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# Environmental Drivers of Faecal Sludge Management in Arid and Semi-Arid 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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## I. INTRODUCTION

Sanitation is not merely a technical service but a human right which supports health, dignity, and the wider ambitions of sustainable development (UN-Water, 2022). Nevertheless, the sanitation gap is alarming worldwide, despite global pledges, such as Sustainable Development Goals (SDG 6.2). In 2023, over 4.5 billion people lacked access to safely managed sanitation services globally, while 892 million people engaged in open defecation, which is concentrated in the global south, in rural low-income settings where infrastructure is fragile and governance is weak (WHO & UNICEF, 2023). While the scope of interventions has increasingly focused on onsite sanitation solutions such as pit latrines and septic systems (Simiyu et al., 2021; Kipngeno et al., 2024), most interventions do not consider the entire sanitation value chain, from containment, emptying, to safe disposal or reuse. Dissected solutions often maintain a dangerous cycle of linking environmental degradation to public health concerns, particularly in arid and semi-arid regions, where climate-induced pressures such as water scarcity, flooding, and warming stretch fragile sanitation systems to their limits (Ortiz-Prado et al., 2025; Karamagi et al., 2025).

Onsite sanitation systems are not just a practical necessity; they are also an enduring reality, and for billions projected to serve over 5 billion people by year 2030, particularly in low-resource, climate-vulnerable contexts (Hans, 2023). In arid and semi-arid lands (ASALs), onsite sanitation is often the only reasonable option available owing to water scarcity, unreliable rainfall, and high temperature

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conditions that prevent sewered systems from functioning properly (Rodrigues et al., 2021; Kithuki et al., 2021; Ngare et al., 2024). However, addressing the safe management of faecal sludge from onsite sanitation systems remains a crucial bottleneck; available evidence indicates that safe treatment and disposal of faecal sludge is often below 10%, if not lower, particularly in low-income and rural contexts (Harper et al., 2020; Peal et al., 2020; Sisay et al., 2024). In Sub-Saharan Africa, where up to 90% of urban sanitation is unsewered, unregulated discharge and failed emptying mechanisms, and institutional weakness have compounded environmental and public health epidemics (Basika et al., 2024). Research conducted in ASAL environments, including studies done in Pakistan, shows us that appropriately pit emptying or faecal sludge treatment rarely takes place (Maqbool et al., 2022), and that informal emptying, unregulated reuse, and uncontrolled faecal disposal still happen, largely owing to cultural, social, institutional, and technological factors (Nzouebet et al., 2019). Unlike urban centers, ASALs lack the data systems, regulatory oversight, and investment frameworks necessary to manage sanitation under extreme environmental constraints.

Despite progress toward country-wide sanitation outcomes in Kenya, this is not the case in rural and arid/semi-arid areas (ASALs) (Kithuki *et al.,* 2021; Sakas *et al.,* 2022; WHO & UNICEF, 2023). The national sanitation policy environment, such as the Kenya Environmental Sanitation and Hygiene Policy (KESHP) 2016-2030, has progressively articulated an integrated and rights-based orientation while endeavoring to reflect global targets, particularly SDG 6.2 (MoH, 2016; WASREB, 2022); together, they are emphasizing the full sanitation value chain with a strong county focus. Despite these advances, ASALs, where some 16 million Kenyans live, represent more than 80% of the country's land mass and deal with chronic sanitation underdevelopment. Certain counties indicate the highest open defecation rates in the country, such as Isiolo, Marsabit, and Wajir counties, while also indicating little access to FSM services (UNICEF, 2022; USAID,2021). While the introduction of community-led total sanitation (CLTS)has improved some community awareness and decreased open defecation, other aspects are problematic, namely faecal sludge management in the face of increasing accumulation (USAID, 2021; Hussein *et al.,* 2023). While policy documents acknowledge ASALs as a priority area, implementation barriers persist. Therefore, tailored investments are urgently needed to reflect the unique environmental, socio-economic, and infrastructural realities of ASALs. Without a robust shift from policy intent to localized action, the sanitation divides in Kenya risk deepening, particularly under increasing climate stress.

Much research in ASAL areas has focused on latrine coverage, hygiene behaviour change, and reduction of open defecation mainly through community-led total sanitation (CLTS) campaigns (Busienei *et al.,* 2019; Whitley et al, 2019; Mustapha *et al.,* 2022; Eliud *et al.,* 2023; Upane *et al.,* 2024; Belete *et al.,* 204). While important, these studies overlook the downstream aspects of the sanitation value chain. In addition, there is still little empirical evidence of FSM performance in ASAL-specific contexts marked by dry soils, water unavailability, and gaps in the accessibility of infrastructure (Lerebours *et al.,* 2021; Hussein *et al.,* 2023). In Kenya specifically, many of the ASAL counties have not focused on locally specific research on FSM practices in ASAL regions (Gitonga *et al.,* 2022), even though they are among the most vulnerable to disease outbreaks related to poor sanitation and disrupted services caused by climate change. The evidence gap has created a policy-research divide since no apparent national sanitation strategies are based on empirical evidence from the dryland environments they intend to serve. This accident has increased emphasis on understanding the role of environmental factors on faecal matter in Isiolo Sub-County, Kenya.

## II. METHODOLOGY

- *Study Design and Location*

A convergent mixed-method study design was adopted, which helps researchers obtain both quantitative and qualitative data (Taherdoost, 2022).). The study was conducted in Isiolo Sub-County, Isiolo County, Kenya between period of September to December 2024. The area was chosen because it is characterized by desert characteristics, with most residents relying on onsite sanitation (USAID, 2021)

- *Study Population*

The study targeted households aged above 18 years from households within Isiolo Sub-County. The total number of households was 29583 (KNBS,2019). The study also included Community health leaders, public health officers, and community health promoters since they may have deep knowledge of sanitation and related practices necessary for the study.

- *Sampling Size Determination and Sampling Techniques*

The sampling formula Yamane (1967) recommended was used to determine a sample of 395 household heads from 29853 Households. A stratified proportionate simple random technique to choose household heads. Additionally, purposive sampling technique was utilized to select members of the Focused Group Discussion, including a chief, sub-chief, village elders, public health officers, two (2) community health promoters, and a volunteer community member.

- *Data Collection and Analysis*

Quantitative data was collected using Structured questionnaires from household heads. Focus group discussion guides were employed to gather qualitative data. Quantitative data was analyzed using the Statistical Package for Social Sciences (SPSS) software Version 26 to generate descriptive statistics in frequency and percentages. A binary logistic regression was used to analyze the association of environmental factors with management of faecal matter. The odds ratio with a 95% confidence interval was used in the final model to identify the factors associated with managing faecal matter. Variables with p-values less than 0.05 were deemed statistically significant. The qualitative data was categorized into themes and presented in narrative form.

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➢ *Ethical Considerations*

Before collecting data, researchers obtained an introductory letter from Meru University of Science and Technology (MUST) and a permit from the Kenya National Commission for Science, Technology and Innovation (NACOSTI) License no. NACOSTI/P/24/38757. The respondents were informed that participation in the study was voluntary, and respondents were required to offer oral consent before participation.

## III. RESULTS AND DISCUSSIONS

➢ *Socio-Demographics Characteristics*

The overall response rate was 89.9%(N=355) which exceeds the recommended threshold of 70% for acceptable survey research (Mugenda & Mugenda, 2003). 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 practice. The study findings in Table 1 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.

The study showed as in Table 1.0 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.

Additionally, 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.

Table 1 Social-Demographic Characteristics of Respondents(n=355)

| Demographics | Category | Frequency (n) | Percentage (%) |
|---|---|---|---|
| Gender | Males | 104 | 29.3 |
| | Female | 251 | 70.7 |
| Religion | Christian | 196 | 55.2 |
| | Muslims | 148 | 41.7 |
| | Atheist | 5 | 1.4 |
| | Other | 6 | 1.7 |
| Employment status | Not employed | 167 | 47.0 |
| | Self -employed | 158 | 44.5 |
| | Employed | 30 | 8.5 |

Source: (Research data, 2024)

➢ *Management of Faecal Matter*

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 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. 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.

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➢ *Influence of Environmental Factors on the Management Faecal Mater*

The degree of participants' agreement to various statements given in a 5-point Likert scale ranging from: 1-Strongly disagree, 2-Disagree, 3-Neutral, 4- Agree and 5-Strongly agree was examined to reveal whether environmental conditions such as climate, soil type, water table, space availability, and land use influence faecal matter management (FMM) in Isiolo Sub-County.The results were as summarized in Table 2.

Table 2 Social Factors Influencing the Management of Faecal Matter (N=355)

| Environmental drivers | Strongly Disagree (n, %) | Disagree (n, %) | Neutral (n, %) | Agree (n, %) | Strongly Agree (n, %) | Mean (SD) |
|---|---|---|---|---|---|---|
| **Rainfall** | 33 (9.3%) | 99 (27.9%) | 17 (4.8%) | 160 (45.1%) | 46 (13.0%) | 3.25(1.25) |
| **Drought** | 10 (2.8%) | 99 (27.9%) | 15 (4.2%) | 187 (52.7%) | 44 (12.4%) | 3.44 (1.11) |
| **Water table** | 11 (3.1%) | 102 (28.7%) | 44 (12.4%) | 149 (42.0%) | 49 (13.8%) | 3.34 (1.1254) |
| **Rock land** | 7 (2.0%) | 117 (33.0%) | 17 (4.8%) | 114 (32.1%) | 100 (28.2%) | 3.5155 (1.2629) |
| **Type of soil** | 13 (3.7%) | 215 (60.6%) | 55 (15.5%) | 33 (9.3%) | 39 (11.0%) | 2.633 (1.07408) |
| **Space** | 7 (2.0%) | 99 (27.9%) | 16 (4.5%) | 173 (48.7%) | 60 (16.9%) | 3.5070 (1.1258) |
| **Land use** | 7 (2.0%) | 65 (18.3%) | 20 (5.6%) | 173 (48.7%) | 90 (25.4%) | 3.771 (1.0821) |

Source: (Research data, 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.

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. 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

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of which emphasized that soil porosity, cohesion, and permeability are critical factors influencing latrine sustainability.

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.

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. 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

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. 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, Aqauaya (2019) emphasized the importance of secure land tenure and spatial planning in determining sanitation access in low-income and informal settlements

- *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 3.

Table 3 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**:** (Research data, 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

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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. 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.

## IV. CONCLUSION

The research establishes that environmental factors such as rainfall conditions, water table levels, type of soil, rocky areas, availability of space, and land use are important factors influencing faecal matter management practices in Isiolo Sub-County. Drought limitations were not extensive, but as other conditions which were found to be drastic and challenging the sustainability of sanitation systems. The findings indicate that faecal matter management is largely based on the context of the physical environment that can either provide conducive capacity for management, or else hinder management of containment and disposal practices. The findings also provide contextual evidence that will help to understand sanitation holding practices in arid and semi-arid environments and debated as part of future research agendas.

## RECOMMENDATION

The results of the study indicate that to effectively improve the management of faecal matter in Isiolo Sub-County, as well as in other arid and semi-arid contexts, a number of measures are necessary. In collaboration with key stakeholders, the County Government should prioritize funding for flood-resilient sanitation infrastructure and consider sanitation needs when developing land-use planning, which encompasses household and community needs. National-level stakeholders should work collaboratively to strengthen the policy framework that enables the protection of fragile ASAL areas while providing equitable access to sanitation for all. Development partners and NGOs should continue to support fixture and service innovations that are appropriate for Isiolo's climatic and spatial context, including structures such as raised latrines, shared toilets, and mechanical emptying technologies. Community health workers and community leaders, continue to be essential in mobilizing households, mobilizing awareness of safe sanitation management, and supporting behaviour change. There is an opportunity to widen attention to sanitation considerations in the context of land use, planning and spatial planning at the local level, to ensure sustainable access to and management of facilities across Isiolo Sub-County.

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- *Conflict of Interest:*
  The Authors Declare no Conflict of Interest.

## REFERENCES

[1]. Aquaya, (2019). Sanitation Policies, Practices and Preferences in Nakuru, Kenya. Retrieved from: https://www.wsup.com/content/uploads/2019/08/Sanitation_Nakuru_final.pdf.

[2]. Basika, E., Komakech, A. J., Nsubuga, M., & Kizito, S. (2024). Faecal sludge management practices in Uganda: challenges and opportunities. *Int J Adv Res (IJSCIA)*, *5*(3), 508-522.

[3]. Belete, B. E., Ambelu, A., & Addis, T. (2024). Factors influencing the adoption and utilization of latrines in Babille woreda, Somali region, Eastern Ethiopia: a cross-sectional study. *Journal of Water, Sanitation and Hygiene for Development*, *14*(2), 69-79.

[4]. Busienei, P. J., & Ogendi, G. M. (2019). *Latrine structure, design, and conditions, and the practice of open defecation in Lodwar Town, Turkana County, Kenya: A quantitative methods research.* Environmental Health Insights, 13, 1–9. DOI: 10.1177/1178630219887960

[5]. County Government of Isiolo (CGI). (2023). Isiolo County Integrated Development Plan 2023-2027 Retrieved from https://www.isiolo.go.ke/downloads

[6]. Dhadho, J., & Okeyo, I. (2023). Adoption of Sanitation Technologies in Tana Delta Sub-County, Kenya: The Environmental Factors' Influence. World Journal of Public Health, 8(4), 305-309. https://doi.org/10.11648/j.wjph.20230804.18

[7]. Eliud, G. K., Kirimi, L. M., & Mburugu, K. N. (2023). Influence of social factors on adoption of sanitation practices in rural areas: a mixed methods study in Nzaui, Kenya. *Pan African Medical Journal*, *46*(1).

[8]. Gitonga, F. K., Kanyepi, T., & Tanyanyiwa, V. I. (2022). Faecal sludge management for sustainable cities: Glimpses from Kenya. In W. Leal Filho (Ed.), *Clean water and sanitation* (pp. 1–14). Springer. https://www.researchgate.net/profile/Vincent-Tanyanyiwa-2/publication/353914771_Faecal_Sludge_Management_for_Sustainable_Cities_Glimpses_from_Kenya/links/6118cc330c2bfa282a464a03/Faecal-Sludge-Management-for-Sustainable-Cities-Glimpses-from-Kenya.pd

[9]. Gituma, K. K. (2022). Tracking the flow of excreta across the sanitation service chain in Nkubu town. African Journal of Science, Technology and Social Sciences, 1(1).

[10]. Government of Kenya (GOK). (2023). National Sanitation Coverage Statistics by County. Ministry of Health.

[11]. Harper, J., Bielefeldt, A., Javernick-Will, A., Veasna, T., & Nicoletti, C. (2020). Context and intentions: practical associations for faecal sludge management in rural low-income Cambodia. *Journal of Water, Sanitation and Hygiene for Development*, *10*(2), 191-201.

[12]. Hussein, M. M., Odongo, A. O., Kerochi, A., & Snuggs, J. (2023). Assessing factors associated with FSM practices among residents living in Baidoa, Somalia. *International Journal of Community Medicine and Public Health*, *10*(11), 4004.

[13]. Kendi, C., Sumba, L., Huka, G. S., & Mirara, S. (2022). Assessment of Challenges Experienced Among Households on Promotion of Sanitation Practices in Tigania West Sub County, Meru County, Kenya

[14]. Kenya National Bureau of Statistics (KNBS). 2019 Kenya population and housing census, Volume I&II: Population by county, Sub-County and wards. Nairobi

[15]. Kipngeno Aaron; Patrick Kubai; Josephine Mutembei. "Social-Cultural Factors Influence on Management of Shared Sanitation, in Nakuru Town West Slums." Volume. 9 Issue 8, August - 2024 International Journal of Innovative Science and Research Technology (IJISRT), www.ijisrt.com. ISSN - 2456-2165, PP:- 2613-2625, https://doi.org/10.38124/ijisrt/IJISRT24AUG1709

[16]. Kithuki, K., Opanga, Y., Watulo, E., & Marita, E. (2021). Water, sanitation and hygiene coverage and practices of a semi-arid county in the Eastern region of Kenya. Journal of Water, Sanitation and Hygiene for Development, 11(2), 327–334. https://doi.org/10.2166/washdev.2021.174

[17]. Legge, H., Halliday, K., Kepha, S., Mcharo, C., Witek-McManus, S., El-Busaidy, H., & Oswald, W. (2021). Patterns and drivers of household sanitation access and sustainability in kwale county, kenya. Environmental Science & Technology, 55(9), 6052-6064. https://doi.org/10.1021/acs.est.0c05647

[18]. Lerebours, A., Scott, R., Sansom, K., & Kayaga, S. (2021). Regulating sanitation services in sub-saharan africa: An overview of the regulation of emptying and transport of faecal sludge in 20 cities and its implementation. *Utilities Policy*, *73*, 101315

[19]. Maqbool, N., Shahid, M. A., & Khan, S. J. (2022). Situational Assessment for Faecal Sludge Management (FSM) in Pakistan.

[20]. Ministry of Health (MoH). (2016). Kenya Environmental Sanitation and Hygiene Policy 2016–2030. Nairobi, Kenya.

[21]. Mustapha, M., Okareh, O. T., Sridhar, M. K. C., & Aliyu, M. M. (2022). Households' awareness and practices on water, sanitation and hygiene (WASH) in an Arid Region of Northwestern Nigeria-Sokoto State. *West African Journal of Applied Ecology*, *30*(2), 47-66.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep008

[22]. Ngare, I. O., Karanja, J., Maina, S., & Gikonyo, S. (2024). Groundwater pollution and climate change vulnerability in Kenya: A review.

[23]. Nzouebet, W. A. L., Kengne, E. S., Wafo, G. V. D., Wanda, C., Rechenburg, A., & Noumsi, I. M. K. (2019). Assessment of the faecal sludge management practices in households of a sub-Saharan Africa urban area and the health risks associated: the case study of Yaoundé, Cameroon. *International Journal of Biological and Chemical Sciences*, *13*(5), 1-23.

[24]. Odagiri, M., Thomas, A., Listyasari, M., Mills, F., Bain, R., Muhammad, Z., … & Willetts, J. (2021). Safely managed on-site sanitation: a national assessment of sanitation services and potential faecal exposure in indonesia. International Journal of Environmental Research and Public Health, 18(15), 8204. https://doi.org/10.3390/ijerph18158204

[25]. Peal, A., Evans, B., Ahilan, S., Ban, R., Blackett, I., Hawkins, P., ... & Veses, O. (2020). Estimating safely managed sanitation in urban areas; lessons learned from a global implementation of excreta-flow diagrams. *Frontiers in Environmental Science*, *8*, 1.

[26]. Rodrigues, E. A. M., Coutinho, A. P., de Souza, J. D. S., Costa, I. R. D. A., Neto, S. M. D. S., & Antonino, A. C. D. (2022). Rural Sanitation: scenarios and public policies for the brazilian semi-arid region. *Sustainability*, *14*(12), 7157.

[27]. Rotowa, O. O., & Ayadi, P. A. (2020). Faecal sludge management in the residential cores of Akure,.Nigeria. J Environ Prot Sustain Dev, 6(2), 32-47

[28]. Sakas, Z., Uwah, E. A., Bhattrai, R. K., Garn, J. V., Gc, K. H., Mutta, A., ... & Freeman, M. C. (2022). Assessing sustainability factors for rural household sanitation coverage in Bhutan, Kenya, Nepal, and Zambia: a qualitative analysis. *Global Health: Science and Practice*, *10*(6).

[29]. Simiyu, S., Chumo, I., & Mberu, B. (2021). Faecal sludge management in Low Income settlements: Case study of Nakuru, Kenya. *Frontiers in Public Health*, *9*, 750309.

[30]. Simiyu, S., Chumo, I., & Mberu, B. (2021). Faecal sludge management in low-income settlements: case study of Nakuru, Kenya. *Frontiers in Public Health, 9*, 750309. https://doi.org/10.3389/fpubh.2021.750309

[31]. Sisay, S. F., Gari, S. R., & Ambelu, A. (2024). Faecal Sludge Management and Sanitation Safety: An Assessment in Addis Ababa, Ethiopia. *Environmental Health Insights*, *18*, 11786302241267187.

[32]. Taherdoost, H. (2022). What are different research approaches? Comprehensive review of qualitative, quantitative, and mixed method research, their applications, types, and limitations. *Journal of Management Science & Engineering Research*, *5*(1), 53-63.

[33]. United Nations Children's Fund (UNICEF). (2022). WASH in ASAL counties: Coverage and needs assessment. Nairobi: UNICEF Kenya. https://www.unicef.org/kenya

[34]. United States Agency for International Development. (2021). Approaches for sanitation access in pastoralist areas within the arid and semi-arid lands of Kenya. https://pdf.usaid.gov/pdf_docs/PA00XWKV.pdf

[35]. UN-Water. (2022). Human rights to water and sanitation. https://www.unwater.org/water-facts/human-rights-water-and-sanitation

[36]. Upane, J. L., Walubuka, E., & Amatu, M. (2024) Social and Cultural Factors Influencing Promotion of Latrine Utilization in Laisamis Sub-County, Marsabit, Kenya.

[37]. Water Services Regulatory Board (WASREB). (2022). Impact Report 14: Performance review of Kenya's water services sector. https://wasreb.go.ke

[38]. Whitley, Lucy, Paul Hutchings, Sarah Cooper, Alison Parker, Abinet Kebede, Solome Joseph, John Butterworth, Barbara Van Koppen, and Adolph Mulejaa. "A framework for targeting water, sanitation and hygiene interventions in pastoralist populations in the Afar region of Ethiopia." *International Journal of Hygiene and Environmental Health* 222, no. 8 (2019): 1133-1144.

[39]. WHO. (2024). Sanitation. World Health Organization Fact Sheet. https://www.who.int/news-room/fact-sheets/detail/sanitation

[40]. World Health Organization (WHO) and the United Nations International Children`s Emergency Fund (UNICEF) Joint Monitoring Program for Water Supply, Sanitation and Hygiene (JMP), 2023. Progress on household drinking water, sanitation and hygiene 2000-2022

[41]. Yamane, Taro, (1967). Statistics, An IntroductoryAnalysis,2nded., NewYork:Harper and Row.