management (FMM) in response to high demand of onsite technologies is vital. A study by Gitonga *et al.* (2021), described sewer systems as the preferred options in Kenya, viewing onsite sanitation solutions as temporary solutions which lack a future-oriented perspective. Therefore, research efforts that would document evidence-based recommendations that could improve the modalities of FSM may likely be an asset to sanitation stakeholders as they tackle sanitation challenge proactively.

Researchers have highlighted that individuals' awareness and knowledge of Sanitation could have significant influence on sanitation practices (Harper *et al.*, 2020; Chandana & Rao, 2021). A study conducted by Harper *et al.* (2020) in Cambodia that examined the intentions and contextual factors associated FSM, established that 16% of respondents had no plans on fate of accumulating faecal matter, explaining due to lack of understanding of available methods for managing filled pits. Similarly, in India, Chandana and Rao (2021) reported that only 10% of selected households emptied sludge from filled up toilets, commenting to be as results of lack of awareness of the public health dangers. A study by Paramita *et al.* (2021) in Egypt and Indonesia that examines the sustainability factors of faecal sludge management found that the awareness and participation of the community were statistically significant. Lack of awareness on FMM activities could facilitate unsafe means of faecal disposal which could promote spread of sanitation-related diseases. Studies by Chandana and Rao (2021),

and Paramita *et al.* (2021) underscored the importance of awareness regarding faecal sludge management methods and associated risks in influencing sanitation behaviours.

Social norms could play a significant role in faecal sludge management, influencing behaviours related to faecal disposal practices. Studies by Cookey *et al.* (2020) in Bangladesh and Harper *et al.* (2020) in Cambodia highlighted the impact of community norms on faecal sludge management. In Bangladesh, 6% of respondents disapproved of inappropriate sludge discharge based on community norms, while 10% believed adherence was occasional, and 26% were unsure of existing norms. Similarly, in Cambodia, 51% of respondents were encouraged by neighbours to practice manually emptying with 17% and 19% of respondents approved for unsafe practices like flooding out and pit piercing. This indicates critical need to understand associated factors.

Similarly, in Kenya, a study by Simiyu *et al.* (2021) that explored faecal sludge management found out that community humiliation and poor perceptions towards faecal sludge emptying led to the stigmatization of pit emptiers and encouraged unsafe emptying practices, especially at night by emptiers who were under the influence of alcohol. The unsafe emptying practice could pose significant risks to public health and safety, as well as the well-being of those involved in faecal sludge management, recognizing need to understand the root causes of community attitudes. However, the mentioned findings conclusion may only apply to some of the study areas since communities have varying beliefs on sanitation matters. This study investigated the influence of social norms on FMM in Isiolo Sub-County.

The adoption, utilization, and sustainability of sanitation technologies could be influenced by climatic conditions, soil type, and water depth level (Odagiri *et al.*, 2021; Dhadho &

Okeyo, 2023; Gituma *et al.*, 2022; Legge *et al.*, 2021; Oswald *et al.*, 2016). A study in Ethiopia by Oswald *et al.*, (2016) to investigated predictors of low sanitation coverage, and found soil conditions related to stability and rock content, challenging on constructions and life spans of latrine, and thus the management of accumulating faecal matter. A study by Odagiri *et al.* (2021) in Indonesia investigated onsite sanitation practices reported that flooding and drought were associated with a 40% increase and an 86% decrease in emptying practice prevalence, respectively. Therefore, further research required to explore the underlying reasons for the observed fluctuations. On the contrary, Gituma *et al.* (2022) conducted research in Meru, Kenya, focusing on tracking excreta flow in the sanitation service chain. The study found that approximately 78% of excreta required better management. The study established that high-water table in the area made pit excavation difficult which showed the need to address environmental aspects in sanitation practices. However, findings may not directly apply to arid and semi-arid lands. The study aimed to fill the gap by focusing on the Isiolo sub-county and providing insights specific to these regions. Past studies by Rotowa and Ayadi (2020); and Simiyu *et al.* (2021) have established that quality and design of sanitation infrastructure could impact the management of excreta, from onsite facilities. A study by Rotowa and Ayadi, (2020) in Nigeria that investigated Faecal Sludge Management (FSM) in residential core found that the type of faecal storage facility had a positive and significant influence on FSM. The study stressed on development of specific standard for construction of quality toilet. Similarly, a study by Simiyu *et al.* (2021) in Kenya established that latrines were unlined and had shallow pits which encouraged manual emptying since they were prone to collapse due to poor construction. Studies have pointed out the need to adopt standard onsite facilities to enhance the sustainability and

effectiveness of this project. This study investigated the quality and design of sanitation technologies in Isiolo Sub-County.

Past studies have pointed out that availability of resources could have a significant impact on onsite facilities management. In Thailand, Taweesan *et al.* (2017) municipality to found out that operation efficiency, treatment feasibility and services performances was affected by inadequate number of vacuum trucks, that were poorly maintained, unsatisfactory faecal matter collection fees and traffic conditions, inadequate number of trained operators, and awareness of people to Faecal matter management problems. In agreement, Hussein *et al.* (2023) conducted a study in Somalia and observed that despite the construction of additional latrines and increased coverage, faecal sludge management (FSM) remained poor due to low technical capacity, including the low number of households served, shortage of trained operators, and insufficient trucks for waste collection. Moreover, studies by Rotowa and Ayadi (2020) in Nigeria and Eliud *et al.* (2023) in Kenya also underscored the impact of skilled personnel on ensuring safe sanitation practices. Rotowa and Ayadi (2020) noted that untrained individuals often constructed onsite sanitation solutions, which could limit future management practices.

Onsite facilities have been adopted in Kenya to eradicate open defecation, especially in arid and semi-arid areas characterized by poverty. However, the majority of studies for instance by Dhadho and Okeyo, (2023); Gituma *et al.* (2022) and Eliud *et al.* (2023) have focused on social, cultural and environmental factors that influence sanitation adoption; there needs to be more focus on the fate of accumulating FM. Researchers like Simiyu *et al.*, (2021) emphasized on the need for further studies to investigate predictors of faecal matter

management. This study investigated social, environmental and technological factors influencing faecal matter management in arid and semi-arid areas.

1.2 Problem Statement

Faecal waste management is a crucial aspect of onsite sanitation facilities, particularly in low-income countries where onsite sanitation (OSS) systems are prevalent due to financial constraints hindering the installation of conventional centralized systems (Maqbool *et al.*, 2022; Mohideen *et al.*, 2020). Onsite sanitation (OSS) systems are designed to treat human waste at the source, offering a hygienic and cost-effective method of waste disposal. Governments in countries like India and Thailand have actively promoted the construction of pit latrines to eliminate open defecation (Koottatep *et al.*, 2022; Chandana & Rao, 2021). However, studies in Asia and Sub-Saharan Africa (SSA) have revealed challenges in managing faecal waste in onsite facilities, impacting their sustainability (Zewde *et al.*, 2021; Berendes *et al.*, 2017).

Research by Koottatep *et al.* (2022) and Jung *et al.* (2017) has shown that poorly managed faecal waste in onsite sanitation systems directly impacts the prevalence of faecal pathogen infections like a liver fluke and diarrhoea. According to Novotny *et al.* (2018), an estimated 3.4 million lives are lost annually due to sanitation-related illnesses. Therefore, it is crucial to consider onsite sanitation systems' operational and maintenance aspects to enhance public health outcomes and mitigate the spread of diseases associated with inadequate sanitation practices.

The Constitution of the Republic of Kenya, 2010, under Article 43(b), guarantees citizens the right to accessible and adequate reasonable sanitation standards. However, as a developing country, Kenya faces significant sanitation challenges, especially in arid and

semi-arid regions. According to a report by the Kenya National Bureau of Statistics (KNBS, 2019), about 62% of households in Isiolo County have access to sanitation facilities. This reflects efforts by sanitation stakeholders that have focused on initiatives like the Community-Led Total Sanitation (CLTS) program and community mobilizations to encourage latrine construction. Despite the intervention, the county is losing 139 million KES yearly (MOH, 2014), and several cases of sanitation-related illnesses, such as cholera and diarrhoea, are being recorded due to poor sanitation. The focus on constructing toilets without adequate consideration for faecal waste management options is a critical concern. Neglecting social, environmental, and technological aspects in sanitation facilities could lead to unsafe practices like Open Defecation (OD) and contribute to the spread of sanitation-related diseases. Addressing these multifaceted issues is crucial to prevent setbacks and improve sanitation standards.

Despite Onsite Sanitation (OS) contribution to scaling up sanitation in Kenya, a few studies have been documented in urban and informal settlements (Simiyu *et al.*, 2021; Gitonga *et al.*, 2022), and minimal focus has been put on arid and semi-arid regions. Existence of limited data on the influence of Social, Environmental and Technological factors on Faecal Matter Management in arid and semi-arid areas warrant the need for this study.

1.3 Justification of the Study

The safe management of faecal matter is crucial for preventing sanitation-related infections, promoting user dignity, and improving community productivity and nutrition. Studies have shown that the presence of onsite sanitation facilities can significantly reduce the prevalence of enteric infections in children, emphasizing the importance of proper faecal sludge management at the household level (Berendes *et al.*, 2017). Addressing the challenges

associated with FSM requires a multidisciplinary approach, encompassing social, environmental aspects, and technological considerations to ensure the provision of safe and sustainable sanitation services, aim of this study.

1.4 Study Objectives

The study was guided by the following objectives:

1.4.1 General objective

To investigate the influence of social, environmental, and technological factors on management of faecal matter in arid and semi-arid areas of Isiolo Sub -County, Kenya.

1.4.2 Specific objectives

- i. To assess the influence of social factors, on management of faecal matter in Arid and Semi-Arid Areas of Isiolo Sub -County, Kenya.
- ii. To examine the influence of environmental factors, on management of faecal matter in Arid and Semi-Arid Areas of Isiolo Sub -County, Kenya.
- iii. To establish the influence technological factors on management of faecal matter in Arid and Semi-Arid Areas, of Isiolo Sub -County Kenya.

1.5 Research Questions

- i. What is the influence of social factors on management of faecal matter in Arid and Semi-Arid Areas of Isiolo Sub -County Kenya?
- ii. What is the influence of environmental factors on management of faecal matter in Arid and Semi-Arid Areas of Isiolo Sub -County Kenya?
- iii. How do technological factors influence management of faecal matter in Arid and Semi-Arid Areas of Isiolo Sub -County Kenya?

1.6 Significance of the Study

The findings of this study have important implications for policy, practice, and research methodologies in the management of faecal matter. From a policy perspective, understanding the impact of social, environmental, and technological factors on faecal matter management can guide the development of tailored interventions and regulations that address the unique needs of the community. Policymakers can use these findings to craft strategies that promote community engagement, ensure environmental sustainability, and incorporate appropriate technological solutions to improve faecal matter management.

Additionally, this research offers valuable insights to local authorities, sanitation practitioners, and community stakeholders engaged in faecal matter management. By identifying the key factors that influence management practices, these practitioners can adjust their strategies to overcome specific challenges and increase the overall efficacy of sanitation programs. This may include implementing community-based initiatives, adopting eco-friendly technologies, and fostering collaborative partnerships to enhance sanitation outcomes in the Sub-County.

Furthermore, this study contributes to the advancement of sanitation research by offering a comprehensive understanding of the various factors that influence faecal matter management. Through a multidisciplinary approach that integrates social, environmental, and technological perspectives, the study lays the groundwork for future research in similar contexts, providing a valuable framework for future studies aimed at improving faecal matter management.

1.7 Limitation of the Study

The study relied on self-reported data, which may be subject to social desirability or recall bias, potentially affecting the accuracy and reliability of the data collected. To address limitation, triangulation was ensured through collections of both quantitative and qualitative data from randomly selected respondents. A reliable and honest feedback was essential for this study. Nevertheless, there was no possibility of the researcher to influence the respondents' honesty. Lastly, the researcher assured respondents confidentiality data and emphasis the importance of truthful responses.

1.8 Delimitation of the Study

The study was delimited to Isiolo sub-County, in Isiolo County, Kenya. and the findings may not be directly transferable to other urban or rural areas with distinct contextual variations. Furthermore, faecal matter management might be influenced by several variables, this study focused only on Social, Environmental and Technological aspects, relying primarily on data available at the time of the research, and potential modifications in policies, technologies, or socio-economic conditions occurring after the study period was not be fully reflected.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter covers an overview of faecal matter management in arid and semi-arid areas (ASALs), concepts of faecal sludge management, and theoretical framework. The chapter also entails literature on, association of social, environmental and technological factors and faecal sludge management, summary of literature and research gap, and the study conceptual framework.

2.1 Overview of Faecal Matter Management in Arid and Semi-Arid Areas (ASALs)

By 2022, 3.5 billion people globally lacked safely managed sanitation, including 1.5 billion without basic sanitation services, of which 673 million people practice open defecation, highlighting the scale of the problem (WHO/UNICEF, 2023). Safe sanitation is a hurdle in low-resource contexts such as Arid and Semi-Arid Areas (ASALs), affecting an estimated 61% of the world's population (Harper *et al.*, 2020; Mallory *et al.*, 2020).

To address this challenge, onsite sanitation facilities have gained global acceptance due to financial constraints hindering the installation of sewer systems. About 2.7 billion people rely on onsite sanitation globally, which is expected to rise to five billion by 2030 (Vyas & Swami, 2021). Studies in Central and Central and South Asian countries such as Bangladesh, India, Nepal, and Pakistan have significantly reduced open defecation to 9% in 2022 from 23% in 2015 (WHO/UNICEF, 2023), properly due to the provision of onsite technologies, however considered temporary solutions (Maqbool *et al.*, 2022), with studies showing that 90% of sludge from facilities remains untreated (Water Aid, 2019). According to a report by (WHO/UNICEF, 2021), most safe sanitation in the same region comes from rural areas.

However, semi and arid characterized countries like Afghanistan, Pakistan, and Sri Lanka have yet to manage the sanitation available to date safely.

In Sub-Saharan Africa (SSA), access to sanitation is remarkable, with a significant drop in open defecation to only 17% (from 21 % in 2015) of the population by 2022, including 25% of rural and 5% of the urban population in OD (WHO/UNICEF, 2023). The adoption of OSS in SSA is ascending, with over 80% of the population using it (WHO/UNICEF, 2017), with the majority, 62% of the urban and peri-urban using it (WHO/UNICEF, 2021). Studies report that only 2% of sludge from this facility is safely managed (UNICEF,2020). Similar findings have been published by Peal *et al.* (2020) through assessing faecal waste flows in 28 cities in Sub-Saharan Africa, including Ethiopia show that most of the faecal sludge produced is not emptied (for 49% of the population), or emptied but not delivered to treatment plants (19%), making these steps the most common 'failure modes' of sanitation in the cities

The sanitation situation in Kenya presents a mix of progress and challenges. By 2022, approximately 31.5% of the population in Kenya had access to safely managed sanitation, with 5% having basic sanitation, 32.7% using unimproved sanitation, and 6.5% practicing open defecation (WHO/UNICEF Joint Monitoring Programme [JMP], 2023). In urban areas, shared sanitation is prevalent, with about 44.9% relying on it, while 39.8% have at least basic sanitation, 14.4% use unimproved sanitation, and 0.9% practice open defecation. A significant portion of the urban population in Kenya, around 84%, depends on onsite sanitation like pit latrines and septic tanks (Grissffi *et al.*, 2022). In arid and semi-arid land areas (ASALs) of Kenya, access to sanitation remains challenging, with only 2% of rural and 35% of urban areas having basic sanitation (KNBS, 2019). The Ministry of Health in

Kenya has adopted the Kenya Environmental Sanitation and Hygiene Policy (KESHP) 2016-2030 to achieve universal and sustainable access to improved sanitation by 2030 (MoH, 2016). This policy includes strategies such as Community-Led Total Sanitation (CLTS), particularly in ASAL regions, to eliminate open defecation by promoting onsite facilities (United States Agency for International Development [USAID], 2020). As the population rate proliferates due to both natural and artificial phenomena, more OSS facilities will be provided to meet the sanitary requirement of the populace, which will translate into the generation of a larger quantity of FS. Halcrow *et al.* (2016) emphasize the importance of taking pragmatic steps to improve Faecal Matter Management (FMM) in response to this situation. According to Gitonga *et al.* (2021), the sewer network system is the preferred option in Kenya, viewing onsite sanitation solutions as temporary and lacking a future-oriented perspective. Therefore, research efforts that would document evidence-based recommendations that could improve the modalities of FSM may likely be an asset to sanitation stakeholders as they tackle this sanitation challenge proactively.

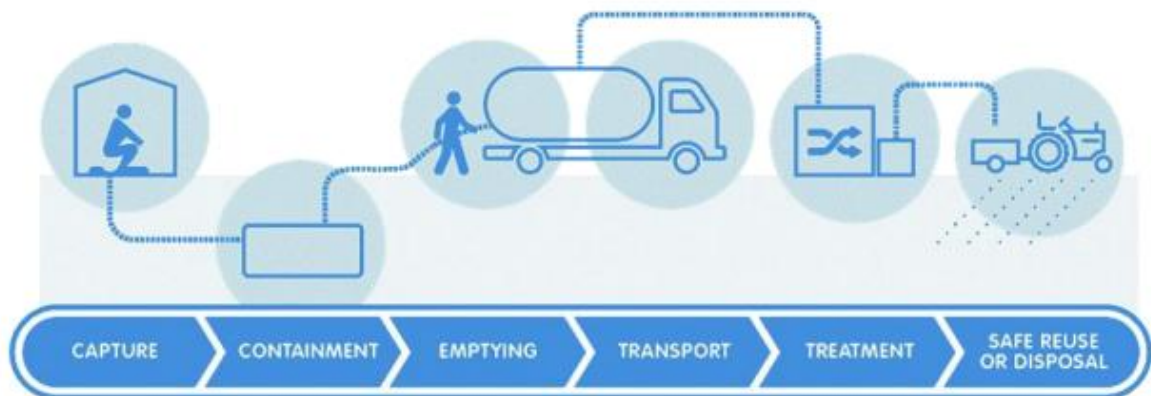
2.2 Concepts of Faecal Sludge Management

According to Sartika (2020) and Simiyu *et al.* (2021), Faecal sludge management (FSM) entails all activities along sanitation value chain, that's adequate storage, collection, transport, treatment, and safe end use or disposal of faecal sludge (FS), within non-sewered sanitation systems such as pit latrines and septic tanks as shown in Figure 2.1. Anderson *et al.* (2015) defined Safe management of household excreta as the containment, collection, and transport of excreta to specified disposal or treatment sites or the safe reuse of excreta depending on local conditions at the household or community level. Faecal sludge, is defined by (Gitonga *et al.*, 2022; Zwede *et al.*, 2021)) as raw or partially digested slurry or

semisolid, is a result of combinations of excreta and blackwater, with or without graywater. Peal *et al.* (2014) define Faecal sludge as Excreta from an on-site sanitation technology (like a pit latrine or septic tank) that may also contain used water, anal cleansing materials, and solid waste.

Figure 2.1:

Sanitation value chain



Harper et al., (2018)

According to Zwede *et al.* (2021), Faecal sludge (FS) has several different properties that can change dramatically. Chemical oxygen demand (COD), biochemical oxygen demand, solid concentration, nutrients, pathogens, and metals are frequent parameters used to characterize Faecal Sludge (FS). Compared to sewage sludge, FS often exhibits 10-100 times greater amounts of organic matter, total solids, ammonium, and helminth eggs. FS was categorized by Zakaria *et al.* (2017) as digested or fresh according on Chemical Oxygen Demand (COD) and as high, medium, and low strength depending on total nitrogen (TN) concentrations.

2.3 Influence of Social Factors on Faecal Matter Management

Studies have pointed out social factors such as age, gender, level of education, awareness of FSM practices, knowledge of sanitation, and social norms (Tomoi *et al.*, 2024; Harper *et al.*, 2018; Chandana & Rao, 2021; Mamera *et al.*, 2020) to influence faecal sludge management. Gender has been mentioned in literature that might have significant impact on the sanitation practices (Mkude *et al.*, 2021; Seleman *et al.*, 2020;).

A study in Ghana by Osumanu and Amin (2023), to assessed sanitation and hygiene practices in Ghana, using data obtained from 200 households, reported that toilet maintenance was about 71.9% when they assigned to woman only as compared to when assign to men and children. they argued that gender division of household's sanitations and hygiene responsibilities hinders men interest in sanitation to participates in certain practices. Similar findings have been reported by Donacho *et al.* (2022) in Uganda, that female headed households were 2.8 times more likely to access safely managed sanitations as compared male headed households. In contrary, a study conducted by Mkude *et al.* (2021) to investigate knowledge and practices on faecal resources recovery in Tanzania, using data from 395 Households, reported that men were more physically mobile, thus exposure to technological innovations than who women restricted to their homes. They findings are in line with studies by (Seleman *et al.*, 2020; Mendes & Njenga, 2018; Routray *et al.*, 2017). As per Seleman *et al.* (2020) study in Tanzania, men were mostly outsides homes, for incoming generating activities hence less incentive to desludge toilet as compared to woman to who experience full toilet more be sight and odors.

Education is a critical factor affecting faecal matter management (Tomoi *et al.*, 2024; Harper *et al.*, 2018; Hussein *et al.*, 2023; Mamera *et al.*, 2020). Harper *et al.* (2018) conducted a

quantitative study in rural Cambodia to examine the household acceptance of safe faecal sludge management practices using a sample of 1472 households in five provinces. Harper *et al.* (2018) reported that the education level achieved by the household members affects the acceptance of safe FSM practices. They argued that higher education exposes household members to new concepts and various aspects of the world. The findings align with Oloruntoba *et al.* (2019) cross-sectional study to identify the determinants impacting faecal disposal habits in a subset of low-income groups in Ibadan, Nigeria., using data gathered from 221 randomly selected homes. They claimed that education had a significant impact. Oloruntoba *et al.* (2019) state that education is crucial for changing behavior and communicating the risks associated with a given course of action.

In accord, a cross-sectional study by Hussein *et al.* (2023) in Somalia assessed the related factors of faecal sludge management and found education statistically significant. Concurrently, Tumoi *et al.* (2024), in a study to review faecal sludge management in 14 Sub-Saharan African countries, including Kenya, reported factors such as age, gender, and level of education to have significant influences on the Willingness to pay for the management of sludge. They submitted that education positively increases the valuation of sanitation. On the contrary, Mamera *et al.* (2020), a mixed method study to examine Community faecal sludge management strategies in eastern Free State, South Africa, recorded that level of education does not influence faecal sludge management. These studies collectively underscore the role of education in shaping attitudes and behaviors toward faecal sludge management. However, these study conclusions may not apply to the study area as the studies were conducted in diverse geographical settings.

Past studies by Tumoi *et al.* (2024), Osumanu and Amin (2024), and Alemu *et al.* (2023), have reported age could have substantial effect on the sanitation practices. A study was conducted by Alemu *et al.* (2023), to determine factors affecting sanitation Ethiopia using Ethiopia Demographic Health Survey data (EDHS). They submitted that age of household among other aspects had significant effect on JMP ladders on the sanitation services. They found Households aged between 51 and 61 were 5.75 times more likely to use the JMP ladder of basic sanitation services than households aged between 18 and 28. In accord a study by Dhital *et al.* (2024) in Nepal, to determine factors associated with utilization of improved sanitation services, reported age to have significant influenced.

Religion plays significant role in sanitation practices (Gitau *et al.*, 2022; Banamwana *et al.*, 2022) A study was Conducted by Gitau *et al.* (2022) to assessed the barrier and opportunities for reuse of faecal sludge in Nairobi Slums. They submitted that the community was aware of some of the recycled faecal sludge products; however, there were mixed attitudes towards the use of these products due to religious perceptions. As per Banamwana *et al.* (2022), study in Rwanda, the adoption of ecological sanitation, that has rational use of human excreta was greatly influenced by religious beliefs. They submitted that most of the residents Muslims, more often washers, and they accuse the Ecosan to expose user to his/her excreta. In contrary, a study in India, by Adukia *et al.* (2021) to determined influence of religion on sanitation, practices reported handwashing, or presence of faecal matter arounds home didn't show any significant associations. The mentioned studies may not apply to studied area due to uniqueness in religion beliefs.

Past studies by Chandana and Rao (2021), Kasiva (2023), Harper *et al.* (2020), and Tomoi *et al.* (2024) have pointed out that awareness and knowledge of sanitation influence safe

sanitation practices. Harper *et al.* (2020) conducted a quantitative study to determine if contextual factors can predict the intentions of randomly selected 3715 rural Cambodian latrine owners when pits fill. They published that 41% of respondents intended to manage faecal sludge unsafely, of whom 16 % had no plan to manage and 2% intended to stop using it. The authors added that only 9% of households were aware of available methods of managing fill pits, likely due to the lack of FSM services in rural Cambodia. Chandana and Rao (2021) reported similar findings in a mixed-method study that assessed the status of sustainable sanitation chains in Maharashtra, India's rural, semi-urban, and urban regions. They noted that awareness of the management of OS needed to be improved. The semi-urban area had only 9% of private companies collecting FS, whereas the rural area they surveyed needed more basic FSM facilities (FS collection, transportation, and disposal. Chandana and Rao (2021) added that only 10% of selected households reported emptied sludge when filled up, possibly due to a lack of awareness of the associated public health dangers.

Similarly, Tomoi *et al.* (2024) noted that, in SSA, knowledge or experience with emptying services impacted the Willingness to pay for faecal sludge management regardless of whether the service is physically accessible in the region. Furthermore, Paramita *et al.* (2021), in a systematic review employing a comparative approach to determine sustainability factors of faecal sludge management in developing countries, such as Egypt and Indonesia, submitted that the awareness and participation of the community influence the sustainability of sludge management service. Additionally, Taweesan *et al.* (2017), in a study to determine factors affecting the performance of faecal sludge management services in Thailand municipalities, found that people's awareness of FSM participation significantly

impacted faecal sludge management. The mentioned studies address awareness's crucial role in ensuring effective faecal sludge management practices, emphasizing the need for community engagement and education to enhance sanitation outcomes. This study investigated the association of awareness of management practices and FSM in Isiolo-county, a different setting from past studies.

Sanitation knowledge tends to shape individual attitudes and perceptions of sanitation practices. Kasiva *et al.* (2023) conducted a convergent mixed-method study to investigate social factors influencing adopting safe sanitation practices in Nzau, Kenya, using data from 100 randomly selected households. They asserted that knowledge of safe sanitation, among other factors, has a significant influence. The findings contrast with the study by Harper *et al.* (2020) on faecal sludge management in rural low-income Cambodia, where 91% of households were aware of the health risks of faecal sludge.

However, 11% and 14% of households believed that liquid faecal sludge from inside a pit and untreated faecal sludge disposed into a body of water is safe, and 20% felt that disposing of untreated faecal sludge onto a field is secure. Furthermore, research conducted by Mamera *et al.* (2020). The survey results showed that the respondents knew different methods of disposing of faecal sludge. 86.2% were aware of land disposal methods, 5% used it as feedstock for livestock, 5% used it for agricultural activities, and only 0.3% used the drying and burning method. This study will investigate the influence of knowledge on sanitation in faecal matter management, unlike Kasiva *et al.* (2023) study that focused on the adoption of safe practices, and in a different context from Harper *et al.* (2020) and Soyinge *et al.* (2021), conducted in Cambodia and Nigeria, respectively.

Social norms have been discussed in the literature to influence faecal sludge management (Cookey *et al.*, 2020; Harper *et al.*, 2020). Cookey *et al.* (2020) studied the perception management of non-sewered sanitation in Bangladesh. The study employed a mixed-method cross-sectional approach to collect data from 67 households through structured household questionnaire surveys, face-to-face key informant interviews, group interviews, and structured observation. Cookey *et al.* (2020) observed that community norms greatly influenced the safe management of sludge. They recorded that 80% of the respondents perceived that community members sometimes practiced scheduled (timely and safe) emptying, while 14% were unsure. Cookey *et al.* (2020) added that 6% agreed that community norms that disapprove of inappropriate faecal sludge discharge exist and are permanently adhered to, while 10% believed adherence was only sometimes, and 26% were unsure if such norms exist.

Similar results were submitted by Harper *et al.* (2020) in Cambodia. The study recorded that 51% of respondents said their neighbors encouraged them to self-empty, while 17% and 19% of respondents said their neighbors approved of unsafe emptying practices, such as flooding out (opening a pit during a flood to empty FS directly into floodwaters) and piercing their pit, respectively. Harper *et al.* (2020) argued that self-empty is nearly always unsafe in rural contexts due to a lack of proper equipment, training, treatment, or safe disposal sites, thereby exposing communities to pathogenic faecal sludge. However, the findings conclusion may only apply to some of the study areas since communities have varying beliefs on sanitation matters. This study investigated the influence of social norms on FSM in Isiolo Sub-County.

2.4 Influence of Environmental Factors on Faecal Matter Management

Studies by (Odagiri *et al.*, 2021 Dhadho & Okeyo, 2023 Sakas *et al.*, 2021 Okechukwuet *et al.*, 2015 Gituma *et al.*, 2022) have identified environmental factors such as geographical characteristics (soil type, topography, water table), climate (floods and drought), and land use and space to influence the adoption of sanitation, operation, and maintenance of technologies including emptying practices, and management of faecal sludge.

Studies have found that climate conditions can have an impact on sanitation practices. (Odagiri *et al.*, 2021; Dhadho & Okeyo, 2023). Odagiri *et al.*, 2021 surveyed Indonesia to provide insights into the current status and practices for onsite sanitation services, using data from a national socio-economic survey coupled with a village census.

The study submitted that regions with high flooding rates had a 40% increase in emptying practice prevalence, while regions with high drought rates had an 86% decrease in emptying practice prevalence. The findings align with Dhadho and Okeyo, (2023) cross-sectional study to investigate environmental factors influencing the adoption of sanitation in Tana Delta Sub-County, Kenya, using data from 385 households through questionnaires and interviews. They found that flooding has significant associations. In accord a based on published report by UNICEF, (2022) on impact of Climate Hazards on Rural Sanitation and Hygiene Practices in Burkina Faso reported that high rainfall had great influence on access and utilization of sanitation facilities. Dhadho and Okeyo, (2023) and Odagiri *et al.* (2021) have highlighted the effect of climatic variation that tends to influence sanitation adaptability, sustainability, and effectiveness and vary across the regions. This study will investigate associations between the climatic condition of Isiolo-County and faecal matter management.

The soil type significantly impacts sanitation practices and outcomes (Legge *et al.*, 2021; Sakas *et al.*, 2021; Oswald *et al.*, 2016; Munamati *et al.*, 2017; Okechukwuet *et al.*, 2015). As per Munamati *et al.* (2017), soil properties are major determinant of sanitation facilities choice in SSA. Legge *et al.* (2021) studied Patterns and Drivers of Household Sanitation Access and Sustainability in Kwale County, Kenya. They observed that the level of coarse fragments in the soil was associated with lower odds of gaining access to sanitation. They argued that soils with higher levels of coarse fragments are typically less cohesive and facilitate percolation of water more rapidly than finer soils, making latrine construction more complex and more easily precipitating the flooding and collapse of existing latrines. Studies by Aquauya, (2019) and Simiyu *et al.*, (2021) in slums of Nakuru Kena and Rangpur, Bangladesh have submitted that in slums of had loose soil causing pits collapse, hence pour flush was commonly preferred technology. Studies by Buseinei *et al.* (2019) in Turkana to assessed latrine structure, design and condition reported similar findings. They submitted that sand soil in the study area makes challenge to construct new pits when existing ones filled and also cannot withstand flooding common in the region.

A similar study was carried out by Coffey *et al.* (2017) to understand latrine adoption in a representative panel of rural Indian households in 2017 and associated soil porosity and ecology to positively impact on latrine ownership and use. Results are in line with a study in Meru, Kenya, by Gituma *et al.* (2022), who reported that the adoption of sanitation was determined by the availability of land and good soil that supports sustainable technologies. A study by Okechukwuet *et al.* (2015), discovered that the excavation of toilet pits was challenging in rocky areas, and building to build sanitation facilities in flood-affected areas was not practical. In such areas, residents were needed to construct very shallow pits, which,

as contended by the authors, fill up quickly and are therefore prone to frequent emptying. The findings align with study by Kendi *et al.* (2022) in Meru alluding that rocky and hilly terrain of the area was making obstacle in sanitation accesses. Mentioned studies have focused on sanitation access, but little has been done on association of soil type with onsite sanitation management, the aim of this study.

Researchers have associated the level of the water table with faecal sludge management. A cross-sectional study by Gituma *et al.* (2022), which investigated excreta flow in Meru, Kenya, found that 78% of excreta were unsafely managed. They identified the main challenge as the high-water table, which was 7-10 meters deep, making it challenging to dig pits and leading to pit flooding during rainy seasons, thereby increasing the frequency of pit emptying. In contrary research by Legge *et al.* (2021), Kwale County, Kenya, opined that the water table, among other factors (slope, depth of bedrock), does not influence sustainable sanitation access. Studies have pointed out the need to address the water depth level, which may not influence sanitation adoptions but plays a crucial role in the long-term acceptability of toilets and public health promotion. This study investigated the association between the depth of the water table in Isiolo-County and faecal sludge management, unlike the Gituma *et al.* (2022) and Legge *et al.* (2021) study, which focused on sustainable sanitation access.

2.5 Influence of Technological Factors on Faecal Matter Management

Technological factors, such as the quality and design of sanitation facilities, accessibility, availability of vacuum trucks, and management skills, have been shown to have a significant impact on faecal sludge management along the sanitation chain. Studies by Devaraj *et al.* (2021), Simiyu *et al.* (2021), Rotowa and Ayadi (2020), Conaway *et al.* (2021), Eliud *et al.*

(2023), Taweesan *et al.* (2017), and Jenkins *et al.* (2015) highlight the importance of these factors in ensuring effective faecal sludge management.

Quality and design of sanitation infrastructure play a crucial role in managing resulting excreta, especially for the onsite sanitation systems (OSS) (Devaraj *et al.*, 2021; Simiyu *et al.*, 2021; Garn *et al.*, 2017). A systematic review study by Garn *et al.* (2017) reported that latrine use depends on sanitation structure and design characteristics such as maintenance, accessibility, privacy, cleanliness, and whether or not the latrine was recently constructed. Furthermore, Devaraj *et al.* (2021) conducted a study in Periya-naicken-Palayam (PNP), a non-sewered Town Panchayat in India, to plan a faecal sludge management system, using data from 8,001 households and 1,667 establishments. The study observed that only 6,394 households and 1,064 establishments had sanitation facilities, with 90.1% and 35.4% connected to septic tanks, respectively. However, many reported septic tanks were not watertight and worked like leach pits. Only 87/525 households and 17/78 establishments had partitions and were waterproof, thereby being able to function as a septic tank.

Most of the septic tanks in households and establishments with both walls and base plastered were single chamber tanks and thus did not induce more significant sedimentation or solid-liquid separation. The study also found that the disposal of septic tank effluents was mostly through leach pits or surface/open drains, and only a small percentage of households and establishments reported connecting containments to soak pits. Muxímpua *et al.* (2012) reported similar findings. They conducted a qualitative study to identify building blocks for effective faecal sludge management in peri-urban areas in Maputo.

The study noted that latrines, including pour-flush latrines, improved latrines with a concrete slab, and traditional latrines built from tires, barrels, and/or time, were the most common

facilities for capturing and storing excreta. They noted that the structural integrity was poor, with low-quality control by constructors or local government, which gave rise to risks of collapse and harm to users.

In agreement, Peal *et al.* (2014), in a comparative study of faecal sludge management in 12 cities in Africa and Asia, found that the quality of household containment was generally poor and adversely affected owners' ability to have their units emptied when they filled up. Additionally, Simiyu *et al.* (2021) reported similar findings in a qualitative study in Nakuru, Kenya. They noted that the latrines had unlined and shallow pits, encouraging manual emptying since they were prone to caving due to poor construction. Furthermore, the type of faecal storage facility was reported by Rotowa and Ayadi, (2020) in Nigeria to positively and significantly influence faecal sludge management.

They commented that a qualitative improvement in types of FS facilities would manifest in adopting standard septic tanks or adapting single-pit technology to lined twin-pit systems that safely contain human excreta. This study investigated the quality and design of sanitation technologies in Isiolo Sub-County.

Accessibility to a containment system, including location, ease of opening lid, and width of the road to accommodate the vehicle or emptying means, has been published by researchers to have an impact on faecal sludge management (Devaraj *et al.*, 2021; Muoghalu *et al.*, 2023; Seleman *et al.*, 2020). A study by Rotowa and Ayadi, (2020) in Nigeria reported that the location and distance of faecal storage from abutting access roads statistically influence faecal sludge management. They argued that the locus of containment facilities enhances easy emptying. In agreement, A survey in Tanzania conducted by Jenkins *et al.* (2015)

published that accessible plots and service availability of service were 23 times more likely to have safe sanitation practices.

These findings support faecal sludge emptying studies (Conaway *et al.*, 2021; Devaraj *et al.*, 2021; Muoghalu *et al.*, 2023). Conaway *et al.* (2021) systematic review study of OSS emptying practices and associated factors in Asian-low and middle-income countries reported that the inaccessibility of many OSSs to vacuum trucks in a community may cause households to resort to unhygienic and illegal manual emptying. Concurrently, Chowdry and Kone, (2012) reported that manual emptying of public sanitation facilities in low-income areas of Kenya was expected due to inaccessibility by trucks due to narrow paths. Findings disagree with a study by Seleman *et al.* (2020) that used qualitative and quantitative methods to analyze the underlying factors for unhygienic desludging in three urban unplanned settlements of Dar es Salaam, Tanzania. They submitted that plot accessibility, among other factors (type of toilet and pit lining), was not statistically significant. They contended that this was likely due to the small sample size, recommending further studies.

Availability of resources, including skilled personnel and vacuum trucks, plays a vital role in faecal sludge management (Taweesan *et al.*, 2017; Rotowa & Ayadi, 2020; Hussein *et al.*, 2023). Hussein *et al.* (2023) conducted a study in Somalia to examine faecal sludge management practices and associated factors. The study found that FSM was poor despite the construction of additional latrines and more excellent coverage. The authors submitted the technical capacity of the city management in terms of available area or space for FS collections, number of trained operators, number of trucks to collect faecal sludge, and number of households to be served to have influence. In accord, Taweesan *et al.* (2017) conducted a study to determine factors influencing the performance of faecal sludge

management services in Thailand municipalities. The study observed that the number of vacuum trucks, training operators, and accessibility have a significant correlation with efficiency in faecal sludge management practices.

The availability of skilled masons was observed by Eliud *et al.* (2023) in Kenya to have a significant influence on safe sanitation practices. Similar findings were submitted by Rotowa and Ayadi (2020). The authors conducted a study to investigate faecal sludge management in the residential core of Akure, Nigeria. Data was collected using Questionnaires from 400 households and interviews from service providers. The majority of respondents, 62%, reported that untrained masons who were illiterate with incompetent technical skills were the constructors of FS storage facilities; the authors contended that it limits the future chance of emptying faecal sludge. Simiyu *et al.* (2021) published research in Nakuru, Kenya, stating that they transported sludge using wheel carts due to the unavailability of trucks, which were costly. This transportation method could lead to spillage due to untarmacked and hilly roads, as well as cracks caused by the trucks. This study investigated the influence of the availability of skilled personnel and local resources on FMM in Isiolo Sub-County.

2.6 Summary of Literature and Research Gap

Developing countries, including Kenya, have made significant strides in sanitation access due to remarkable efforts by state Governments and other stakeholders. Table 2.1 illustrates research gaps that need to be filled.

Table 2.1*Knowledge gap*

Author	Title	Knowledge gap	Focus of the study
Gitonga <i>et al.</i> (2021)	Faecal Sludge Management for Sustainable Cities: Glimpses from Kenya	Significant strides in sanitation access but poor management of faecal sludge	This study focused on the management of faecal sludge, a critical but under-researched aspect of sanitation in Kenya.
Simiyu <i>et al.</i> (2021)	Faecal Sludge Management in Low Income Settlements: Case Study of Nakuru, Kenya	Limited studies on faecal management in Kenya They study used qualitative data	The current study contributed to the body of knowledge by focusing on faecal matter management in arid and semi-arid areas of Kenya. This study employed a mixed-method approach, incorporating both quantitative and qualitative data to provide a more comprehensive analysis. The study focused on social, environmental aspects that influence faecal matter management unlike

Peletz <i>et al.</i> , 2020	Expanding safe faecal sludge management in Kisumu, Kenya:	The study does not fully explore the role of community engagement in faecal sludge management, which is crucial for the success of any faecal sludge management initiative	This study investigated factors(social) that could influence faecal sludge management.
Chowdhry & Kone, (2012)	Landscape Analysis and Business Model Assessment in Faecal Sludge Management: Extraction and Transportation Models in Africa - Kenya:	The study highlights the need for further on the improvement of faecal sludge management practices in Kenya, particularly in low-income urban settlements	The study filled gap by understanding factors that impact faecal matter management in low resource context.

Source: Researcher, (2023)

2.7 Theoretical Framework

Behavior change interventions are typically complex and involve many interacting components. The development, implementation and evaluation of effective behavior change interventions are fundamental for advancing behavioral science and its application. However, both the theory and practice of interventions depend on having a good understanding of the

nature and content. The study was guided by social cognitive theory and integrated behavioral model for Water Sanitation and Hygiene (IBM-WASH).

2.7.1 Social cognitive theory (SCT)

The Social Cognitive theory (SCT) was put forth by Bandura, (1986), argues that individual behavior is influenced a reciprocal interaction of personal factors, environmental and behavioral factors. In the context of managing faecal matter in arid and semi-arid areas, SCT provides a robust framework to analyze how social, environmental, and technological factors influence management practices. The personal factors such as knowledge on sanitation, awareness of faecal matter management practices, attitudes and self-efficacy toward sanitation practices could play a significant role (Islam *et al.*, 2023).

If proper sanitation practices are observed and valued, they are more likely to be adopted by others. Behavioral factors, like the skills and habits related to proper faecal waste disposal, are also in management of faecal sludge. Importantly, SCT highlights the significant influence of environmental factors, including social norms, sanitation infrastructure, technological solutions, and climatic condition can create the context in which these behaviors occur (Bandura, 1986). Overall, the theory of social cognitive provides a useful framework for understanding the various factors that may influence sanitation behavior as in the context of this study faecal matter management.

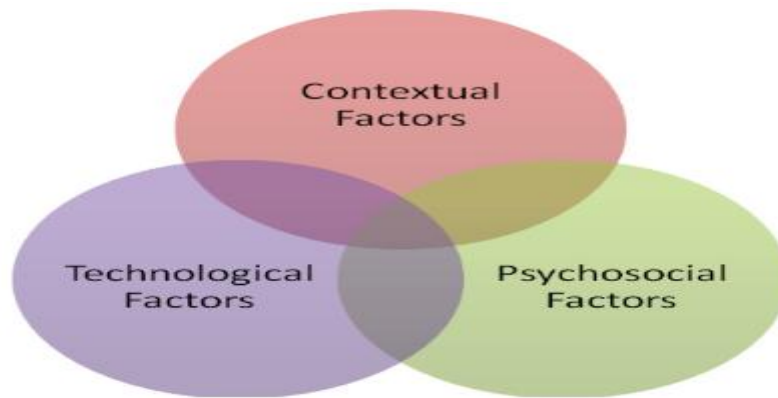
2.7.2 The integrated behavioral model for water sanitation and hygiene (IBM-WASH)

The integrated behavioral model for water sanitation and hygiene (IBM-WASH) was first developed by Dreibelbis *et al.*, following systematic review of 15 existing models and frameworks used in the WASH sector to address the limitations of existing models and provide a more comprehensive understanding of WASH behaviors (Tamene & Afework,

2021; Dreibelbis *et al.*, 2013). IBM-WASH model specially developed to understand water, sanitation, and hygiene interventions and behaviors, dynamically in a resource scarce setting since it provides across the board. For this study IBM-WASH framework, the faecal matter management is influenced by broad factors (Contextual, psychological, and technological) factors within at different levels (Structural, community, household, individual and habitual) (Kabir *et al.*, 2021).

Figure 2.2:

The integrated behavioral model for water sanitation and hygiene [IBM-WASH]



Deibelbis et al, (2013)

The contextual dimension in the Integrated Behavioral Model for Water, Sanitation, and Hygiene (IBM-WASH) as shown as in Figure 2.2, represents the background characteristics of the setting, individual, or environment that significantly influence the adoption of specific products or behaviors, often beyond the scope of influence of program activities. The contextual dimension encompasses factors such as policy and regulation, climate and geography at the societal level; access to resources, built and physical environment at the community level; roles and responsibility, and availability of space at the household level; individual level including, wealth, age, gender, employment, and favorable environment at

habitual level, which may influence sanitation behavior (Yeasimin *et al.*, 2017; Dreibelbis *et al.*, 2013), including faecal sludge management.

The psychosocial dimension of the IBM-WASH model includes factors such as culture, knowledge, values, norms, shame and disgust, existing water and sanitation habits, and leadership (Dreibelbis *et al.*, 2013). These factors can influence the adoption of specific products or behaviors related to faecal sludge management. The technological dimension addresses the physical product or technology component and the characteristics of this hardware, which have a strong influence on behavioral outcomes (Dreibelbis *et al.*, 2013). It includes aspects such as location (Hulland *et al.*, 2013), accessibility and availability (Devine, 2010), individual vs. collective ownership, maintenance of the product, the perceived cost, value of the product, and ease/effectiveness of routine use of the product (Dreibelbis *et al.*, 2013), determines the sanitation behavior.

Overall, the IBM-WASH model provides a conceptual and practical tool for improving the understanding and evaluation of the multi-level, multi-dimensional influences on water, sanitation, and hygiene behaviors, including faecal sludge management, in infrastructure-restricted settings. This framework comprises social, environmental, and technological aspects; study focused on understanding its influence on faecal sludge management.

2.8 Conceptual Framework

A conceptual framework is a structure that guides research by outlining the key variables and their hypothesized relationships, thereby providing a foundation for understanding how these variables interact (Salawu *et al.*, 2023). The conceptual framework of this study diagrammatically shows the relationship between the independent variables namely; “*Social*,

Environmental and Technological factors”, and dependent variable ‘*Management of faecal matter*’ as shown as in Figure 2.3.

Social factors are key drivers in shaping sanitation behaviors within communities. These include age, gender, education levels, awareness of fecal sludge management (FSM) practices, and social norms. Age plays a significant role in the adoption of safe FSM practices, with older generations often adhering to traditional methods and younger generations more inclined to adopt modern, safer practices. Gender dynamics also could influence the distribution of sanitation responsibilities, where women, especially in many traditional settings, are often the primary caretakers of household sanitation, including the management of fecal matter. Awareness of FSM practices is crucial communities that are well-informed about the dangers of improper fecal sludge management are more likely to take preventive actions. Additionally, cultural practices and social norms within communities may either encourage or hinder the adoption of safe FSM practices.

Environmental factors are critical in shaping the feasibility and effectiveness of FSM practices. The physical environment, including the type of soil, topography, and water table, directly affects the design and construction of sanitation facilities. For example, in areas with rocky terrain or high-water tables, it may be more challenging to dig latrines or septic tanks that function effectively and safely. Additionally, climatic conditions, such as rainfall and drought, can impact the sustainability of sanitation infrastructure. Heavy rainfall may lead to the flooding of latrines, rendering them unusable or unsafe, while droughts can exacerbate water scarcity and hinder sanitation maintenance. Furthermore, the availability of land and its allocation for residential, commercial, and agricultural purposes can influence the planning and installation of FSM systems.

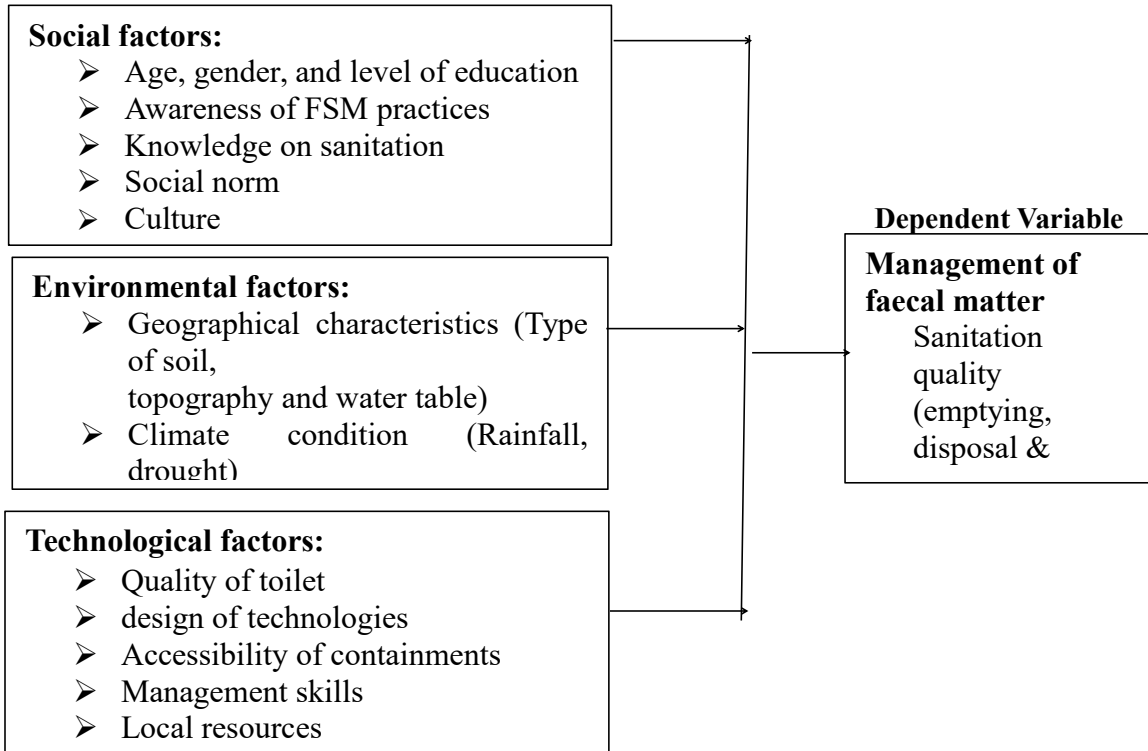
Technological factors relate to the availability and quality of sanitation infrastructure. The design and quality of toilets, pit latrines, and septic systems could play a key role in ensuring that fecal sludge is safely contained and managed. Poorly designed or substandard sanitation technologies can result in overflow or contamination, posing risks to public health. The proximity and ease of access to FSM services and facilities can significantly influence individual and collective FSM behaviors. Additionally, the availability of infrastructure such as sewage treatment plants or vacuum trucks can significantly improve FSM, but their absence may force communities to rely on unsanitary practices. Finally, local resources, such as building materials and skilled labor, could be essential for constructing and maintaining sanitation facilities that are durable and capable of withstanding environmental stresses.

Effective faecal matter management was the primary dependent variable, measured by evaluating the overall quality of sanitation services along the service chain. This included the condition of sanitation facilities, fecal matter disposal methods, and the presence of necessary infrastructure like handwashing stations. Responses were initially collected using a Likert scale and then converted into binary values: "managed" for good practices (e.g., good or excellent quality) and "unmanaged" for poor practices (e.g., fair, poor, or very poor quality).

Figure 2.3:

Conceptual framework

Independent Variable



Literature Review, (2023)

CHAPTER THREE: RESEARCH METHODOLOGY

3.0 Introduction

This section describes the procedures and methodologies used to assess the influence of Social, Environmental, and Technological factors on managing faecal matter in Arid and Semi-Arid Areas of Isiolo Sub-County, Kenya. The chapter details the research design, target population, sample size determination, sampling procedures, data collection methods, study instrument methods, data analysis techniques, and ethical issues for consideration while conducting the study.

3.1 Research Design

The study adopted a convergent design with a mixed-methods approach to investigate the influence of Social, Environmental, and Technological Factors on Faecal Matter Management in Isiolo Sub-County. The design was suitable as it permits integration of both qualitative and quantitative research methods (Creswell *et al.*, 2003), allowing researchers to gather comprehensive and complementary data vital to making sound inference or generalizations of findings.

3.2 Location Study

The study was conducted in Isiolo Sub-County, in Isiolo County, Kenya. Isiolo County borders Marsabit County to the North, Samburu and Laikipia Counties to the West, Garissa County to the South East, Wajir County to the North East, Tana River and Kitui Counties to the South and Meru and Tharaka Nithi Counties to the South West. The area was chosen since it is characterized by desert characteristics, with majority of the residents relying on onsite sanitation (USAID, 2021). It covers an area 25,605 km² and lies between Longitudes 36° 50' and 39° 50' East and Latitude 0° 05' South and 2° 0' North. Its capital is Isiolo Town

strategically located on the Lamu Port, South Sudan, Ethiopia Transport (LAPSET) corridor positioning it for development into a resort city by 2030. Isiolo county has a total population of 268,002 persons as 2019 census and of this 139,510 are males; 128,483 are females; 9 intersex persons. There is an average size of 4.6 persons per household and a population density of 11 persons per square Km (KNBS,2019). County average Growth rate between 2009 and 2019 was about 2.8%, which is higher than the national average of 2.2% because of demographic dynamics changes such as immigration, increasing fertility rates, low mortality rates and higher life expectancy (County Government of Isiolo (CGI), 2023). In Isiolo County 53% of the population resides in rural areas, while the remaining 47% (130,067) live in urban area by 2019 (CGI,2023). Isiolo County is made of three sub-counties Garbatulla, Isiolo, and Merti. Isiolo Sub-County is made up of five wards namely; Burat, Ngaremara, Bulla Pesa, Oldonyiro, and Wabera, and covers, 2,691 sq.km with estimate population of 133,167 by 2022 within 29,853 households (KNBS,2019).

The county consists of three climatic zones, semi-arid, arid, and very arid (KNBS, 2019). The semi-arid zone covers about 5% of the total county area which includes central Isiolo and Kinna wards. These areas receive an annual rainfall of 250-650 mm, while the arid zones which cover 30% of the county receives an annual rainfall of 300-350 mm and is made up of the Central Garbatulla divisions and mostly supports annual grasslands. The very arid zones consist of Merti and Sericho divisions and cover 65% of the county area that receives an annual average rainfall of 150 -250 mm. The county normally experiences a bimodal rainfall pattern, with the short rains occurring in October, November and December, and the long rains in March, April, and May. The average rainfall is 580.2 mm, and the average temperature is 29 °C (Republic of Kenya 2013).

3.3 Study Population

The study targeted the household heads of Isiolo Sub-County, Kenya. According to the Kenya National Bureau of Statistics (KNBS, 2019), the total number of households in the study area was 29,583, spread across five administrative units (wards), including Burat (8,951 households), Ngaremara (1,918 households), Bulla Pesa (5,936 households), Oldonyiro (4,316 households), and Wabera (8,732 households), as shown in Table 3.1. Household heads were targeted since they were users of onsite facilities and could provide valuable information on practices, challenges, and perceptions related to fecal matter management. The study also targeted community leaders, such as village elders, as they possess in-depth knowledge of sanitation matters and related practices necessary for the study. Community leaders, including public health officers and community health promoters, were included as participants since they are responsible for developing and implementing government policies.

Table 3.1:

Population and households in Isiolo sub-County

Strata /ward	Population	Number of households
Wabera ward	38,166	8732
Bulla pesa	23,860	5936
Burat Ward	38,755	8951
Oldonyiro	16580	4316
Ngaremara	4,590	1918
Total	121061	29853

Source: Kenya National Bureau of Statistics [KNBS], (2019)

3.3.1 Inclusion criteria

The study engaged household heads over the age of 18 years within Isiolo Sub-County, residents using onsite sanitation facilities, and residents who gave consent to participate in the study.

3.3.2 Exclusion criteria

The study excluded households under age of 18 years, residents using off-site sanitation system and residents who failed to give consent to participate in the study since the study was voluntary based.

3.4 Sampling Technique and Sample Size Determination

This section provides sample size determination and sampling procedure.

3.4.1 Sample size determination

The sample size was determine using Yamane, (1967) formula, used by Osumanu and Amin (2023) to calculate the required sample size from 219,971 households, a total of 400 households were used for the study. The formula is as shown in equation 3.1;

$$n = \frac{N}{(1 + Ne^2)} \quad (3.1)$$

Where: n = Desired Sample; N = Target Population Size; and e = Sampling error taken to be 0.05 or 5%

$$n = \frac{29853}{(1 + 29853(0.05^2))}$$

$$n = 395$$

The study targeted 395 Household heads within Isiolo Sub-County.

3.4.2 Sampling technique

The study employed stratified and simple random sampling techniques to select household heads who were residents in Isiolo Sub-County. The study area was classified into five strata (ward) that is, Burat (8951 households), Ngaremara (1918 households), Bulla Pesa (5936 households), Oldonyiro (4316 households), and Wabera (8732 households). The sample size for each ward was identified through proportionate to size simple random sampling technique, as shown in Table 3.2. To identify respondents, the researcher employed a simple random sampling technique. For qualitative data, the researcher used a purposive sampling technique to identify government officials such area chief and public health officers and community health to participate in focused group discussions. To determine the sample size for each unit, the number of households in each cluster was divided by the total number of households in Isiolo Sub-County (29,853) and then multiplied by 395, as was depicted in Table 3.2.

Table 3.2:

Sampling frame (N=395)

Ward	Number of households	Sample size
Wabera ward	8732	116
Bulla pesa	5936	79
Burat Ward	8951	118
Oldonyiro	4316	57
Ngaremara	1918	25
Total	29853	395

Source: Kenya National Bureau of Statistics [KNBS], (2019)

3.5 Data Collection Instruments

Quantitative data was collected from Household heads within the households in the five wards. The data was collected using structured questionnaires. The structured questionnaire (Appendix C), that contains four main sections, background information's of respondents, and associations of environmental, technical and technological factors with effective management of faecal sludge. The questionnaires were entered into online software (mWater Survey) and was administered by trained enumerators to Households head on face-to-face interviews.

Qualitative data was collected using focused group discussion guide (Appendix D) from purposively selected FGD participants who included key informants comprise of community health workers, community health promoters, sanitation experts and local administrators through an interview guide with the aim to capture all dimension of the study such opinions, views perception, and feeling of the respondents

An observation checklist, a tool for gathering data through observation, was used. The research checklist (Appendix E) contained questions about the status of household toilets in terms of hygiene, usability, safety, and overall functionality were entered into the mWater Survey Tool. The research assistant recorded evidence by placing a tick on the appropriate column on what was observed on the checklist.

3.6 Pre-Testing of Research Instruments

According to O'Neill (2022), the pilot study sample should be 10% of the sample size planned for the final quantitative data study. A pilot study was conducted in Tigania East, Meru County since this area had similar characteristics with the study area. A sample size of 40 (10% of 395) household heads were selected purposively for the instrument pre-test. The

questions that were ambiguous were restructured, and the clear questions was used for the study. The duration of each respondent's completion of the questionnaire was documented and found to be an average of 15 minutes, which was deemed appropriate.

3.6.1 Validity of the research instruments

Ensuring validity in research is essential to confirm that the instruments measure the intended constructs accurately and appropriately (Cheung *et al.*, 2024). In this study, a combination of validity techniques content, face, and construct was employed to enhance the credibility of the data collection instruments. These techniques were selected based on established practices in applied sanitation research and behavioral health studies (Taherdoost, 2021).

To assess content validity, the initial versions of the instruments questionnaires, focus group discussion guides, and observation checklists were reviewed by two academic supervisors and a panel of experts from the Sanitation Research and Innovation Centre (SRI) at Meru University of Science and Technology. The reviewers evaluated each item for relevance, clarity, and alignment with the study's conceptual and theoretical frameworks. Their feedback led to the restructuring of certain items to eliminate redundancy, remove ambiguous language, and ensure comprehensive coverage of the key dimensions of social, environmental, and technological factors influencing faecal matter management. According to Khidhir and Rassul (2023), expert judgment is a reliable method for evaluating the relevance and appropriateness of research instruments, particularly in field-based studies where contextual understanding is essential.

Face validity was established through a pilot test conducted in Tigania East, Meru County, involving 40 purposively selected household heads. This region was chosen due to its

demographic and environmental similarities to Isiolo Sub-County. Participants were encouraged to provide feedback on question clarity, cultural relevance, and general flow. Their insights resulted in the rewording of several items and the adjustment of sequencing to enhance respondent understanding. As noted by Lim (2024), face validity is a foundational step that ensures respondents interpret items as intended, thereby improving response accuracy. Construct validity was addressed by linking all questionnaire items to the theoretical domains identified in the Social Cognitive Theory (SCT) and the Integrated Behavioral Model for Water, Sanitation and Hygiene (IBM-WASH). Each variable such as awareness, knowledge, gender norms, environmental barriers, and technological access was operationalized based on existing literature in sanitation behavior (Dreibelbis *et al.*, 2013; Kabir *et al.*, 2021). This alignment ensured that the questionnaire items were not only relevant but also conceptually robust, reflecting the theoretical underpinnings of sanitation behavior and adoption in resource-constrained environments.

3.6.2 Reliability of the research instruments

Reliability refers to the consistency and stability of a research instrument in measuring the intended constructs over time. The study internal consistency reliability was assessed using Cronbach's alpha, a widely accepted statistical measure for evaluating how well a set of items measures a single latent construct (Ahmad *et al.*, 2024). Responses from this pilot study were analyzed to compute Cronbach's alpha values for each major construct: Social Factors, Environmental Factors, Technological Factors and Faecal Matter Management (FMM). As presented in Table 3.3, all constructs yielded alpha values above the minimum acceptable threshold of 0.70, indicating strong internal consistency. According Izah *et al.*

(2023), Cronbach's alpha values between 0.80 and 0.90 are considered indicative of good to excellent reliability, with scores above 0.80 preferred for behavioral research

Table 3.3:

Reliability test

Factor	Cronbach's alpha	Outcome
Social Factors	.851	Reliable
Environmental factors	.833	Reliable
Technological Factors	.875	Reliable
Fecal Matter Management	.803	Reliable

Source: Researcher, (2024)

3.7 Data Collection Procedure

Prior to data collections permit was obtained from relevant institutions and bodies and training of eight (8) research assistant. The quantitative data was gathered from household's heads that were selected randomly, using structured questionnaires electronically using mWater survey. In addition, data on status of sanitation facilities was recorded using observation checklist electronically. On other hand, qualitative data, was collected using Focus Group Discussion (FGD) guides. A total of 7 FGD participants based on the principle of saturation of qualitative data were considered (). The respondents selected for Focus Group included a chief, sub-chief, village elders, public health officers, community health promoters and volunteer member of the community. A total of two (2) FGD were held to ensure that varied insights opinions and beliefs on management of faecal matter.

3.8 Data Processing, Analysis and Presentations

Quantitative data collected from the households was cleaned, coded and analyzed in descriptive statistics and inferential statistics (logistic regression) using Statistical Packaged for Social Science (SPSS) Version 26. Descriptive statistics like frequency, percentages, mean and standard deviations were obtained and presented in table and graph. A mean score of 1-2.9 was considered as low score (general disagreement) and mean of 3-5 was considered as high score (general agreement) (Hashemi *et al.*, 2025).

To examine the relationship between the dependent variable management of faecal matter and the independent variables (i.e., social, environmental, and technological factors), two inferential statistical approaches were employed: binary logistic regression and multiple linear regression. Binary Logistic regression was done in univariate and multivariate analyses to yield unadjusted and adjusted odd ratios. Logistic regression analysis was suitable because the dependent (outcome) variable will be binary and the independent (predictor) variables can be binary, continuous, or categorical. In univariable analysis, the association between management of faecal matter and indicators of social, environmental and technological factors was done in turn and findings presented in unadjusted odds ratio a confidence interval of 95%. Further, multivariable analysis on the indicators with p-value less than 0.25 in univariable model was done, and results presented as adjusted odds ratio at 95% Confidence intervals (CI) The findings were presented by cross-tabulation tables. The assumptions of collinearity (VIF), and normality will be checked. The Hosmer and Lomeshow Chi-square test was used to assess the model's appropriateness.

In addition to categorical analysis, a multiple linear regression model was employed to assess the relative strength and direction of influence of the three thematic predictor

categories (social, environmental, and technological factors) on faecal matter management. Unlike the binary model, the dependent variable was computed as a composite index score, reflecting sanitation quality. The general multiple linear regression model was defined as shown in equation 3.2.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \epsilon \quad (3.2)$$

Where: Y = Composite faecal matter management score, β_0 = Constant, X_1 , X_2 , and X_3 represent social, environmental, and technological factor indices respectively; β_1 , β_2 , β_3 = Regression coefficients and ϵ = Error term

Qualitative data from Focus Group Discussions (FGDs) were transcribed verbatim and analyzed thematically. Coding was done manually to identify emerging patterns and contextual insights relevant to the study objectives. Themes were triangulated with quantitative findings to enhance interpretability and validate statistical associations through lived experiences and community narratives. Selected quotations were integrated to exemplify key points.

3.9 Logistical and Ethical Considerations

Prior to data collections, an introductory letter from Meru University of Science and Technology, school of engineering and architecture (SEA), department of civil and environmental engineering (Appendix F), entails full details of the researcher. In addition, research permit was obtained from the Kenya National Commission for Science, Technology and Innovation (NACOSTI) License no. NACOSTI/P/24/38757 and permit from County Government of Isiolo (Appendix F) before starting the research process.

The respondents were informed the participation in this study was voluntary based, and respondents were required to offer oral consents before interviews (Appendix B). The

researcher ensured the confidentiality of data by assigning respondents unique codes and maintaining their anonymity. Also, data was stored securely in password-protected digital files, accessible to only authorized personnel. Any respondents who wished to stop answering questions was free to do with no consequences.

CHAPTER FOUR: RESEARCH RESULTS AND DISCUSSIONS

4.0 Introductions

This section covers data analysis, presentations and interpretation of findings on the data gathered from Households' Heads, and key informants in Isiolo Sub-County, Isiolo County based on factors that influences the management of faecal matter.

4.1 Response Rate

The study targeted 395 household heads across five wards in Isiolo Sub-County for the quantitative survey. Structured questionnaires were administered digitally using the mWater Survey platform. The response rate, was depicted in Table 4.1.

Table 4.1:

Response rate by ward (N=395)

Cluster/ward	Targeted	Failed		Responded	
	Frequency	Partially filled	Non response	Frequency	Percent
Bulla pesa	79	0	9	70	17.7%
Burat Ward	118	2	13	103	26.5%
Ngaremara	25	0	5	20	5.1%
Oldonyiro	57	3	2	52	12.7%
Wabera	116	3	3	110	27.8%
Total	395	8	32	355	89.8%

Source: Research data, (2024)

The overall response rate was 89.9%, which exceeds the recommended threshold of 70% for acceptable survey research (Mugenda & Mugenda, 2003). This high level of participation

enhances the reliability of the study’s findings and supports generalizability within the study area. The response rate was highest in Wabera Ward (27.8%) and Burat Ward (26.5%), which may reflect their relatively higher population densities and urban characteristics. Conversely, Ngaremara Ward recorded the lowest response rate (5.1%), potentially due to its dispersed settlement pattern and higher prevalence of pastoralist lifestyles. The study did not achieve a 100% response rate due to non-response and partially filled forms, which were ignored during analysis. The study found that most of the residents were busy during the data collection period, engaging in casual jobs such as farming in the neighborhood, and others were pastoralists busy looking after their animals such as goats, cattle, and sheep, as was reported in the Focus Group Discussion (FGD).

4.2 Demographic Characteristics

This section presents the demographic characteristics of the respondents who participated in the study. The variables assessed include gender, age, level of education, religion, employment status, and household size. Understanding these attributes is essential for contextualizing the factors influencing faecal matter management in Isiolo Sub-County.

4.2.1 Gender of the respondents

The findings in Table 4.2 shows gender distributions of the participants.

Table 4.2:

Gender of participants (N = 355)

Gender	Frequency (n)	Percent (100%)
Males	104	29.3
Female	251	70.7

Source: Researcher, (2024)

The findings in Table 4.2 reveal that the majority of the respondents were female (70.7%), while males accounted for 29.3%. The gender distributions could be attributed to gender roles, for instance, males being away for jobs during the daytime and women leaving home for household chores such as cooking and taking care of children. Female household members, who are regular users, could be more concerned about the operations and maintenance of sanitation facilities. The observed trend aligns with findings by Seleman *et al.* (2020) in Tanzania, who reported that women are generally more engaged in sanitation practices due to their domestic roles. Similarly, Osumanu and Amin (2023) observed that households led by women were significantly more likely to adopt safe sanitation practices.

4.2.2 Age of the respondents

The respondents were asked to indicate their age category. The results are shown in Table 4.3.

Table 4.3:

Age distribution of respondents (N = 355)

Age Bracket in years	Frequency (n)	Percentage (%)
18-35	125	35.2
36-50	209	58.9
51 and above	21	5.9

Source: Researcher, (2024)

As shown in Table 4.3, the majority of respondents (58.9%) were aged between 36 and 50 years, followed by those aged 18–35 years (35.2%). Respondents aged 51 and above comprised the smallest proportion at 5.9%. The high of participants in the age group 36-50 could be because of reproductive age, during which individuals are likely to be more

engaged in household and community activities, including managing sanitation facilities. The low participation of age categories of 51 and above is possibly due to low engagement in the daily operational aspects of household management, often deferring these responsibilities to younger household members. This finding resonates with Alemu *et al.* (2023), who reported that middle-aged adults were more likely to invest in sanitation infrastructure due to their economic activity and responsibilities.

4.2.3 Level of education of the respondents

The respondents were requested to indicate their level of education, and the findings were shown in Table 4.4.

Table 4.4:

Level of education(N=355)

Education Attained	Frequency(n)	Percentage (%)
No Education	92	25.9
Primary	79	22.3
Secondary	103	29.0
Tertiary	81	22.8

Source: Researcher, (2024)

The findings revealed that (29%) of the respondents had secondary education, 22.3% had primary education, 22.8% had tertiary education., and 25.9% had no formal education. The results revealed that most respondents were literate, which could facilitate the adoption and understanding of sanitation practices and policies. However, the fact that about half of respondents attained primary education or have never been to school could be because locals may encounter challenges while accessing education institutions, leading to school

dropouts. The lack of primary education indicates potential challenges in disseminating information and implementing educational interventions related to faecal matter management. A study by Oloruntoba *et al.* (2019) in Nigeria posited that education is crucial for changing behavior and communicating the risks associated with a given course of action. Similarly, Kasiva (2023) reported that educated individuals are more likely to adopt safe sanitation practices.

4.2.4 Religion of the respondents

The respondents were tasked to indicate their religious afflictions, and results were shown in Table 4.5.

Table 4.5:

Religious affiliation of respondents (N = 355)

Religion	Frequency (n)	Percentage (%)
Christian	196	55.2
Muslims	148	41.7
Atheist	5	1.4
Other	6	1.7

Source: Researcher, (2024)

The study findings in Table 4.5 indicate that more than half, (55.2%) of respondents were Christians, while 41.7% were Muslims. A small group of respondents identify as Atheists (1.4%) or belonging to other religions (1.7%). Religious beliefs and practices can significantly influence attitudes and behaviors related to faecal matter management. Studies have reported that religion significantly influences the reuse and disposal of excreta (Gitau

et al.,2022). Furthermore, a study by Mkude *et al.* (2022) in Tanzania reported that the adoption of Eco-San toilets was greatly hindered by the Muslim religion.

4.2.5 Employment status of the respondents

The participants required to indicate their employment status, and finding summarized in Table 4.6.

Table 4.6:

Employment status of respondents (N = 355)

Employment status	Frequency(n)	Percentage (%)
Not employed	167	47.0
Self -employed	158	44.5
Employed	30	8.5

Source: Researcher, (2024)

The study showed that (47.0%) of respondents were not employed, (44.5%) were self-employed, and only a tiny percentage (8.5%) were employed in formal jobs. The high proportion of self-employment and unemployment could be due to the economic structure area, characterized by pastoralism and agricultural activities (CGOI, 2023). Households with unstable incomes may deprioritize sanitation investments, particularly those involving periodic emptying or upgrading of latrines. These findings align with those of Basika and Komakech (2024) and Akumuntu *et al.* (2017), who argued that affordability is a major determinant of FSM adoption in low-income settings.

4.2.6 Household size of the respondents

Respondents were asked to report the number of members in their households. The findings are summarized in Table 4.7.

Table 4.7:

Household size of respondents (N = 355)

Household size	Frequency(n)	Percentage (%)
< 2	33	9.3
2-5	201	56.6
6-9	106	29.9
10 or more members	15	4.2

Source: Researcher, (2024)

The findings showed that the largest proportion, (56.6%) of the respondents, had 2-5 members, 29.9% had 6-9 members, 9.3% recorded less than 2 members, and only 4.2 % identified 10 or more members. The findings suggest a significant proportion had 2-5 members, a trend toward medium-sized family units, which could be due to the utilization of family planning services. However, about a third of respondents had large family units, which could be attributed to cultural practices supporting more prominent families. The diversity in household size may necessitate varying demands in allocating sanitation resources, as large households may require robust infrastructure to demand and accumulate sludge. Medium-sized households may find it easier to manage sanitation infrastructure, while larger households may experience more rapid filling of pit latrines and strain on shared sanitation facilities. These findings mirror those reported by Harper *et al.* (2020), who found a positive correlation between household size and frequency of toilet filling.

4.3 Faecal Matter Management in Isiolo Sub- County

This section presents the findings on faecal matter management in Isiolo Sub-County, focusing on sanitation technologies, toilet sharing, waste discharge methods, pit management, and overall service quality.

The study investigated the sanitation technologies in Isiolo sub-county and findings were presented in Table 4.8.

Table 4.8 :

Sanitation facilities in Isiolo Sub- County(N=355)

Variable	Frequency(n)	Percentage (%)
Sanitation Facilities		
Flush toilets	67	18.9
Ventilated improved pit latrine	129	36.3
Traditional pit latrine	145	40.8
No facilities or bush or field	10	2.8
Other	4	1.1
Sharing of toilets		
Yes	101	28.5
No	254	71.5

Source: Researcher, (2024)

The study results as shown as in Table 4.8, that most (40.8%) of the respondents were using traditional pit latrines, 36.3% identified Ventilated Improved Pit latrines (VIP), and 18.9% were using flush toilets. A small proportion of 1.1% of respondents used other technologies such as EcoSan, and 2.8% had no toilet facilities. The high reliance on pit latrines could be

due to ease and construction costs. From the FGD, participants noted that pit latrine facilities were common since it was culturally acceptable for both the washers and squatters.

“.....toilet is not just a cement, iron sheets roof, and mortar structure, but something we can construct using cheap, locally available material pit such as wood and mud...”

“... pit latrine suits community traditions and beliefs...”

The findings confirmed a report by USAID (2021) on the success of the community-led Led Sanitation (CLTS) program in the ascendancy of latrine adoption in the study area. In accord, Bagaja *et al.* (2024) study to investigate social-demographic factors associated with the uptake of CLTs in Isiolo County found that over 50% of respondents owned pit latrines.

The study further investigated whether participants were sharing toilets with other households in the study area. As depicted in Table 4.8, the majority (71.5%) of the respondents were using private toilets compared to (28.5%) who indicated sharing toilets with other households.

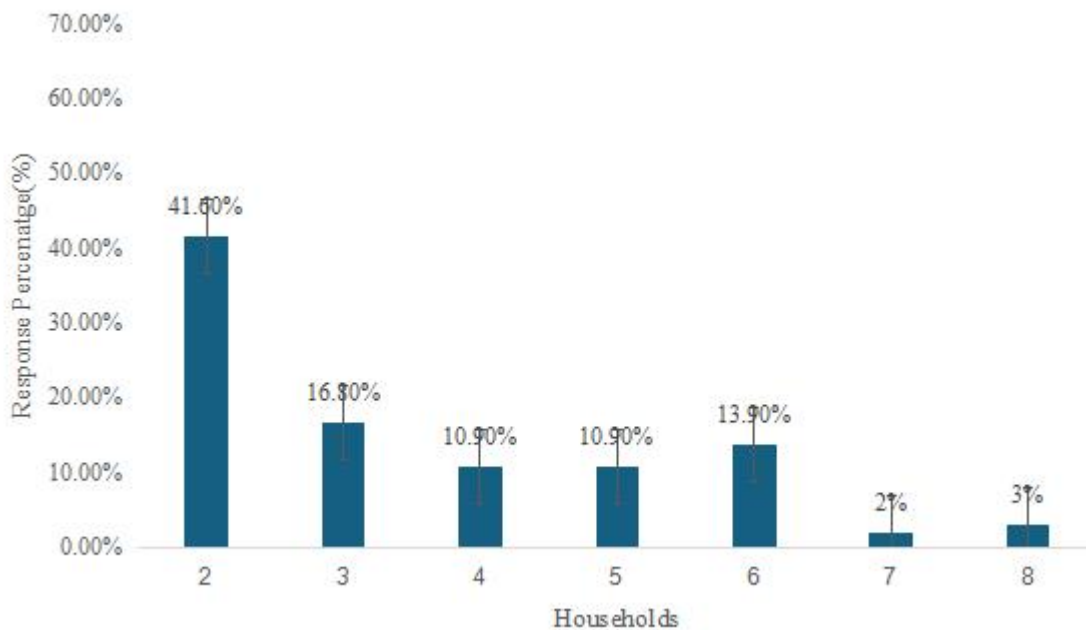
The high proportion of respondents using private toilets could be due to concerns about insecurity, especially during nighttime, hygienic issues, and human dignity concerns associated with shared toilets. Using private toilets could be more likely maintained since households are directly responsible for their facilities, hence improved faecal matter management. About a third of respondents (28.5%) using shared toilets may be attributed to a lack of understanding of dangers related to poorly maintained latrines. However, findings are slightly higher than 22% shared sanitation situations in Kenya (UNICEF/WHO,2019) in the study area because of cultural issues, accessibility of latrines, and financial constraints of constructing private facilities, as was reported by FGD.

“Most households share toilets because of the high cost involved in regular digging toilets that filled faster due to the rock nature of the area, which encourages shallow pits. The problem increases the cases of open defections.”

The study further determined the number of households using shared toilets, and findings were demonstrated as in Figure 4.1.

Figure 4.1:

Number of households sharing toilets



Source: Researcher, (2024)

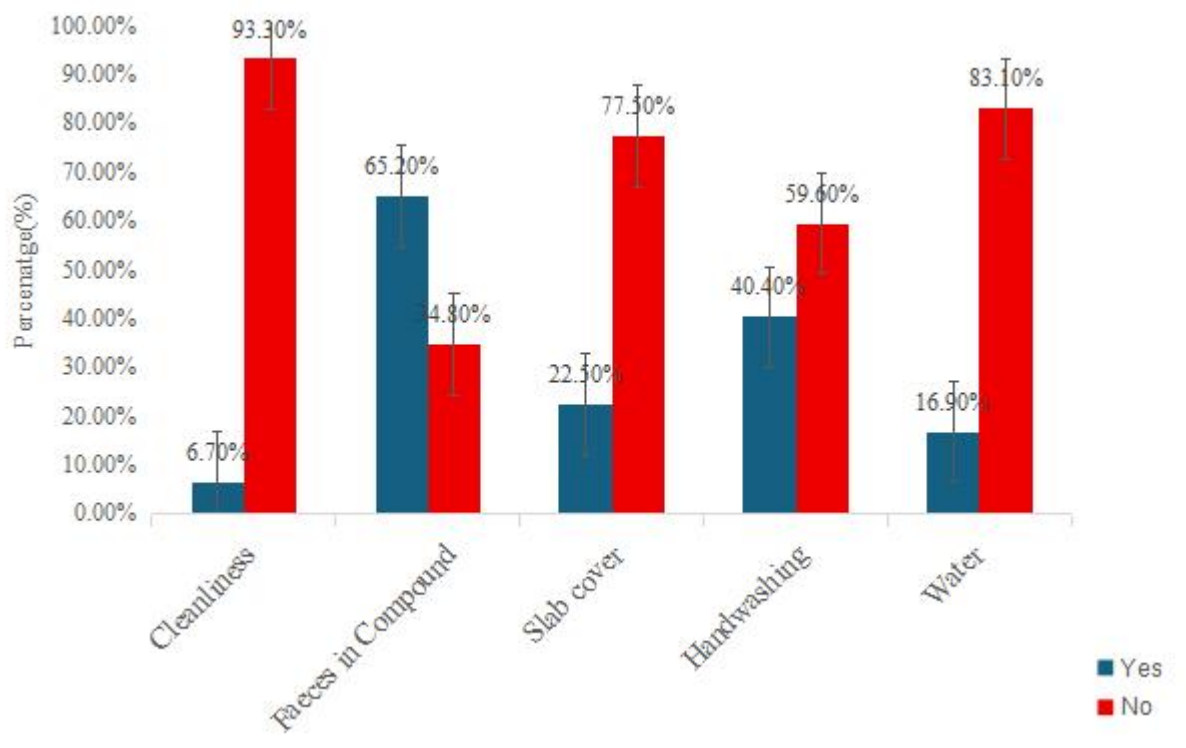
Among (28.5%) households that shared facilities, some toilets were used by up to ten households, as reported in Figure 4.1. In highly populated areas such as Wabera and Burat, community toilets, school latrines, and church facilities were often used by non-members of those institutions as was reported in Focused Group Discussion. A participant explained:

“In some areas such as Ngaremara, sharing toilets is common among even 10 or more households. Some (women and children) also use toilet facilities in schools and churches, and men defecate in bushes.”

Such usage patterns challenge the notion of safe, private sanitation, particularly for women and children, and expose communities to increased faecal contamination. The status of the sanitation facilities was checked using an observational checklist, and findings presented in Figure 4.2

Figure 4.2:

Quality of sanitation facilities in Isiolo Sub- County



Source: Researcher, (2024)

The majority (93.3%) observed had faeces and urine on the slab, compared to only 6.7% of the clean toilets. In addition, feces were observed in 34.8% of compounds of the surveyed households, indicating Open Defecation (OD). The poor maintenance of the toilet facilities

was possible because of soiling by children and insufficient access to cleaning materials and water supply, as was reported in the Focused Group Discussion.

A respondent reported that;

"In most cases, facilities are shared, associated with unhealthy habits of soiling toilets, and no one cares. Furthermore, others desired to maintain facilities, but inadequate resources and the design nature of toilets limit it."

Less than half (40.4%) of observed toilet facilities had handwashing facilities. Results suggest that most households may not be aware of the need for hand hygiene, resulting in poor sanitation practices. However, the study's findings were higher than the 25% reported by UNICEF (2020) in Kenya and 36.2% in Uganda (Keera, 2019), as households have handwashing facilities with soap and water at their homes. Studies in Nepal by Kafle and Pradham (2018) reported that (90%) of surveyed homes had adequate handwashing facilities, thus improving access to sanitation. As reported in the Focused Group Discussion, the study noted that community sensitization programs promoted the discrepancy.

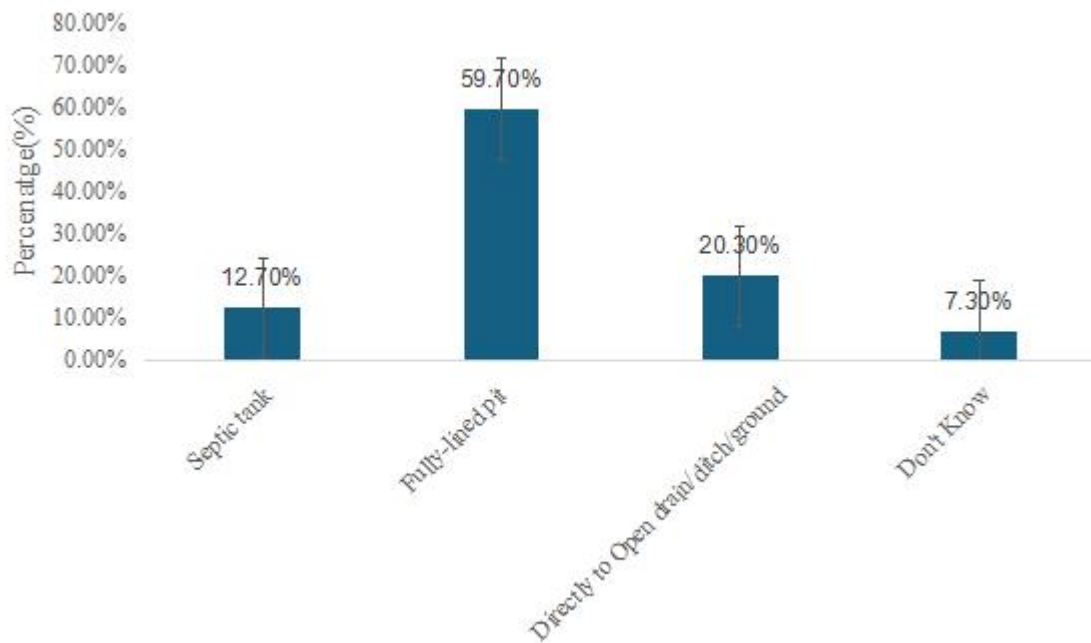
".... We (community health promoters) have been educating community members through public baraza, dialogue days, and household visits on the importance of owning a latrine and handwashing using soap and water after visiting the toilet."

The most (77.5%) of the observed toilets lacked squat hole cover compared to 22.5% of the observed toilets with cover lids. The design may result from a lack of skilled personnel responsible for toilet construction, thus contributing to poor sanitation practices such as Open Defecation. The study findings support research by Bagaja *et al.* (2024) in Isiolo County and Mwapesa *et al.* (2023) in Malawi. They submitted that most of the observed facilities lacked tight fittings, preventing the utilization and maintenance of toilets.

The study further assessed the discharge of content from Sanitation facilities, and findings presented in Figure 4.3

Figure 4.3:

Discharge of toilet content



Source: Researcher, (2024)

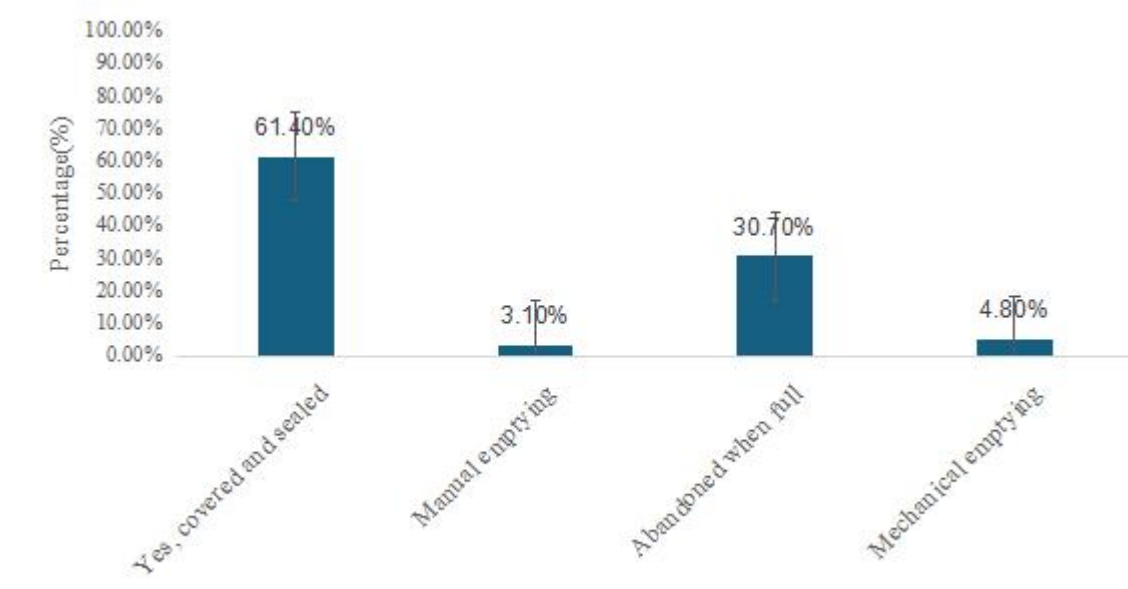
As presented in Figure 4.3, the majority of respondents (59.7%) reported using lined pits for excreta containment, while 12.7% indicated the use of septic tanks. Notably, (20.3%) of households discharged faecal waste directly into open ground, ditches, or surface drains practices that are considered unsafe. Additionally, 7.3% of respondents were unaware of what happened to excreta after defecation, indicating a knowledge gap regarding downstream waste flow. The low uptake of septic tanks may be attributed to the high capital and operational costs associated with their installation and maintenance. These costs are often prohibitive for households in low-income and rural settings. As noted by Furlong (2015), only approximately 5% of households in low- and middle-income countries utilize

septic tanks, highlighting the limited access to safely managed sanitation infrastructure. The reliance on lined pits suggests a preference for affordable and locally manageable containment technologies. However, the fact that one in five households engages in open discharge presents significant challenges for effective faecal sludge management (FSM). Open discharge increases environmental contamination, poses risks to public health, and undermines progress toward Sustainable Development Goal (SDG) 6.2, which aims for safely managed sanitation for all. These findings are in line with studies by Koottatep *et al.* (2021) and Peal *et al.* (2014), who report similar trends in peri-urban settlements across sub-Saharan Africa and Southeast Asia, where inadequate FSM systems lead to unsafe disposal of human waste.

The participants were tasked to identify how they managed filled pits. The result was shown in Figure 4.4.

Figure 4.4:

Management of filled up pits



Source: Researcher, (2024)

As presented in Figure 4.4, more than half, 61.4%(n=218) of respondents reported filled pits were being covered and sealed, 30.7%(n=109) recorded being abandoned when filled up, 4.8%(n=17) emptied by professionals, and 3.1% were being emptied manually. The high prevalence of covering and sealing pits indicated that many households prefer this method due to its simplicity and cost-effectiveness. However, the study showed the highest proportion of a third abandoning toilets when full, which signifies a gap in knowledge and a potential lack of infrastructure, as was reported in FGD.

“...nobody cares about the fate of faecal matter beyond toilet facilities. When it is filled, some are abandoned, as others sealed with soil and construct new ones, especially in rural settings....”

“...we have few cases of mechanical emptying of septic tanks, but mostly within an urban setting.”

The study examined the overall sanitation quality along the service chain. The respondents were required to rate the quality of sanitation services in their community regarding faecal sludge management (including emptying, transport, treatment, and disposal). The results were summarized in Table 4.9 and Figure 4.5.

Table 4.9:

Quality of Sanitation Services (N=355)

Quality of Sanitation Service	Frequency (n)	Percentage (%)
Excellent	27	7.6
Good	163	45.9
Fair	108	30.4
Poor	47	13.2

very poor

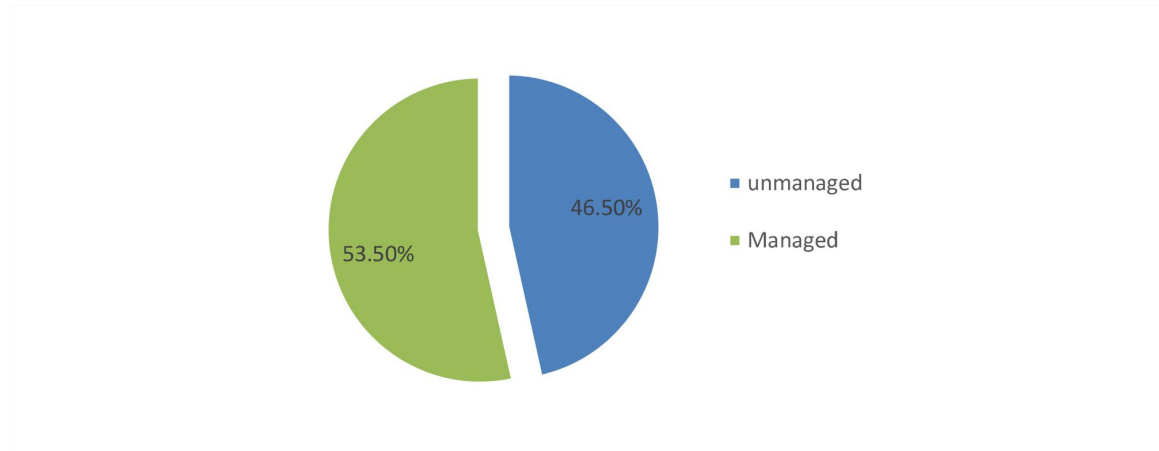
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2.8

Source: Researcher, (2024)

Figure 4.5:

Management of the faecal Matter



Source: Researcher, (2024)

As presented in Table 4.9, the majority of respondents (45.9%) rated the quality of sanitation services in their households and communities as "good." This was followed by 30.4% who rated services as "fair," 13.2% as "poor," 7.6% as "excellent," and 2.8% as "very poor." These results suggest a mixed perception of sanitation conditions, with a notable proportion of respondents expressing dissatisfaction.

For further analytical clarity, these ratings were reclassified into two categories, as shown in Figure 4.5. Ratings of "excellent" and "good" (representing 53.5% of responses) were categorized as managed faecal matter, reflecting positive perceptions and likely adherence to safe sanitation practices. In contrast, ratings of "fair," "poor," and "very poor" (46.5%) were grouped under unmanaged faecal matter, indicating perceived inadequacy in service quality, facility maintenance, or waste containment. While there have been gains in improving access to sanitation, concerns remain about the sustainability, cleanliness, and safety of these

services. These findings echo those of Peal *et al.* (2020) and Afework *et al.* (2022), who assert that user satisfaction is a critical yet under-measured component of sanitation programming. When services are perceived as poor, households are less likely to maintain and invest in sanitation infrastructure, thus exacerbating the cycle of poor hygiene and public health risks.

4.4 Influence of Social Factors on the Management Faecal Mater

The study assessed the influence of the social factors such as age, gender, level of education, awareness of FSM practices, knowledge of sanitation, and social norms influence on faecal matter management.

4.4.1 Influence of level of education on the management faecal matter

The respondents were tasked to identify their level of agreement with the idea that level of education influenced the faecal matter management, using five-point Likert scale and findings illustrated in Table 4.10.

Table 4.10:

Influence of level education on the management of faecal matter (N=355)

Education	Frequency (n)	Percentage	Mean (SD)
influences			
Strongly disagree	5	1.4	3.82(SD=099)
Disagree	54	15.2	
Not Sure	20	5.6	
Agree	198	55.8	
Strongly agree	78	22.0	
Total	355	100.0	

Source: Researcher, (2024)

The study showed that majority (55.8%) of the sample population agreed that the level of education of household head had an impact on the management of faecal matter, 22% strongly agreed, 15.2% disagreed, 5.6% were not sure, and a small proportion, 1.4% strongly disagreed. The findings showed an average of 3.82 (SD=0.99) indicating that respondents supported the idea that the level of education among household head influences faecal matter management. These findings imply that literacy may enhance a household's ability to understand sanitation protocols, interpret health information, and adopt hygienic practices. As reported in the focus group discussions, educated individuals were perceived to be more aware of the health implications of poor sanitation and more willing to invest in safe containment systems. A participant reported that;

"We experience challenges in some units(villages) when campaigning for households to construct toilets since residents do not understand the benefit and need of owning or maintaining available toilets. However, in some households with school-going children, they help us educate parents about the need for toilets in homesteads."

"...the educated persons are more likely to be employed and may have enough resources to build and maintain toilet facilities..."

The findings support Harper *et al.* (2018) study in Cambodia, which examined the household's acceptance of faecal sludge management practices. They submitted that the education level achieved by the household members affects the acceptance of safe FSM practices. They argued that higher education exposes household members to new concepts and various aspects of the world. However, the findings disagree with the conclusion made by Mamera *et al.* (2020), a mixed-method study to examine Community faecal sludge

management strategies in eastern Free State, South Africa, that education had no impact on the FSM practices.

4.4.2 Influence of age on the management faecal matter

Respondents also assessed whether age influenced sanitation behaviour, particularly in the disposal and maintenance of faecal matter. The results are shown in Table 4.11.

Table 4.11:

Influence of age on faecal matter management (N = 355)

Age influence	Frequency (n)	Percentage (%)	Mean (SD)
Strongly disagree	9	2.5	3.51(1.148)
Disagree	94	26.5	
Not Sure	27	7.6	
Agree	157	44.2	
Strongly agree	68	19.2	

Source: Researcher, (2024)

The study showed that most respondents (44.2%) agreed that age influences faecal matter management, while 26.5% disagreed. However, 19.2% strongly agreed, 7.6% neutral and 2.5% strongly disagreed. A mean of 3.51(SD=1.148) was recorded, showing age as a predictor in faecal matter management, possibly due to beliefs and responsibilities associated with specific age groups, as was reported in FGD.

“The elderly are fixated with traditional practices, and more often, they encourage unsafe sanitation practices.”

“.... the younger generations (middle age-group) are more likely to utilize safe sanitation practices since they may have resources and understanding of related dangers...”

Past studies have demonstrated agreement on the impact of age on sanitation (Tumoi *et al.*, 2024; Osumanu & Amin,2024; Alemu *et al.*, 2023).

4.4.3 Influence of gender on the management faecal matter

The respondents were asked to indicate their level of agreement to some statement on influence of gender on the management of the faecal matter. The findings were presented in Table 4.12.

Table 4.12:

Influence of gender and gender roles on faecal matter management (N = 355)

Variables	Frequency (n)	Percentage (%)	Mean (SD)
Gender			2.93(1.152)
Strongly disagree	21	5.9	
Disagree	158	44.5	
Not Sure	30	8.5	
Agree	118	33.2	
Strongly agree	28	7.9	
Gender Roles			3.22(1.158)
Strongly disagree	8	2.3	
Disagree	138	38.9	
Not Sure	23	6.5	
Agree	141	39.7	

Strongly agree 45 12.7

Source: Researcher, (2024)

The study revealed that 44.5% of respondents disagreed that the gender of household head impacts faecal matter management, 33.2% agreed, 8.5% neutral, 7.9% strongly agreed, and 5.9% strongly disagreed. A mean of 2.93(SD=1.152) indicated general disagreement with the notion that the gender of the household's head influences the management of faecal possibility due to community-driven activities that may encourage collective responsibilities for sanitation activities.

On the other hand, the mean of 3.22(SD=1.158) shows that respondents agreed that gender roles within households affect the allocation of responsibilities related to faecal management. The results could be due to deeply rooted gender-related issues set for female and male household members. From the FGD, the study found that men were primary decision-makers primarily responsible for the construction of pit latrines and cleanliness as a duty to women and children. Participants reported that;

“...the construction of toilets, including digging pits, building and related expenses, and desludging, is a duty for male household members. However, an issue related to cleanliness is the role of the wife and children. However, since most of the time, men are away for livestock keeping and other tasks, they may ignore the condition of the toilet.”

“...sometimes I (male respondents) might want to clean toilet, but my children(wife) would not allow me to do so...”

The study concurred with findings published by Seleman *et al.* (2020) in Tanzania and Osumanu and Amin, (2023) in Ghana that gender roles significantly impact sanitation practices.

4.4.3 Influence of awareness on sanitation on the management of faecal matter

Participants were instructed to rate level of agreement with statement awareness on sanitation matters influence disposal of faecal matter at the household level and findings presented in Table 4.13.

Table 4.13:

Influence of awareness on sanitation on the management of faecal matter (N = 355)

Awareness on Sanitation	Frequency (n)	Percentage (%)	Mean (SD)
Strongly disagree	5	1.4	4.19(0.776)
Disagree	14	3.9	
Not Sure	7	2.0	
Agree	211	59.4	
Strongly agree	118	33.2	

Source: Researcher, (2024)

The study showed that most (59.4%) of the respondents agreed that awareness of sanitation matters influences the disposal of faecal matter at the household level, 33.2% strongly agreed, 2.0% were not sure, 3.9% disagreed, and only 1.4% strongly disagreed. The high mean score (M = 4.19, SD = 0.77) reflects broad consensus that increased awareness enhances safe disposal practices. The findings could be because awareness often comes hand-in-hand with increased access to sanitation resources and facilities, making it easier for

households to manage faecal matter correctly. This observation is supported by Taweesan *et al.* (2017) in Thailand and Paramita *et al.* (2021) in Indonesia and Egypt, who found that awareness and participation were strongly linked to sustainable faecal sludge management. Similarly, Harper *et al.* (2020) found that inadequate awareness led to unsafe disposal practices, especially in rural Cambodia.

4.4.5 Influence of Knowledge on the Management of Faecal Matter

The study examined participants level of agreement with statemen, knowledge on ways of managing and safe disposal faecal matter, influences management of faecal matter. The results were shown in Table 4.14.

Table 4.14:

Influence of knowledge on the management of faecal matter (N = 355)

Variables	Frequency (n)	Percentage (%)	Mean (SD)
knowledge on ways of managing faecal matter			1.89(0.916)
Strongly disagree	118	33.2	
Disagree	198	55.8	
Not Sure	11	3.1	
Agree	16	4.5	
Strongly agree	12	3.4	
Knowledge on safe disposal influence FMM			4.09(0.814)
Strongly disagree	6	1.7	
Disagree	16	4.5	

Not Sure	19	5.4
Agree	214	60.3
Strongly agree	100	28.2

Source: Researcher, (2024)

The study found that most (55.5%) of the respondents disagreed with the notion that they had Knowledge of appropriate ways of managing faecal matter, 33.2% strongly disagreed, 4.5% agreed, 3.1% were neutral, and only 3.4% strongly agreed. The low mean score of 1.89 (SD = 0.916) indicates a significant knowledge deficit among residents regarding appropriate faecal matter management practices. This lack of knowledge may be attributed to deeply embedded cultural taboos and myths that discourage open discussion of sanitation and human waste. Such socio-cultural constraints can limit exposure to public health education and reduce community engagement with safe sanitation solutions. These findings are consistent with a study by Mkude *et al.* (2021) in Tanzania, which reported low to moderate knowledge of faecal sludge reuse. The authors attributed this to cultural and religious beliefs that stigmatize human excreta, thereby limiting the dissemination and acceptance of sanitation-related information.

In contrast, when asked whether knowledge of safe faecal disposal influences how households manage faecal matter, 60.2% agreed and 28.2% strongly agreed, with only a small percentage expressing disagreement. The corresponding mean score of 4.09 (SD = 0.814) reflects a general consensus that such knowledge plays a critical role in influencing disposal behavior. This suggests that while technical knowledge on treatment or reuse may be low, awareness of the risks of improper disposal such as environmental contamination or disease can still guide households toward safer practices. Households may be making

pragmatic decisions based on perceived health risks or financial consequences, even if lacking technical understanding of FSM systems. These results are in line with the findings of Mamera *et al.* (2021), who reported that households in South Africa demonstrated relatively high awareness of various disposal methods, with 86.2% citing land application, 5% using faecal sludge as feedstock for livestock, and another 5% for agricultural use. Conversely, a study by Harper *et al.* (2020) in Cambodia found significant gaps in understanding, where many respondents believed that discharging untreated sludge into fields or water bodies posed no health risk. This highlights the variation in sanitation knowledge across different cultural and geographical settings and reinforces the need for context-specific education strategies.

4.4.6 Influence of social norms on the management of faecal matter

The influence of the community social norms was assessed and findings was shown in Table 4.15.

Table 4.15:

Influence of social norms on the management of faecal matter (N= 355)

Social norms	Frequency (n)	Percentage (%)	Mean (SD)
Strongly disagree	6	1.7	3.23 (1.085)
Disagree	122	34.4	
Not Sure	49	13.8	
Agree	141	39.7	
Strongly agree	37	10.4	

Source: Researcher, (2024)

When respondents were asked whether community social norms influence the management of faecal matter, (39.7%) agreed, 34.4% disagreed, 13.8% were not sure, 10.4% strongly agreed, and only 1.7% strongly disagreed. At the resultant mean of 3.23(SD=1.085), suggests that communal values and beliefs may either promote or discourage hygienic faecal matter practices. Focus Group Discussions revealed that some residents consider it taboo for adult males to share toilet facilities with their children, resulting in open defecation by men. In other cases, poor perception of pit emptiers discouraged households from safely emptying their latrines.

A respondent in a focused Group discussion reported that;

“It is taboo, according to some residents, to use the same sanitation by father and children. They consider man excreta as not harmful, and in most cases, they defecate in bushes...”

The consistent findings have been reported by Coockey *et al.* (2020) in Bangladesh that community norms promote inappropriate faecal sludge discharge. In Cambodia, Harper *et al.* (2020) reported community norms encourage unsafe practices such as self-emptying, flooding out (opening a pit during a flood to empty FS directly into floodwaters), and piercing their pit.

4.5 Influence of Environmental Factors on the Management Faecal Mater

This section presents findings on how environmental conditions such as climate, soil type, water table, space availability, and land use influence faecal matter management (FMM) in Isiolo Sub-County. Environmental variables play a critical role in determining the design, sustainability, and usability of sanitation infrastructure.

4.5.1 Influence of climatic condition on the management of faecal matter

The respondents were instructed to rate level of agreement with some statement on 5-point Likert scale regarding climatic aspects, and results depicted as in Table 4.16.

Table 4.16:

Influence of climate conditions on the management of faecal matter(N=355)

Climatic conditions	Frequency (n)	Percentage (%)	Mean (SD)
Rainfall			3.2451(1.25063)
Strongly disagree	33	9.3	
Disagree	99	27.9	
Not Sure	17	4.8	
Agree	160	45.1	
Strongly agree	46	13.0	
Drought			3.439(1.10654)
Strongly disagree	10	2.8	
Disagree	99	27.9	
Not Sure	15	4.2	
Agree	187	52.7	
Strongly agree	44	12.4	

Source: Researcher, (2024)

At a mean score of 3.44 (SD = 1.11), the majority of participants agreed that drought conditions influence faecal matter management in Isiolo Sub-County. This finding may be attributed to the reduced frequency of pit filling during prolonged dry periods, leading to less strain on sanitation infrastructure. Drought-related water scarcity may also affect

cleaning practices, but it minimally compromises the physical integrity of sanitation systems. These observations align with the findings of Odagiri *et al.* (2021) in Indonesia, who reported significantly lower rates of pit emptying in drought-affected regions compared to those experiencing frequent flooding.

The study found that (45.1%) of respondents agreed that rainfall leads to water ingress and structural failure of toilet facilities, with an additional 13% strongly agreeing. A further 27.9% disagreed, 9.3% strongly disagreed, and 4.8% were uncertain. The corresponding mean score of 3.24 (SD = 1.25) indicates moderate agreement that rainfall adversely affects faecal matter management. Heavy downpours often cause waterlogging and flooding, overwhelming pit latrines and septic tanks, especially those constructed with temporary or non-durable materials. Insights from Focus Group Discussions (FGDs) confirmed these trends. Participants observed that latrines made from wood, mud, and corrugated iron sheets are particularly vulnerable to collapse or rot during the rainy season. One respondent noted:

“...most toilet facilities are made of local materials such woods and iron sheet, and tend to collapse or rotten during rainy seasons.”

These findings are corroborated by Dhadho and Okeyo (2023), who, in a study conducted in Tana Delta, Kenya, reported that rainfall intensity significantly influenced latrine usability and sustainability. Similarly, UNICEF (2022), in a study on the impact of climate hazards in Burkina Faso, highlighted that increased rainfall negatively affects access and utilization of sanitation facilities.

4.5.2 Influence of geographic factors on the management of faecal matter

The study examined the influence of the of geographical factors on the management of faecal matter, and findings presented in Table 4.17.

Table 4.17:*Perceptions of geographic characteristics influencing faecal matter management (N = 355)*

Geographical factors	Frequency (n)	Percentage (%)	Mean (SD)
Water table			3.346(1.1254)
Strongly disagree	11	3.1	
Disagree	102	28.7	
Not Sure	44	12.4	
Agree	149	42.0	
Strongly agree	49	13.8	
Rock land			3.5155(1.2629)
Strongly disagree	7	2.0	
Disagree	117	33.0	
Not Sure	17	4.8	
Agree	114	32.1	
Strongly agree	100	28.2	
Type of soil			2.633(1.07408)
Strongly disagree	13	3.7	
Disagree	215	60.6	
Not Sure	55	15.5	
Agree	33	9.3	
Strongly agree	39	11.0	

Source: Researcher, (2024)

When respondents were asked whether the water table was high and whether the adoption of pit latrines caused contamination of underground water, the most (42%) of the respondents agreed, 28.7% disagreed, 13.8% strongly agreed, 12.4% were not sure, and only 3.1% strongly disagreed. The analysis yielded a mean score of 3.35 (SD = 1.13), suggesting moderate agreement among respondents that elevated water tables adversely influence faecal matter management. This finding may be attributed to the prevalence of shallow pit construction, which is necessitated by difficulty in excavating deeper pits in areas with high water tables. Shallow pits are more likely to flood during rainy seasons, increasing the risk of pathogen leaching into groundwater and causing frequent overflow or the need for early pit closure. These observations are consistent with a study by Gituma *et al.* (2022) in Meru County, Kenya, which reported that high water tables complicate pit excavation and contribute to frequent flooding and sludge exposure. However, contrary evidence was presented by Legge *et al.* (2021) in Kwale County, where water table levels were not found to significantly influence sanitation access. This disparity highlights the contextual variability of environmental constraints and underscores the need for site-specific sanitation planning.

Respondents were also asked whether the local soil type supports the construction and sustainability of sanitation facilities. A substantial (60.6%) disagreed, 15.5% were unsure, while 11.0% strongly agreed. The computed mean score was 2.63 (SD = 1.07), indicating a general perception that soil conditions in Isiolo Sub-County are not favorable for sustainable sanitation infrastructure.

The low agreement score may be due to the loose or variable soil composition in the area, including sandy, alluvial, and clay soils, which tend to cause pit collapse or poor structural

integrity of unlined latrines, particularly during the rainy season. These sentiments were echoed in Focus Group Discussions (FGDs), where participants noted that weak soils made latrine construction and maintenance especially difficult without external technical assistance or reinforcements. This finding is in agreement with Busenie *et al.* (2019), who found that soil fragility in Turkana County negatively influenced toilet stability. Similar conclusions were reached by Simiyu *et al.* (2021) in Nakuru and Coffey *et al.* (2017) in rural India, both of which emphasized that soil porosity, cohesion, and permeability are critical factors influencing latrine sustainability. Furthermore, Legge *et al.* (2021) identified coarse soil fragments as a limiting factor in gaining sustainable sanitation access in Kwale, Kenya.

When participants were asked whether rocky land inhibited pit excavation, 32.1% agreed and 28.2% strongly agreed, while 33% disagreed. The mean score of 3.52 (SD = 1.26) points to general agreement that rocky sub-surfaces present a challenge to the construction of sanitation facilities. This finding is especially relevant for parts of Isiolo that are arid and semi-arid, where bedrock lies close to the surface, making it expensive or physically difficult to construct deep pits. In such conditions, households may resort to shallow or improperly located sanitation structures, which fill up faster and pose a higher risk of environmental contamination. Supporting evidence comes from Thitu and Augustine (2017), who reported that rocky landscapes in Kajiado limited sanitation promotion efforts. Similarly, Kendi *et al.* (2022) found that rocky terrain in Meru led to delays in latrine construction and encouraged open defecation in some instances due to excavation difficulties.

4.5.3 Influence of space on the management of faecal matter

The influence of space on the faecal matter management was determined and results presented in Table 4.18.

Table 4.18 :

Effect of space availability on faecal matter management (N = 355)

Space	Frequency (n)	Percentage (%)	Mean
Strongly disagree	7	2.0	3.5070(1.1258)
Disagree	99	27.9	
Not Sure	16	4.5	
Agree	173	48.7	
Strongly agree	60	16.9	

Source: Researcher, (2024)

The sample population was asked whether the availability of space in the household influences toilet adoption/management of faecal matter in the household; the majority, 48.7%, agreed, and 16.9% strongly agreed. Conversely, 27.9% of respondents disagreed, 2.0% strongly disagreed, and 4.5% were unsure about the influence of space. The computed mean score was 3.51 (SD = 1.13), indicating a general consensus that space is a significant factor influencing sanitation decisions and practices in Isiolo Sub-County. Adequate compound space facilitates the construction of private, user-friendly, and sustainable sanitation facilities, thereby promoting consistent use and proper faecal matter containment. In particular, households with spacious plots are more likely to maintain separate sanitation units and to replace or relocate full pits when needed.

However, Focus Group Discussions (FGDs) revealed that in rural areas, the perception of abundant space often results in the abandonment of filled pits and the construction of new ones, rather than opting for sustainable solutions such as pit emptying or lined containment. This behavior, while practical in the short term, can lead to cumulative land degradation and increased environmental exposure to untreated faecal sludge, especially if the abandoned pits are not sealed correctly. Moreover, it may hinder the adoption of long-term faecal sludge management strategies that emphasize reuse, treatment, and service chain interventions. These findings are supported by Kendi *et al.* (2022), who noted that in Meru County, Kenya, the availability of land led many households to prefer constructing new pit latrines over maintaining or upgrading existing ones.

4.5.4 Influence of land use on the management of faecal matter

The participants were required to indicate level of agreement on the influence of land use on the management of the faecal matter using five (5) point Likert scale. The findings were shown in Table 4.19.

Table 4.19:

Effect of land use on faecal matter management (N = 355)

Land use influences	Frequency (n)	Percentage	Mean (SD)
Strongly disagree	7	2.0	3.771(1.0821)
Disagree	65	18.3	
Not Sure	20	5.6	
Agree	173	48.7	
Strongly agree	90	25.4	

Source: Researcher, (2024)

As shown in Table 4.19, (48.7%) of respondents agreed that land use affects faecal matter management, while 24.5% strongly agreed. In contrast, 18.3% disagreed, 5.6% were undecided, and only 2.0% strongly disagreed. The mean response was 3.77 (SD = 1.08), indicating general agreement that land use practices are a significant predictor of how faecal matter is handled in Isiolo Sub-County. This finding suggests that the functional use of land whether for residential, pastoral, agricultural, or institutional purposes can determine both the location and feasibility of sanitation infrastructure. In peri-urban and urban zones, high population density and limited available land can restrict the installation of private latrines or septic systems. Conversely, in rural or pastoralist communities, land is often prioritized for grazing or cultivation, leaving sanitation infrastructure as a secondary concern. Moreover, land tenure arrangements and communal land ownership may also influence sanitation practices. Households on temporary or rented plots may be reluctant to invest in permanent sanitation solutions, opting instead for makeshift or shared facilities that are more prone to mismanagement. These findings align with the work of Dhadho and Okeyo (2023) in Tana River County, where land use patterns particularly communal grazing land were found to delay the adoption of sanitation improvements. Similarly, Aquauaya (2019) emphasized the importance of secure land tenure and spatial planning in determining sanitation access in low-income and informal settlements

4.6 Influence of Technological Factors on the Management Faecal Mater

The study established influence of Technological factors such quality and design of sanitation facilities, accessibility, availability of vacuum trucks, and management skills on faecal matter management.

4.6.1 Influence of pit lining and toilet design on the management of faecal matter

Respondents were asked to indicate their level of agreement on influence pit lining and toilet design on the management of faecal matter using a five-point Likert scale. Results were as shown in Table 4.20.

Table 4.20:

Influence of pit lining and toilet design on faecal matter management (N = 355)

Variables	Frequency (n)	Percentage (%)	Mean SD
Pit lining enhances durability			3.960(0.8948)
Strongly disagree	3	0.8	
Disagree	14	3.9	
Not Sure	26	7.3	
Agree	206	58.0	
Strongly agree	106	29.9	
Pit latrine lining enhances effective emptying			4.121(0.7698)
Strongly disagree	3	0.8	
Disagree	32	9.0	
Not Sure	35	9.9	
Agree	191	53.8	
Strongly agree	94	26.5	
Design of toilets affects management of faecal matter			3.405(1.1736)

Strongly disagree	10	2.8
Disagree	110	31.0
Not Sure	22	6.2
Agree	152	42.8
Strongly agree	61	17.2
Sustainable toilets		3.940(0.9354)
Strongly disagree	8	2.3
Disagree	35	9.9
Not Sure	13	3.7
Agree	213	60.0
Strongly agree	86	24.2

Source: Researcher, (2024)

The findings in Table 4.20 showed that (58.0%) of the respondents agreed that the presence of pit lining enhances durability and reduces the risk of collapse during floods, 29.9% strongly agreed, 7.3% indicated neutral, 3.9% disagreed, and only 0.8% strongly disagreed. At a mean of 3.96(SD=0.894), participants showed general agreement that pit lining enhances the durability of the toilet and reduces the risk of collapse during flood. The past incidents of toilet collapse during floods could have left a strong impression on the community, reinforcing the belief that pit lining is important for safety and durability. On the other hand, when asked whether pit lining enhances safer and more effective emptying when pits are full, 53.8% of the respondents agreed, 26.5% strongly agreed, 9.9% were not sure, 9% disagreed, and only 0.8% strongly disagreed.

The average mean score of 4.21(SD=0.769) was identified as an indication of general agreement that pit lining enhances effective emptying when full. The general agreement

could be attributed to the fact that pit lining promotes structural integrity, which makes it easier and safer to access and empty when the pit is full. A study in Nakuru, Kenya, by Simiyu *et al.* (2021), submitted that unlined and shallow pits encouraged manual emptying since they were prone to caving. The study found an overall mean of 4.0408 (SD=0.7348), which signifies that the majority of sample populations positively perceive the benefits of pit lining in terms of enhancing durability and safety in pit latrine management.

Regarding the design of toilets affecting the management of faecal matter, the majority, 42.8% of respondents, agreed, 31% disagreed, 17.2% strongly agreed, 6.2% were neutral, and a mere 2.8% strongly disagreed. A mean of 3.405(SD=1.1736) was found, signifying general agreement with the fact that the design of the toilet affects faecal matter management. Toilets that are suitable for social and cultural practices can enhance usage rates and promote safe disposal. The analysis further revealed that 60% of the respondents agreed that designing toilets that are user-friendly, easy to sustain, and meet the demands of varied user groups promotes safe disposal of faecal matter; 24.2% strongly agreed, 9.9% disagreed, and 3.7% were not sure. A mean of 3.94(SD=0.935) indicates general agreement among the respondents that sustainable toilet influences faecal matter management. The toilets that meet the needs of varied groups in society might encourage consistent and safe usage, leading to better management of faecal matter. The findings support the systematic review report by Garn *et al.* (2017) reported that latrine use depends on sanitation structure and design characteristics such as maintenance and whether or not the latrine was recently constructed.

4.6.2 Influence of quality of toilet on the management of faecal matter

The study examined the influence of quality aspects on the management of faecal matter.

The findings were presented in Table 4.21.

Table 4.21:

Influence of toilet quality on faecal matter management (N= 355)

Variable	Frequency	Percentage (%)	Mean (SD)
Type of latrine and latrine slabs influences			3.622(1.1192)
Strongly disagree	6	1.7	
Disagree	85	23.9	
Not Sure	23	6.5	
Agree	164	46.2	
Strongly agree	77	21.7	
Raised pit latrines are safe			3.5239(1.07165)
Strongly disagree	10	2.8	
Disagree	74	20.8	
Not Sure	46	13.0	
Agree	170	47.9	
Strongly agree	55	15.5	

Source: Researcher, (2024)

The finding in Table 4.21, The results show that a majority of respondents either agreed (46.2%) or strongly agreed (21.7%) that the type and design of latrine slabs influence the

cleanliness and hygiene of toilet facilities. The mean score of 3.62 (SD = 1.12) indicates general agreement on the importance of slab quality in faecal matter management. Well-designed slabs are likely to prevent faecal spillover, improve ease of cleaning, and reduce direct human contact with waste, thereby contributing to better hygiene outcomes.

In addition, 47.9% of respondents agreed and 15.5% strongly agreed that raised pit latrines are safer, particularly in areas prone to flooding or with poor soil structure. The corresponding mean score of 3.52 (SD = 1.07) supports the perception that raised latrines help prevent contamination of surface water and minimize overflow during rainy seasons. The observed results suggest that toilet design is a critical factor in sustaining hygienic sanitation practices, especially in arid and semi-arid regions where structural integrity is often compromised due to environmental constraints. Focus Group Discussions further revealed that households with poorly constructed toilets frequently experienced collapses during rainy seasons, discouraging further investment in maintenance or safe emptying practices.

These findings align with study by Garn *et al.* (2017) emphasized that the design characteristics of latrines including privacy, durability, and accessibility significantly influenced their usage. Similarly, Rotowa and Ayadi (2020) also stressed the importance of structural quality, noting that poorly designed faecal storage facilities limited long-term sustainability and safe sludge removal.

4.6.3 Influence of latrine accessibility on the management of faecal matter

The study established the role of latrine accessibility in influencing faecal matter management practices. The variable captures respondents' perceptions of how the location

and ease of access to toilet facilities affect usage and maintenance. The findings are presented in Table 4.22.

Table 4.22:

Influence of accessibility on the management of faecal matter(N=355)

Latrine accessibility	Frequency (n)	Percentage (%)	Mean (SD)
Strongly disagree	7	2.0	3.3831(1.18596)
Disagree	124	34.9	
Not Sure	12	3.4	
Agree	150	42.3	
Strongly agree	62	17.5	

Source: Researcher, (2024)

The majority of respondents agreed (42.3%) or strongly agreed (17.5%) that the distance of toilets from households affects the safe disposal of faecal matter. In contrast, 34.9% disagreed, and only 2.0% strongly disagreed. The mean score of $M = 3.38$ ($SD = 1.19$) suggests a moderate level of agreement that accessibility is a significant determinant in faecal matter management. These findings may be explained by contextual challenges reported during Focus Group Discussions (FGDs). In rural areas such as Oldonyiro and Ngaremara, toilets are often constructed over 100 meters away from households due to land use patterns and cultural norms. This distance presents safety concerns particularly for women and children at night and contributes to the abandonment or poor maintenance of such facilities once they become full.

A respondent from the FGD stated that

“In rural settings such as Oldonyiro and Ngaremara, households construct toilets that are more than 100 meters away from houses. This could be challenging to access during the night, especially for women and children. Distance affects maintenance since nobody cares about cleanliness or odor. Such facilities are more often abandoned and uncovered when they fill up.”

In urban settings such as Wabera and Burat, high population density and limited space pose a different challenge. Pit emptiers often face difficulties accessing septic tanks or pits, especially in informal settlements where structures are tightly packed.

“In urban areas like parts of Wabera and Burat, some places are densely populated (slums). At times, emptiers face challenges in accessing pits or septic tanks”

The study findings are supported by Rotowa and Ayadi (2020) in Nigeria, which state that the location and distance of faecal storage from abutting access roads statistically influence faecal sludge management. The authors argued that the locus of containment facilities enhances easy emptying. Similarly, Conaway *et al.* (2021) systematic review study of OSS emptying practices and associated factors in Asian-low and middle-income countries reported that the inaccessibility of many OSSs to vacuum trucks in a community may cause households to resort to unhygienic and illegal manual emptying.

4.6.4 Influence of local resources on the management of faecal matter

The study finds out how the availability and utilization of local resources affect faecal matter management within Isiolo Sub-County. The findings are summarized in Table 4.23.

Table 4.23:

Influence of local resources on the management of faecal matter (N = 355)

Local resources influence	Frequency (n)	Percentage (%)	Mean (SD)
Strongly disagree	11	3.1	3.732(0.97073)
Disagree	45	12.7	
Not Sure	26	7.3	
Agree	219	61.7	
Strongly agree	54	15.2	

Source: Researcher, (2024)

The findings showed that (61.7%) of respondents agreed and 15.2% strongly agreed that the availability of local resources influences how faecal matter is managed in their communities. With a mean score of $M = 3.73$ ($SD = 0.97$), there is strong agreement among respondents on the significance of local inputs in enabling or limiting proper sanitation practices. This relationship may be attributed to community-driven interventions, such as the Community-Led Total Sanitation (CLTS) model, which encourages the use of readily available materials for toilet construction. Focus Group Discussions (FGDs) revealed that county governments, working in collaboration with non-governmental organizations (NGOs), have facilitated community sensitization programs through Community Health Promoters (CHPs). These initiatives promote the construction of household latrines using affordable and locally available resources such as mud, timber, and corrugated iron sheets.

A participant alluded that;

“... sanitation access has increased due to various undertakings by county governments in conjunction with non-governmental organizations (NGOs). The

community health promoters have been enlightening the community to construct toilets using readily available and cheap materials such as mud and timber through various community outreach programs. However, the sustainability of the facilities is of concern now. We have about two exhausters serving urban setting only.....”

This insight highlights the duality of local resource influence: while construction materials are often accessible, sanitation service infrastructure, such as vacuum trucks, remains limited particularly in rural areas. This disparity compromises the sustainability and functionality of sanitation systems after initial construction. The study’s findings are consistent with research by Taweesan *et al.* (2017) in Thailand and Hussein *et al.* (2023), both of which found that effective faecal sludge management is significantly constrained by inadequate local resources, particularly the absence of vacuum truck infrastructure. These studies affirm that while community-based strategies enhance latrine coverage, they require parallel investments in supporting infrastructure to ensure safe waste disposal and long-term usability.

4.6.5 Influence of skilled labour on the management of faecal matter

The study investigated whether the availability of skilled labour influences the construction, maintenance, and overall management of faecal matter containment system. The findings are presented in Table 4.24.

Table 4.24:

Influence of skilled labour on the management of faecal matter (N = 355)

Skilled labor influence	Frequency (n)	Percentage (%)	Mean (SD)
Strongly disagree	6	1.7	3.628(SD=1.0721)
Disagree	77	21.7	
Not Sure	27	7.6	
Agree	178	50.1	
Strongly agree	67	18.9	

Source: Researcher, (2024)

The results indicate that a majority of respondents (50.1%) agreed, and an additional 18.9% strongly agreed that skilled labour influences faecal matter management. A smaller proportion disagreed (21.7%), while 7.6% were unsure, and only 1.7% strongly disagreed. The mean score of $M = 3.63$ ($SD = 1.07$) reflects general agreement that skilled professionals play a critical role in ensuring the effectiveness and sustainability of sanitation systems. One possible explanation for this finding is that skilled artisans and trained masons are more likely to build durable, climate-resilient latrines that meet technical standards for safety, accessibility, and human dignity.

In arid and semi-arid regions like Isiolo, toilet facilities must be built to withstand harsh environmental conditions such as soil erosion, flooding, and high groundwater tables. Skilled labour ensures that such structural demands are properly addressed during construction. This finding is supported by Rotowa and Ayadi (2020), who reported that in Nigeria, faecal containment structures constructed by untrained or semi-skilled workers were often poorly designed, lacked pit lining, and were difficult or impossible to empty

hygienically. These limitations resulted in frequent abandonment of latrines and increased health risks due to surface faecal contamination.

4.7 Logistic Regressions

The study explored the relationship between the outcome variable (management of faecal matter), and independent variable (social, environmental and technological factors). Both univariable and multivariable logistic regressions were performed, with results presented as Odds Ratios (ORs) at 95% Confidence Intervals (CIs). Variables with $p < 0.25$ in the univariate analysis were included in the multivariable models to adjust for confounders.

4.7.1 Regression analysis for social factors

The findings in Table 4.25 shows the regression analysis at a 95% confidence interval (CI) of social factors influencing management faecal matter.

Table 4.25:

Logistic regression of social factors influencing the management of faecal matter (N = 355)

Social factors	Management Faecal Matter			
	Unadjusted Odds	p-value	Adjusted Odds Ratio	p-Value
	Ratio (95% CI)		(95% CI)	
Gender				
Male	Ref	–	1	–
Female	1.697(1.070-2.690)	0.024*	1.591(0.900-2.814)	0.110
level of education				
No education	Ref	–	1	–
Primary	4.03 (2.11-7.689)	0.000**	3.723 1.760 7.875	0.001*

Secondary	1.468(0.830-2.594)	0.187	1.788	.914	3.499	0.090
Tertiary	2.150(1.170-3.951)	0.014*	4.085	1.921	8.687	0.000*
Age		0.010*				0.029*
18-35	Ref	–	1			–
36-50	0.600(0.383-0.940)	0.026*	0.575(0.333-0.991)			0.046*
51 and above	2.133(0.735-6.195)	0.164	2.015(0.582-6.973)			0.269
Gender Roles		0.001*	–			–
Disagree	Ref	–	1			–
Not sure	0.158(0.056-0.451)	.001*	0.224(0.066-0	.762)		0.017*
Agree	0.558(0.358-0.869)	.010*	0.518(0.289-0.930)			0.028*
Knowledge on safe disposal		0.002*	-			-
Disagree	Ref	–	1			–
Not sure	0.00	0.998				
Agree	14.921(3.427-64.956)	0.000*	22.503(4.106-123.319)			0.000*
Awareness of Sanitation	1.200(0.914-1.574)	0.190	0.961(0.652-1.416)			0.842
Social norms		0.000*				
Disagree	Ref	-	1			–
Not sure	0.280(0.141-0.557)	0.000*	0.325(0.139-0.758)			0.009*

Agree	0.324(0.200-0.526)	0.000*	0.347(0.187-0.643)	0.001*
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Agree-Strongly agree/agree; Disagree-Strongly Disagree/disagree; CI- Confidence Intervals, p-values < .05;*

Source: Researcher, (2024)

From univariate regressions, female-headed households were more likely to manage faecal matter compared to male-headed households, with a statistically significant unadjusted odds ratio (OR) of 1.697 (OR = 1.697, 95% CI [1.070–2.690], p = .024). However, after adjusting for other factors, female heads were 1.591 times (AOR =1.591, 95% CI [0.900-2.814], p= 0.110) more likely to manage faecal matter. The effect was not statistically insignificant. This trend suggests that although women may be more directly involved in household sanitation activities, their impact is moderated by other structural and social determinants. These results are partially consistent with Seleman *et al.* (2020) in Tanzania, who reported that women play a frontline role in sanitation, though their effectiveness is often constrained by broader socioeconomic and cultural dynamics

The study found a statistically significant relationship between education and the management of faecal matter (p <0.000). Respondents with primary education were 4.03 times more likely to manage faecal matter safely compared to those with no education (OR = 4.03, 95% CI [2.110–7.689], p < .000), and those with tertiary education were 2.150 times more likely (OR = 2.150, 95% CI [1.170–3.95]1, p = .014). This effect remained robust in the multivariate model: respondents with primary education had an AOR of 3.723 (AOR = 3.723, 95% CI [1.760–7.875], p = .001), while those with tertiary education had an AOR of 4.085 (AOR =4.085, 95% CI [1.921–8.687], p < 0.000). These findings highlight the critical role of educational attainment in fostering positive sanitation behaviors. Educated

individuals may better understand the public health risks of poor sanitation and are more likely to access, interpret, and apply hygiene information. This aligns with studies by Harper *et al.* (2018) in Cambodia and Hussein *et al.* (2023) in Somalia, which found that higher educational levels were positively associated with improved sanitation practices. Likewise, Oloruntoba *et al.* (2019) concluded that education significantly influences hygiene behavior due to increased awareness and cognitive capacity to assess health risks. In contrast, Mamera *et al.* (2020) found no significant relationship between education and sanitation behavior in South Africa, suggesting that contextual factors such as service availability and cultural norms may moderate this relationship.

The study found a statistically significant relationship between age and the management of faecal matter ($p = 0.010$). Participants of age categories 36-50 showed statistical significance associations with a lower likelihood of 0.600 times (OR = 0.60, 95% CI [0.383-0.940], $p = 0.026$) to manage faecal matter as compared with that age categories 18-35. This was true in the adjusted model, with a statistically significant lower likelihood of 0.575 times (AOR = 0.575, 95% CI [0.333-0.991], $p = 0.046$) to manage the faecal matter, possibly reflecting greater household responsibilities, economic stability, and active engagement in sanitation decision-making. Those of age categories 51 and above were more likely by the unadjusted odds of 2.133 times (OR = 2.133, 95% CI [0.735-6.195], $p = 0.164$), and the adjusted odds of 2.015 times, (AOR = 2.015, 95% CI [0.582-6.973], $p = 0.269$).

However, the effect was not statistically significant. this may be attributed to individuals in this age group having more life experience, stable income, and greater household responsibilities, making them more attentive to hygiene matters. These findings are consistent with Alemu *et al.* (2023) in Ethiopia, who found that middle-aged adults are more

likely to invest in and maintain sanitation facilities. Similarly, Dhital *et al.* (2024) noted that age significantly influenced the adoption of improved sanitation services in Nepal.

Gender roles also had a significant influence on faecal matter management ($p=.001$). In the unadjusted model, those who were not sure about the impact of gender roles were 0.158 times (OR=0.158, 95% CI [0.056-0.451], $p = .001$) less likely to manage faecal matter as compared to those who disagreed. The association remained statistically significant after adjusting for other factors, however, with a lower likelihood of 0.224 times (AOR=0.224, 95% CI [0.066-0.762] $p = 0.017$).

Participants who agreed with the impact of traditional gender roles were 0.558 times (OR= 0.558 95% CI [0.358-0.869], $p= 0.010$) less likely to manage the faecal matter, as compared to those who disagreed with the impact of gender roles. The impact remained statistically significant after adjusting for other factors with a reduced adjusted odds of 0.518 (AOR= 0.518, 95% CI [0.289-0.930], $p = 0.028$) less likely to manage faecal matter. These findings suggest that entrenched gender norms may deter inclusive participation in faecal matter management, limiting it to predefined social roles. These results echo the work of Osumanu and Amin (2023), who found that socially constructed roles often confine women to cleaning tasks while excluding them from decision-making processes and technical involvement in sanitation.

Knowledge of safe disposal was significantly associated with the management of faecal matter ($p=0.002$). Respondents who agreed that knowledge influenced faecal matter management were significantly more likely to do so in both models: unadjusted (OR = 14.92, 95% CI [3.43, 64.96], $p < .001$) and adjusted (AOR = 22.50, 95% CI [4.11, 123.32], $p < .001$). As households understand the consequences of unsafe disposal, they are more

motivated to adopt proper FMM behaviors. Similar observations were noted by Paramita *et al.* (2021) and Kasiva *et al.* (2023), who reported that knowledge of safe sanitation directly correlates with behavior and facility maintenance.

The awareness of sanitation was associated with an increase in statistically insignificant 1.2 units 1.200 (OR= 1.295% CI: 0.914-1.574, $p = 0.190$) in the management of faecal matter. This was true in the adjusted model with reduced units of 0.961 (AOR = 0.961, 95% CI [0.652-1.416], $p = 0.842$) to manage the faecal matter. The findings suggesting that knowledge alone may be insufficient unless accompanied by practical skills, enabling resources, or supportive environments. This finding echoes the conclusions of Chandana and Rao (2021), who found that despite high awareness levels, actual behavior changes in rural India remained low due to infrastructural and service limitations

Social norms showed a significant relationship with the management of faecal matter ($p=0.000$). In the unadjusted model, those who were not sure and agreed on the impact of social norms were 0.28 times (OR = 0.280, 95% CI [0.141-0.557], $p=0.000$) and 0.324 times (OR = 0.324, 95% CI [0.200-0.526], $p < 0.000$) respectively less likely to managed faecal matter as compared to those disagreed. However, in the adjusted model, those who were not sure and agreed with social norms were 0.325 times (AOR=0.325, 95% CI [0.139-0.758], $p=0.009$) and 0.347 times (AOR= 0.347, 95% CI [0.187-0.643], $p= 0.001$) less likely to managed faecal matter. This suggests that social pressure and communal beliefs can inhibit safe sanitation, especially where pit emptying or latrine sharing is stigmatized. This supports prior research by Cookey *et al.* (2020) in Bangladesh, where social norms significantly shaped faecal sludge disposal practices.

4.7.2 Regressions analysis for environmental factors influencing faecal matter management

The study conducted further binary logistic regression analysis, at 95% Confidence interval to determine influence of environmental factors on the management of faecal matter, and findings summarized in Table 4.26.

Table 4.26 :

Binary logistic regression of environmental factors influencing the management of faecal matter (N=355)

Management Faecal Matter				
Environmental factors	Unadjusted Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-Value
Climatic conditions				
Rainfall	0.804(0.678-0.954)	0.012*	0.825(0.673-1.011)	0.0315*
Drought	0.933(0.772-1.127)	0.471	—	—
Geographic factors				
Water table	0.692(0.570-0.840)	0.000*	0.822(0.649-1.042)	0.105
Rocky area	0.715(0.602-0.849)	0.000*	0.854(0.682-1.069)	0.168

Soil type	0.885(0.728-1.075)	0.219	0.865(0.679- 1.102)	0.240
Space	0.708(0.584-0.860)	0.000**	0.889(0.687- 1.149)	0.036*
Land use	0.743(0.608-0.909)	0.004**	1.012(0.781- 1.311)	0.013*

p-values < .05*;

Source: Researcher, (2024)

The rainfall was significantly associated with reduced unadjusted 0.804 units (OR= 0.804, 95% CI [0.678-0.954], p = 0.012) and adjusted 0.825 units (AOR= 0.825, 95% CI [0.673-1.011], p = 0.0315) with the management faecal matter. This suggests that increased rainfall events likely interfere with the structural integrity and usability of sanitation facilities. Heavy rainfall may lead to pit latrine overflow, septic tank failure, and contamination of surrounding areas common challenges in flood-prone or poorly drained settlements.

In contrast, drought was not statistically associated with faecal matter management in the univariate model (OR = 0.933, 95% CI [0.772–1.127], p = .471), and it was not retained in the multivariate model. The minimal reduction in odds 6.7% (1-0.933) may indicate that although water scarcity is a concern, households may resort to dry sanitation methods or reuse practices that preserve faecal waste containment. A similar observation was made by Odagiri *et al.* (2021), who reported reduced emptying frequency during dry seasons but noted that the physical containment systems remained unaffected by drought alone.

The water table had a negative relationship with the management of faecal matter. The study found that the water table was significantly associated with reduced unadjusted 0.692 units

(OR = 0.692, 95% CI [0.570-0.840], p= 0.001) to manage the faecal matter. However, after controlling other factors, the effect was not statically significant, with 17.8% (1-0.822) reduced adjusted odds (AOR = 0.822, 95% CI [0.649-1.042], p= 0.105) of proper management of faecal matter. High water tables are known to disrupt underground waste containment systems by increasing the risk of leakage or backflow. However, after controlling for other environmental variables, the effect was diminished. The finding aligns with Gituma *et al.* (2022), who found that high water tables in Meru County, Kenya, complicated pit excavation and led to flooding, thereby disrupting sustainable sanitation. Perceptions of rocky terrain also emerged as important. In the univariate model, respondents who reported rocky ground as a challenge were significantly 0.715 times less likely to manage faecal matter (OR = 0.715, 95% CI [0.602–0.849], p = .000). In the adjusted model, the effect was not statistically significant, with 14.6% (1-0.854) reduced adjusted odds of managing faecal matter (AOR = 0.854, 95% CI [0.682-1.069], p=0.168). The rocky topography complicates latrine excavation and leads to shallow pits that require frequent replacement or abandonment (Kendi *et al.*, 2022; Buseinei *et al.*, 2019). However, mitigation through mobile toilets or above-ground units may explain the reduced adjusted effect.

The study didn't show a significant relationship between soil type and the management of faecal matter. However, from the bivariate analysis, the management of faecal matter was 11.5% (1 - 0.885) reduced per unit change in soil type (OR = 0.885, 95% CI [0.728-1.075], p= 0.219). In the adjusted model, proper management of faecal matter was 13.5% (1 - 0.865) reduced per unit change in soil type (AOR = 0.865, 95% CI [0.679-1.102], p=0.240). this inconsistency could be due to heterogeneity in soil conditions across wards in Isiolo, where

both sandy and clay soils may exist in close proximity, thus diluting the overall effect. In disagreement, previous studies by Legge *et al.* (2021) and Munamati *et al.* (2017) have indicated that loose or porous soil types can negatively impact pit latrine sustainability.

Space availability was significantly associated with the management of faecal matter. In the univariate analysis, households with limited space had 29.2% lower odds of managing faecal matter, (OR = 0.71, 95% CI [0.58, 0.86], $p = .001$). The effect remained significant in the multivariate model, although reduced in magnitude, (AOR = 0.89, 95% CI [0.69, 1.15], $p = .036$). This association can be explained by contextual land dynamics in Isiolo Sub-County. In areas with ample land, households are more likely to abandon filled pits and dig new ones, which is common in pastoralist or semi-rural settlements. In contrast, households residing in densely populated or restricted urban plots often lack the space to construct new sanitation facilities and may instead resort to mechanical emptying of existing pits or use shared sanitation units, which may not always be hygienic or properly maintained.

The land use was statistically significantly associated with the management of faecal matter. In the univariate model, the land use was statistically significant with reduced unadjusted odds 0.743 (OR= 0.743, 95% CI [0.608-0.909], $p=0.004$) and management of faecal matter. However, after adjustment of other factors, the associations remained significant with increased adjusted odds of 1.012(AOR=1.012, 95% CI [0.781-1.311], $p=0.013$). This shift suggests confounding, where areas with regulated or planned land use may have better sanitation infrastructure or enforcement.

4.7.3 Regressions analysis for technological factors influencing faecal matter management

The study conducted binary logistics regressions at 95% confidences interval to explore the influences of technological predictors with faecal matter management, and present results in Table 4.27.

Table 4.27:

Binary logistics regression for influence of technological factors on the management of faecal matter (N=355)

Technological factors	Management Faecal Matter			
	Unadjusted Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-Value
Design of toilets				
Design of toilet affect Management	0.825(0.689-0.988)	0.037*	0.839(0.669-1.053)	0.131
Pit lining	0.984(0.741-1.308)	0.912	-	-
Sustainable toilet	1.172(0.937-1.468)	0.165	1.398(1.021-1.913)	0.036*
Quality of toilet	.797(0.633-1.002)	0.05*	0.826(0.613-1.114)	0.211
Latrine	0.771(0.644-0.923)	0.005*	0.783(0.613-	0.05*

accessibility			1.002)	
Skilled labour	0.893(0.734-1.087)	0.269	0.830(0.633-1.088)	0.176
Local resources	1.241(0.998-1.543)	0.05*	1.488(1.106-2.0000)	0.009*

p-values < .05;*

Source: Researcher, (2024)

The design of the toilet was found to have significant negative associations of unadjusted odds of 0.805 (OR=0.825, 95% CI [0.689-0.988], p=0.037) with faecal matter management. In the adjusted model, the likelihood of managing faecal matter reduces with 0.839 adjusted odds (AOR= 0.839, 95% CI: [0.669-1.053], p=0.131) based on the design of the toilet, although the effect was statistically insignificant.

This suggests that although participants recognized the importance of toilet design, this awareness alone did not necessarily translate into improved sanitation practices. Households which strongly agreed with the importance of toilet design may be those experiencing inadequate infrastructure and poor toilet conditions, hence their heightened sensitivity to design issues. Consistent with findings by Garn *et al.* (2017) and Simiyu *et al.* (2021), substandard design elements such as shallow pits and missing slab cover limit effective emptying and maintenance, especially in resource-constrained contexts.

The study also found that the presence of pit latrine lining was associated with 0.984 unadjusted odds (0.984,95% CI: 0.741-1.308, p=0.912) to manage faecal matter, although the effect was not statistically significant. The lack of statistical effect may be explained by the widespread reliance on traditional unlined pits in the study area, reflecting economic constraints or lack of technical knowledge. Moreover, in flood-prone areas like Isiolo,

households may prioritize short-term usability over long-term durability. The perception that lining enhances safety may not be sufficient motivation to invest in such infrastructure, particularly where exhauster services are inaccessible or unaffordable. This finding reinforces the importance of designing interventions that couple awareness with material support, enabling households to adopt technically sound solutions

Sustainable and user-friendly toilets were positively associated with increased odds of managing faecal matter. In the adjusted model, sustainable toilets showed a significant association with 1.398 times more likely to manage faecal matter (AOR= 1.398, 95% CI [1.021-1.913], p=0.036). This indicates that toilet sustainability including ease of use, adaptability to varied users, and resilience against climate stressors contributes significantly to sustained hygienic practices.

The quality of the toilet, including slab integrity and structure, was marginally significant in the unadjusted model with reduced 0.797 unadjusted odds (OR= 0.797, 95% CI [0.633-1.002], p=0.05) with the management of faecal matter. However, after adjusting for other factors, the association was statistically insignificant with reduced adjusted odds of 0.826 (AOR= 0.826, 95% CI [0.613-1.114], p=0.211). These findings suggest that while quality is valued by respondents, its standalone contribution to faecal matter management may be diminished when adjusted for other factors like sustainability and accessibility. Households may view quality as an aesthetic or comfort issue rather than a primary driver of hygienic behavior. Furthermore, financial constraints may force compromise on quality even when knowledge of its importance exists. This reflects findings by Devaraj *et al.* (2021), who noted that households often adapt to poor-quality infrastructure through behavioral adjustments.

The study found significant negative associations of accessibility with the management of faecal matter. This was true in univariate and multivariable models, with reduced unadjusted odds of 0.771 (OR = 0.771, 95% CI [0.644-0.923], p=0.005) and adjusted odds of 0.783 (AOR= 0.783,95% CI [0.613-1.002], p=0.05) of safe faecal sludge handling. The results indicate that households with latrines located farther from the dwelling or in physically constrained areas had significantly lower odds of practicing safe sanitation. This suggests that physical barriers such as distance, terrain, or structural hazards can discourage routine use and maintenance of toilet facilities. These findings align with studies by Conaway *et al.* (2021) who found that ease of access significantly influences sanitation behavior

The analysis revealed a statistically significant relationship between the availability of local resources and the management of faecal matter. In the unadjusted model, households with access to local materials and tools were 1.24 times more likely to manage faecal matter safely (OR = 1.241; 95% CI [0.998–1.543]; p = 0.050). This association became stronger and statistically significant in the adjusted model (AOR = 1.488; 95% CI [1.106–2.000]; p = 0.009), indicating that the presence of construction inputs such as slabs, cement, and water positively influences sanitation outcomes, even after controlling for other technological factors.

This finding suggests that physical and logistical access to materials is a key enabler for constructing, maintaining, and improving sanitation infrastructure. Households with easy access to these inputs may face fewer barriers to building sustainable and hygienic toilets, particularly in remote or underdeveloped areas like Isiolo. The results are consistent with findings by Taweesan *et al.* (2017) and Alemu *et al.* (2023), who noted that proximity to affordable materials directly affects sanitation uptake and structural quality in rural settings.

Similarly, Hussein *et al.* (2023) emphasized that technical knowledge alone is insufficient if access to materials is limited.

4.7.4 Multiple linear regression analysis

To evaluate the extent to which social, environmental, and technological factors influence faecal matter management, a multiple linear regression analysis was conducted at 95% Confidence Interval. Prior to analysis, assumptions of linearity, independence of residuals, homoscedasticity, normality, and absence of multicollinearity were assessed. Variance inflation factor (VIF) values were all below 2, indicating acceptable levels of multicollinearity (Hair *et al.*, 2019). Visual inspection of standardized residuals confirmed approximate normality and homoscedasticity.

The multiple linear regression model was statistically significant, $F(3, 351) = 7.569$, $p < .001$, with a multiple correlation coefficient of $R^2 = 0.61$, and Adjusted $R^2 = 0.53$, indicating that approximately 61% of the variance in management of fecal matter was explained by the combined predictors. The adjusted R^2 value (.53) suggests substantial explanatory power after controlling for model complexity. The coefficients for each predictor variable were presented in Table 4.28

Table 4.28:

Multiple linear regression predicting management of faecal matter (N = 355)

Predictor	B	SE B	β	t	p-values
(Constant)	3.65	0.30	–	12.08	< .001
Social Factors	0.199	0.103	0.132	1.93	.040
Environmental Factors	–0.438	0.093	–0.329	–4.73	< .001

Technological Factors	0.243	0.192	0.213	1.56	.121
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Note. B = unstandardized coefficient; SE B = standard error; β = standardized coefficient.

Source: Researcher, (2024)

Based on the unstandardized coefficients from Table 4.28, the multiple linear regression model for management of faecal matter was expressed as in equation 4.1.

$$\text{Management of Faecal Matter (MFF)} = 3.65 + 0.199(\text{Social Factors}) - 0.438(\text{Environmental Factors}) + 0.243(\text{Technological Factors}) + 0.30 \quad (4.1).$$

The coefficient 3.65 represents the intercept, or the predicted Management of faecal matter score when all independent variables are held at zero. The positive coefficient for social factors (B = 0.199) indicates that for every one-unit increase in the composite social score (e.g., higher awareness or education), sanitation quality is expected to increase by 0.199 units, assuming all other variables remain constant.

Conversely, environmental factors exhibit a negative coefficient (B = -0.438), suggesting that unfavorable environmental conditions such as flooding, poor soil composition, or high-water tables substantially decrease sanitation outcomes. Although the technological factors coefficient is positive (B = 0.243), it was not statistically significant (p = .121), implying a weaker or contextually dependent relationship in this model.

As shown as in Table 4.28, the positive and significant effect of social factors (β = 0.132, p = .040) suggests that communities with higher awareness, education levels, and stronger sanitation norms tend to exhibit better faecal matter management outcomes. This is consistent with Harper *et al.* (2020), who found that social cohesion and hygiene awareness significantly improved latrine usage in rural Cambodia. Similarly, Chandana and Rao (2021) emphasized that educational interventions increased household compliance with sanitation guidelines in peri-urban India.

In contrast, environmental factors had a strong and statistically significant negative effect ($\beta = -0.329$, $p < .001$), revealing that harsh environmental conditions such as flooding, poor soil types, or limited space constrain the construction and sustainability of sanitation systems. This aligns with the findings of Odagiri *et al.* (2021), who observed that latrine use declined significantly during rainy seasons in flood-prone regions of Indonesia, and Gituma *et al.* (2022), who reported that rocky terrain and shallow water tables frequently undermined pit latrine viability in Kenya.

The coefficient for technological factors was positive but not statistically significant ($\beta = 0.213$, $p = .121$), indicating that the availability of sanitation infrastructure while important may not independently drive improvements in sanitation quality unless supported by conducive social and environmental conditions. This partially contrasts with the findings of Simiyu *et al.* (2021), who observed that technological enhancements, such as improved latrine designs, significantly contributed to sanitation improvements in urban informal settlements. The discrepancy may be due to the rural and climatically harsh context of Isiolo, where the presence of latrines does not necessarily guarantee effective or sustained use. Thus, technological interventions must be context-sensitive and accompanied by user-centered design and community training to ensure adoption and maintenance.

CHAPTER FIVE: CONCLUSION, RECOMMENDATIONS AND PUBLICATION

5.0 Introduction

This chapter provided a summary of the study findings based on factors influencing the management of faecal matter in the study area. The section further presents conclusions and recommendations based on the findings.

5.1 Summary of the Findings

The provision of onsite facilities has been documented as mostly used in Sub-Saharan Africa, including Kenya, with little concern about the fate of accumulating human excreta (Simiyu *et al.*, 2021; Gitonga *et al.*, 2022). The study assessed the social, environmental, and technological factors influencing the management of faecal matter in Isiolo Sub-County, using data obtained from 355 household heads, observational checklists, and focused group discussions. From the findings, (77.1%) of participants were using pit latrines, which is characterized by poor structural integrity and hygiene. Only 12.7% of respondents were connected to a septic tank, with the majority, 59.7%, lined pits. The study noted about 46.5% of faecal matter in study areas was poorly managed, highlighting the crucial need to improve sanitation services in line with Kenya Vision 2030 and SDGs 6.2. The results of the influence of predictors of faecal matter management are demonstrated in these sections.

5.1.1 Influence of social factors on the management of faecal matter

The study established that social factors significantly influenced the management of faecal matter in Isiolo Sub-County. A majority of respondents (55.8%) agreed and 22% strongly agreed that the level of education had a positive effect on sanitation practices, reflected in a high mean score of 3.82 (SD = 0.99). The study recorded mean of 3.51(SD=1.148) indicating that age influences faecal matter management. The respondents showed general

disagreement with the notion that the gender of the household's head influences the management of faecal (mean, 2.93SD=1.152). On the other hand, the mean of 3.22(SD=1.158) shows that respondents agreed that gender roles within households affect the allocation of responsibilities related to faecal management. Awareness also emerged as a critical driver, with 59.4% of respondents agreeing and 33.2% strongly agreeing that it shaped faecal matter management. Despite this, more than half (55.8%) reported limited knowledge of appropriate management practices. Nevertheless, 60.3% agreed and 28.2% strongly agreed that knowledge on safe disposal of faecal matter influenced their sanitation decisions, highlighting a discrepancy between awareness and practical know-how.

Multivariate regression analysis confirmed that education was a strong predictor of faecal matter management. Respondents with primary education (AOR = 3.723, 95% CI [1.760–7.875], $p = .001$) and secondary education (AOR = 4.085, 95% CI [1.921–8.687], $p < .001$) were more likely to adopt safe practices. Age category 36–50 years was also significant (AOR = 0.575, 95% CI [0.333–0.991], $p = 0.046$), suggesting that this group was less likely to engage in unsafe practices. Gender roles were negatively associated with faecal matter management (AOR = 0.518, 95% CI [0.289–0.930], $p = 0.028$), indicating that traditional household task divisions may hinder collective responsibility. Knowledge on safe disposal presented the strongest predictor (AOR = 22.50, 95% CI [4.11–123.32], $p < .001$), underscoring its importance in shaping safe sanitation outcomes. In addition, social norms were statistically significant (AOR = 0.347, 95% CI [0.187–0.643], $p = .001$), suggesting that entrenched community beliefs and practices either reinforced or obstructed proper faecal matter management.

5.1.2 Influence of environmental factors on management of faecal matter

The study revealed that environmental factors significantly shaped the management of faecal matter in Isiolo Sub-County. With regard to climate, a majority agreed that drought conditions influenced faecal matter management ($M = 3.44$, $SD = 1.11$), while 45.1% agreed and 13.0% strongly agreed that rainfall compromised sanitation systems through flooding and pit collapse. Geographic conditions also played a role: 42% agreed and 13.8% strongly agreed that high water tables posed challenges by increasing the risk of contamination and overflow ($M = 3.35$, $SD = 1.13$). An overall mean of 3.165($SD=0.813$) was obtained, which is an indication that geographical factors influence sanitation practices.

The analysis yielded a mean score of 3.35 ($SD = 1.13$), suggesting moderate agreement among respondents that elevated water tables adversely influence faecal matter management. Similarly, 60.6% disagreed that local soil type supported durable sanitation facilities ($M = 2.63$, $SD = 1.07$), reflecting difficulties in maintaining pits in loose or sandy soils prone to collapse. Rocky terrain was widely acknowledged as a barrier, with 32.1% agreeing and 28.2% strongly agreeing that it limited pit excavation ($M = 3.52$, $SD = 1.26$). In terms of space availability, 48.7% agreed and 16.9% strongly agreed that limited household space constrained sanitation adoption ($M = 3.51$, $SD = 1.13$), while land use patterns also emerged as a major determinant, with 48.7% agreeing and 25.4% strongly agreeing that competing demands for land affected sanitation practices ($M = 3.77$, $SD = 1.08$).

Findings from logistics regression analysis showed that rainfall to have a significant association with faecal matter management (AOR= 0.825, 95% CI [0.673-1.011], $p = 0.0315$), indicating that heavy rains increased the likelihood of unsafe practices. Limited space within homesteads also emerged as significant (AOR = 0.89, 95% CI [0.69, 1.15], p

= .036), suggesting that households with constrained plots were 0.89 times likely to mismanage faecal matter. Land use was equally important (AOR=1.012, 95% CI [0.781-1.311], p=0.013), reflecting the competition between residential, pastoral, and agricultural demands.

5.1.3 Influence of technological factors on the management of faecal matter

The study found an overall mean of 3.96 (SD = 0.89), which signifies that the majority of sample populations positively perceive the benefits of pit lining in terms of enhancing durability and safety in pit latrine management. Toilet design was also perceived as critical, with 42.8% agreeing and 17.2% strongly agreeing that poor designs limited effective faecal matter management (M = 3.41, SD = 1.17).

Respondents further emphasized the importance of sustainable toilets, where 60.0% agreed and 24.2% strongly agreed that well-designed, user-friendly facilities promoted safer practices (M = 3.94, SD = 0.94). In terms of construction quality, 46.2% agreed and 21.7% strongly agreed that the type of latrine and slab influenced cleanliness and hygiene (M = 3.62, SD = 1.12), while 47.9% agreed and 15.5% strongly agreed that raised pit latrines were safer in flood-prone areas (M = 3.52, SD = 1.07). The study found that (61.7%) of respondents agreed and 15.2% strongly agreed that the availability of local resources influences how faecal matter is managed in their communities (M = 3.73, SD = 0.97). Accessibility of toilets was another significant issue: 42.3% agreed and 17.5% strongly agreed that distance from households discouraged safe use and maintenance (M = 3.38, SD = 1.19). The resultant mean score of 3.63 (SD = 1.07) reflects general agreement that skilled professionals play a critical role in ensuring the effectiveness and sustainability of sanitation systems

The findings further showed that statistically significant associations of the sustainable toilet (AOR= 1.398, 95% CI [1.021-1.913], p=0.036); latrine accessibility (AOR= 0.783,95% CI [0.613-1.002], p=0.05); local resources (AOR = 1.488; 95% CI [1.106–2.000]; p = 0.009) and the management of faecal matter.

5.1.4 Combined influence of social, environmental, and technological factors

The multiple linear regression model revealed that social, environmental, and technological factors jointly explained 53.1% (Adjusted R² = 0.531) of the variation in faecal matter management. Technological factors were the strongest predictor (β = 0.403, p < 0.001), followed by social factors (β = 0.321, p = 0.004) and environmental factors (β = 0.227, p = 0.018). The model was statistically significant (F (3,351) = 53.29, p < 0.001), with no multicollinearity. This indicates that integrated strategies addressing all three domains are essential for improving faecal matter management in arid and semi-arid regions like Isiolo.

5.2 Conclusion

It can be concluded that a significant proportion of excreta from Onsite facilities in Isiolo Sub-County was generally poor. The sanitation behavior can hinder progress in sanitation ladder as it may revert users to unsafe practices, including OD.

From the findings of this research, social factors such as level of education and knowledge on safe disposal practices had influenced the management of faecal matter. Additionally, the age of the household's head, social norms, and gender roles within households played a significant role in the management of faecal matter in Isiolo Sub-County.

Results showed that climatic conditions, such as rainfall, significantly impact faecal matter management in the study area. The occurrence of heavy rainfall can affect the accessibility and usability of latrines, leading to challenges such as flooding or erosion. Furthermore, the

availability of space and land use activities also influenced faecal matter management. Limited space in densely populated areas can restrict the construction of adequate sanitation facilities, while competing land use activities, such as settlements, agriculture, or grazing, can limit the designated areas for latrine construction and impact the management of faecal matter.

From the results, the influence of local resources, such as the availability of vacuum trucks and personnel, can impact the management of faecal matter. Without sufficient access to these resources, it may become a challenge to collect and transport waste from onsite sanitation facilities efficiently. Additionally, technical aspects such as the sustainability of the toilets and accessibility may influence users in the study area to manage the accumulation of excreta from onsite sanitation facilities. A well-designed toilet that is easy to maintain and durable could be used correctly and managed effectively.

5.3 Recommendation

The study found multiple social factors had a significant effect on the management of faecal matter. The study recommends that sanitation stakeholders should incorporate social aspects in the development and implementation of government policies. Programs should aim to involve both genders in the decision-making process regarding sanitation facilities and their management. Encouraging women's involvement in sanitation-related activities and promoting gender equality in household responsibilities can help ensure better management of faecal matter.

From findings, the study recommends sanitation innovations that improve the design and construction of sanitation facilities to withstand heavy rainfall and prevent flooding shou.

Additionally, it is crucial to develop strategies that make efficient use of available space and land.

The study noted technological factors play a crucial role in the management of faecal matter. The study recommends the need to promote the adoption and use of sustainable toilet technologies. The availability of local resources revealed significant associations in improving sanitation practices. Therefore, the study recommends the utilization of resources to strengthen community-led sanitation initiatives. Encouraging local entrepreneurship in sanitation service provision, such as pit emptying and maintenance, can create economic opportunities while improving sanitation outcomes. Community-based organizations and local governments should collaborate to develop sustainable management plans that integrate local resources effectively.

5.4 Suggestion for Further Studies

The management of faecal matter is influenced by social, environmental, and technological factors. Future studies should be focused on other aspects such as demographic, economic, and cultural influence on the management of faecal matter, not only in Isiolo-sub-County but also in other semi-arid and area areas. The understanding of sanitation-related behavior drivers is crucial for the government and other sanitation agencies in the development and implementation of policies and projects that are sustainable and effective.

5.5 Publication

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APPENDICES

Appendix A :Publication

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Environmental Drivers of Faecal Sludge Management in Arid and Semi-Areas: A Case Study of Isiolo Sub-County, Kenya

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Abstract: Access to safe and adequate sanitation remains a significant challenge in arid and semi-arid lands (ASALs), where harsh climatic conditions, chronic water scarcity, and poor infrastructure hinder sustainable service delivery. To address this issue, on-site sanitation facilities have gained global acceptance. However, studies indicate that faecal sludge from these systems is often poorly managed, resulting in widespread environmental contamination, groundwater pollution, and increased public health risks. The study investigated how environmental factors influence the management of faecal matter in Isiolo Sub-County, Kenya. A convergent mixed-methods design was adopted, combining household surveys and focus group discussions (FGDs) to capture quantitative and qualitative perspectives. Household heads (N=355) were selected using stratified and proportionate random sampling, while qualitative insights were gathered from purposively selected informants. Data were analysed in Statistical Package for Social Science (SPSS) version 26.0, using descriptive statistics and binary logistic regression, while qualitative data were thematically analysed and presented in narrative form. Findings showed that 46.5% of faecal matter was poorly managed, with regression analysis identifying rainfall (AOR = 0.825, p = 0.0315), space availability (AOR = 0.889, p = 0.036), and land use (AOR = 1.012, p = 0.013) as significant predictors. Qualitative data highlighted the collapse of temporary latrines during heavy rains, rocky soils limiting pit depth, and a lack of compound space for replacement pits. The study concludes that environmental conditions are critical to ASALs' sanitation sustainability. The study recommends that government and sanitation stakeholders adopt context-specific, climate-resilient sanitation technologies and integrate land-use planning with faecal sludge management strategies.

Keywords: Arid and Semi-Arid Areas, Faecal Matter, Environmental Factors, Onsite Sanitation, Kenya.

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Appendix B : Informed Consent

This study is aimed at investigate the influence of Social, Environmental, And Technological factors on management of faecal matter in Arid and Semi-Arid Areas of Isiolo Sub -County, Kenya. The data gathered will only be used for academic purposes and will not be accessed by any third party. The aim is to yield insight into adoption of sustainable and acceptable sanitation solutions. The researcher only wants to learn your views on sanitation to expand the existing knowledge about sanitation practices. Note that participation in this study is voluntary, you may agree or decline taking part in the study. If you agree to participate in the exercise, your honest response to questions will be required. Note that there will be no right or wrong argument. Participants will be permitted, if they wish to, to decline participation even when the survey is mid-way. You will be engaged for the survey or interview for 10-25 minutes. Kindly indicate your stand in participating in this study verbally.

Do you agree to take part in this exercise

Yes { }

No { }

Appendix C : Household Survey Tool

Instructions: Please respond to the following questions by selecting the correct answer or providing your response in the designated area.

Section A: Background Information

1. Age of respondent: 18- 35 years 36- 50years 51 and above years
2. Gender of respondent: Male Female
3. What do you do for a living?
Not Employed Self-Employed Formally Employed
4. Level of education of the respondent:
No education
KCSE
KCPE
University/College
5. Which religion are you affiliated to: Christian Muslim Atheist
Other
6. Household size
<2 members 2-5 members 6-9 members 10 or more members

Section B; Management of Feacal Matter

1. B) Identify the sanitation facility your using?

Automatic cistern flush /Pour/manual flush {}
Ventilated improved pit latrine {}
Traditional pit latrine {}
No facilities or bush or field {}
Other {}

B) do you share facility with other households,
Yes {} No. {}

C) if yes how many.....

2. Where does content from your facility discharge into?

Septic tank {}
Fully-lined pit {}
Directly to open drain/ditch/ground {}
Don't know {}

3. Is the faecal sludge from your sanitation facility in disposed of in a safe and hygienic manner?

Yes, covered and sealed

Yes, it is emptied by a professional service and transported to a treatment facility or disposal site. {}

No, it is emptied manually or disposed of in open areas without proper treatment. {}

No, it's abandoned when it's filled up {}

4. How would rate on 5-point Likert scale the overall quality of sanitation services in your community in terms of faecal sludge management (including emptying, transport, treatment, and disposal)?

Excellent {}

Good {}

Fair {}

Poor {}

Very Poor {}

Section C: Influence of Social Factors on management of faecal matter

Please use the 5-point Likert scale, where 5 signifies strongly agree, 4 signifies agree, 3 indicates neutral, 2 represents disagree, and 1 represents strongly disagree, to indicate how much you agree or disagree with the statements.

	Social Factors	5	4	3	2	1
a)	The level of education of the household head influences their understanding and management of faecal matter					
b)	Age influences management of faecal matter					
c)	Gender influences management of faecal matter at the household head					
d)	Gender roles within the household affect the allocation of responsibilities related to faecal management					
e)	Awareness on sanitation matters influence disposal of faecal matter at the household level					
f)	I have knowledge on the appropriate ways of managing faecal matter					
g)	Knowledge on safe disposal of faecal matter influences management of faecal matter					
h)	The community has social norms which influence management of faecal matter					

Section D; Influence of technological factors on management of faecal matter

Please use the 5-point Likert scale, where 5 signifies strongly agree, 4 signifies agree, 3

indicates neutral, 2 represents disagree, and 1 represents strongly disagree, to indicate how much you agree or disagree with the statements.

	Technological Factors	5	4	3	2	1
a.	The presence of lining in pit latrines enhances their durability and reduces the risk of collapse during floods					
b.	Pit latrine lining enhances safer and more effective emptying when the pits are full.					
c.	The type and design of pit latrine cover slabs affect the ease of cleaning and hygiene in the latrines					
e.	Raised pit latrines mitigate the risk of toilets contamination					
f.	Keeping the pit latrine depths above the water table reduces the risk of groundwater contamination					
g.	The distance of the latrines from the households affect safe disposal of faecal matter					
h.	Designing toilets that are user-friendly, easy to sustain, and meet the demands of varied user groups promotes safe disposal of faecal matter					
i.	Availability of skilled labor influence management of faecal matter					
j.	Availability of local resources influence management of faecal matter					
	The design of toilets affects management of faecal matter					

Section E; Influence of environmental factors on management of faecal matter

In a scale of 1- 5 where 5 is strongly agree, 4 is agree, 3 is neutral, 2 is disagree, and 1 is strongly disagree, to indicate how much you agree or disagree with the statements.

	Environmental Factors	5	4	3	2	1
a)	Toilet type affect toilet adoption					
b)	Water table is high and adoption of pit latrines cause contamination of underground water					
c)	The land is rocky which affect excavation of toilets					
d)	The type of soil in this area support toilets adoption					
e)	Availability of space at the household influence toilet adoption/management of faecal matter at the household					
f)	Community land use practices significantly affect our household's faecal matter management strategies					
g)	If it rains, water gets in the toilets and the toilets collapse					
h)	The sun in our region destroys the walls and roof of the toilets					
i)	When it is hot, the toilet smells					

Appendix D : Observation Checklist

1. Does the household have a toilet?
Yes []
No []
2. Observe the type of latrine/toilet in the household.
Ventilated Improved Toilet []
Flush Toilet with Septic Tank []
Pit Latrine with Cover Slab []
Pit Latrine without Cover Slab []
3. Does the latrine/toilet facility present adequate conditions of cleanliness?
Adequately Clean (no feces or urine) []
Not Clean (feces or urine on the floor) []
4. Check if there are feces in the compound (walk around the compound)
Yes []
No []
5. Check if there are feces in the village along the roadsides/bushes/farm.
Yes []
No []
6. Does the squat hole latrine/toilet have a cover?
Yes []
No []
7. Are there hand-washing facilities in the compound?
Yes []
No []
8. Is there sufficient water available in the compound?
Yes []
No []

Appendix E : Focus Group Discussion Guide

1. How do the following issues affect safe faecal management?

Age.....

Gender.....

Knowledge/awareness level.....

2. How has technology affected the design and construction of on-site sanitation facilities, particularly with regards to faecal emptying, conveyance, and disposal?

3. What are the challenges encountered in emptying, transportation, treatment/disposal of faecal matter?
.....
.....

4. What are the challenges facing faecal management in relation to technological suitability/design factor in toilets?
.....
.....

5. How do factors such as cost, availability of materials, and cultural beliefs influence the technological suitability of on-site sanitation facilities?
.....
.....

6. Do you consider the technology in use to be effective when it comes to faecal emptying, conveyance, and disposal? Give reasons for your response

7. Is the technology being used scalable to meet the demands of the growing population? Is it user-friendly and sustainable

8. Is the technology used for faecal emptying, conveyance, and disposal in on-site sanitation facilities adaptable to different types of waste, including solid and liquid waste?

9. What role do government policies and regulations play in promoting the use of technology in on-site sanitation facilities?

Appendix F : Permit from County Government of Isiolo



ISILO COUNTY GOVERNMENT
OFFICE OF THE DIRECTOR
HEALTH SERVICES



REF. ISO/CONT/DDMS/P.E/VOL.1/16

Date: 10TH JUNE, 2024

THE SCMOH
THE SCPHO
ISILO SUB COUNTY

**RE: RESEARCH AUTHORIZATION: KIRIMI JULIUS MUTHURI: REG NO
EG407/202395/22**

The above named is a student in the department of Civil and Environmental Engineering at Meru University of Science and Technology pursuing Master's degree in sanitation.

The research he has been approved to conduct is on "*Influence of Social, Environmental and Technological factors in Management of Faecal Matter in Arid and Semi-Arid Areas: A case of Isiolo Sub County, Kenya*"

This letter therefore serves as an authorization from the County Department of Health Services Isiolo for him to conduct the study in your Sub County. He will be expected to adhere to all laid down MOH guidelines, work and research ethics. He is also expected to share the findings of the research with this office.

Accord him the necessary support.

Thank you



MOHAMED ABDI BORU
DIRECTOR MEDICAL SERVICES
ISILO COUNTY

Appendix G : Introductory Letter



MERU UNIVERSITY OF SCIENCE & TECHNOLOGY

P.O Box, 972-60200 Meru-Kenya
Phone: +254 (0) 712 524 293, +254 (0)799 529 958, +254 (0)799 529 959
Email: engineering@must.ac.ke Website: www.must.ac.ke

SCHOOL OF ENGINEERING AND ARCHITECTURE DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

TO: Whom It may concern

DATE: 5th June, 2024

Dear Sir/Madam,

RE: INTRODUCTORY LETTER FOR KIRIMI JULIUS MUTHURI, REG NO. EG407/202395/22

The above-named, is a student in the Department of Civil and Environmental Engineering at Meru University of Science and Technology, pursuing a Master's degree in Sanitation. He has been approved to conduct research on "Influence of Social, Environmental and Technological Factors in Management of Faecal Matter in Arid and Semi-Arid Areas: A Case of Isiolo Sub -County, Kenya" aimed at completing his studies. This is therefore, to request that you grant him any assistance needed to enable him meet the program requirements for his graduation.

Kindly contact us for any further enquiries.

Thank you

A handwritten signature in blue ink, appearing to read "Mirara Simon W.", written over a horizontal line.

Mirara simon w.
Chair of Department Civil and Environmental Engineering
Meru University of Science and Technology

Email: CODcivilengineering@must.ac.ke
Smirara@must.ac.ke



MUST IS ISO 9001:2015 CERTIFIED

Appendix H : Research License


REPUBLIC OF KENYA


NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY & INNOVATION

Ref No: **622498** Date of Issue: **16/August/2024**

RESEARCH LICENSE



This is to Certify that Mr. Julius Kirimi Muthuri of Meru University of Science and Technology, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in on the topic: INFLUENCE OF SOCIAL, ENVIRONMENTAL, AND TECHNOLOGICAL FACTORS ON MANAGEMENT OF FEACAL MATTER IN ARID AND SEMI-ARID AREAS : A CASE OF ISIOLO SUB-COUNTY, KENYA for the period ending : 16/August/2025.

License No: **NACOSTI/P/24/38757**

622498
Applicant Identification Number


Director General
NATIONAL COMMISSION FOR
SCIENCE, TECHNOLOGY &
INNOVATION

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Scan the QR Code using QR scanner application.

See overleaf for conditions

Appendix I : Plagiarism Report

