

**ORIGINAL RESEARCH ARTICLE****Socio-cultural and economic drivers of open defecation and sanitation interventions in nomadic communities: A case study of Lodokejek Ward, Samburu County, Kenya****John Otieno Osir¹, Patrick G. Home¹, Elijah Ngumba¹**

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Abstract

Open defecation (OD) remains a widespread challenge in developing countries, significantly impacting public health, especially in nomadic communities with limited sanitation infrastructure. Despite National WASH interventions, open defecation remains prevalent in Kenya, with rates of 14% nationally but exceeding 70% in pastoralist regions such as Lodokejek Ward, Samburu County. The study contributes new evidence by integrating pastoral nomadism intensity, moranism and socioeconomics to understand the drivers of Open Defecation and Sanitation interventions in Nomadic Communities. A cross-sectional mixed method involving household surveys, focus group discussions, key informant interviews, and transect walks was conducted among 200 households. Quantitative data was analyzed via SPSS v16 (Chi-square, Pearson r) while qualitative data was analyzed via thematic coding in NVivo. Ethical approval was obtained, and informed consent and anonymity were ensured. Results revealed significant associations with socioeconomics of the study area and knowledge gaps. Open defecation was strongly associated with socio-cultural norms, economic constraints, and sanitation-related knowledge gaps ($p < 0.001$). From the results, 51.5% lacked latrines ($r=0.45$, $p<0.01$). The study recommends culturally tailored Community Led Total Sanitation (CLTS) approach, subsidies for nomads, and gender-inclusive designs for nomadic communities to achieve SDG 6.2.

Keywords: Community Led Total Sanitation (CLTS), interventions, nomadic communities, open defecation

1.0 Introduction

Water supply resources are faced with critical challenges such as scarcity, contamination and unequal distribution. These pressures threaten environmental sustainability and economic productivity and also public health. In the poorer and drier regions, the association between the lack of water security and sanitation vulnerability goes hand in hand. Safe sanitation is not therefore only a public health intervention. It is a structural determinant of dignity, and education as well as gender equity and the reduction of poverty.

Globally, sanitation is one of the most apparent indicators of human development ([Workman et al., 2021](#)). Safely managed sanitation services are described as the use of improved sanitation services that are not shared with other people and where excreta is safely disposed

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of or treated (WHO and UNICEF, 2015). Despite the decades of international commitment to sanitation, there are still sanitation coverage gaps. Sanitation was not the initial part of the Millennium Development Goals (MDGs) and was not made part of the water targets until the 2002 Johannesburg World Summit on Sustainable Development (Clasen et al. 2010). This delayed prioritization was part of the problem in the case of structural underinvestment and slow movement in a large number of regions.

Recent statistics globally indicate that approximately two billion people lack access to basic sanitation facilities and hundreds of millions of people still practice open defecation (Fagunwa et al., 2025; Abalaka & Tokula, 2022). While there is reduction in the prevalence at the global level over the past decade, the progress has been uneven. Rural populations also bear the lion's share of the burden of the unavailability of improved sanitation, with open defecation being especially concentrated in geographically remote and economically marginalized communities (Ahmed Yusuf et al. 2026; Humňalova & Ficek 2023). Sustainable Development Goal (SDG) 6.2 has made universal access to adequate and equitable sanitation by the year 2030 as a target. Nevertheless, there are chronic disparities in the rural areas, which means that an increase in the infrastructure is not enough.

In Sub-Saharan Africa, sanitation problems are aggravated by rapid population growth, weak institutional structure and weak fiscal capacity. Some countries still have open defecation rates of over 50% in rural areas (Appiah-Effah et al, 2024). Moreover, the circumstance of open defecation free (ODF) slippage in which societies become backsliders following certification just abides gains. Annual slippage rates of some parts of Africa ranges between 10-13% (Abebe & Tucho, 2020). These patterns show that the behavioural, cultural and structural drivers are still not well addressed.

Kenya is no exception to these more general regional trends. While the national prevalence of open defecation is estimated to be around 14%, there are large variations across the geography (Njuguna, 2019). There are 15 counties that contribute most of the cases in the country (KNBS, 2019). Arid and semi-arid counties, such as Turkana County, Wajir and Samburu have rates of over 60%. Samburu County was one of the counties that registered the highest prevalence during 2019 census with 65.6% prevalence of open defecation in households with over 200,000 people being affected by it (KNBS, 2019).

However, these figures cannot be understood as infrastructure deficits only. In pastoralist and nomadic communities, sanitation behaviour is influenced by the mobility pattern, mechanism of land tenure, cultural practices and livelihood strategies. Pastoral households are regularly on the move with the seasons of the grazing cycle and availability of water. Permanent constructions such as the latrine carrying along with the habit can be considered impractical in conditions of mobility or economically inappropriate. In addition, the low population density minimises the risk of environmental contamination as per high density settlements. Cultural beliefs, notions of purity, exclusion of waste from living spaces, use of common land are also deciding factors for sanitation.

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Conventional models of sanitation often make assumptions about the population, usually sedentary, the land ownership (stable) and the infrastructure. These assumptions are not in conformity with nomadic production systems. As a result, interventions based on static latrine construction at the household level may have low rates of uptake, or high rates of abandonment. Continuous imbalances are thus indications of lack of fit between socio-ecological conditions in pastoralist areas and formulation of intervention.

Within Samburu County, Lodokejek Ward has some acute sanitation needs. Open defecation prevalence in the ward is estimated at about 70% which is very high as compared to the county average of 55% and 14% nationally. The use of a latrine is still far behind the county and national benchmarks (KNBS, 2022). These disparities imply that there are localised socio-cultural and economic determinants, which fail to get reflected adequately in aggregate statistics.

Understanding why open defecation continues to be practiced in Lodokejek Ward involves going beyond the descriptive prevalence data in a more contextualized approach to understand mobility patterns, economic constraints, gender roles, environment conditions as well as perceptions of sanitation in the community. Such analysis is critical in the design of adaptive, culturally responsive interventions that can achieve sustainable behaviour change. This study therefore aims to assess socio-economic and cultural factors influencing open defecation, evaluate sanitation-related knowledge gaps, and identify context-appropriate intervention strategies in Lodokejek Ward, Samburu County.

2.0 Materials and methods

2.1 Study area

Samburu County in Kenya borders Baringo County to the west, Laikipia County to the south, Isiolo County to the east and Turkana County to the north as presented in figure 3.1. Samburu County comprises 3 sub-counties (Samburu East, Samburu North, Samburu West), 3 constituencies (matching sub-counties), and 15 wards: Samburu North (Angata, Nanyokie, Baawa, El Barta, Nachola, Ndoto, Nyiro); Samburu West (Lodokejek, Loosuk, Maralal, Suguta Marmar, Poro); Samburu East (Wamba East, Wamba North, Wamba West, Waso). Lodokejek ward is in Samburu West sub-county. The study area has a population of 184,552 (KNBS, 2022), with a corresponding average population growth rate of 3.5% per annum. Pastoralism is the main economic stay in the area with regular or constant movement with their livestock in search of pasture and water.

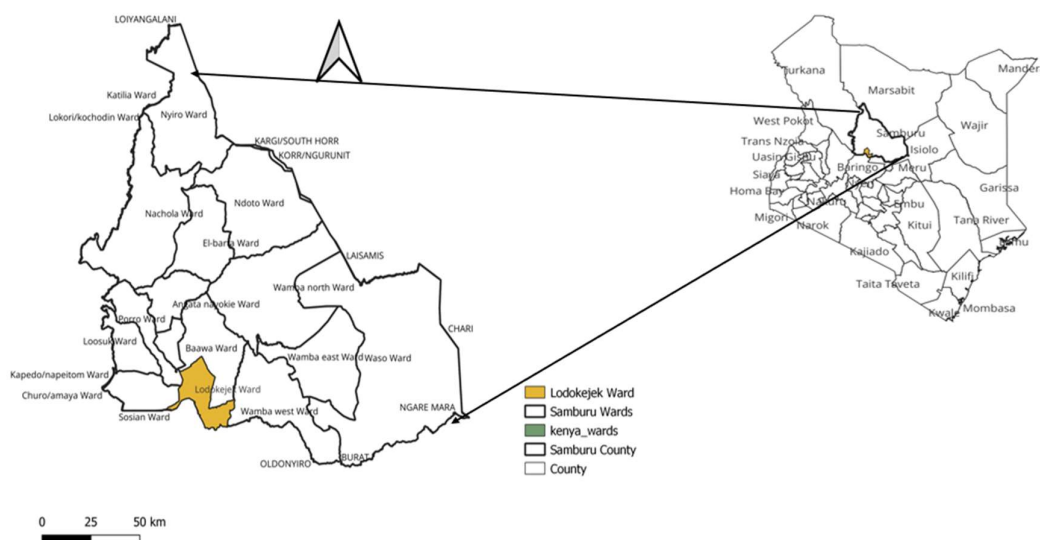


Fig. 2.1: Location of Lodokejek ward in Samburu County

2.2 Livelihoods and settlement mobility in the study area

Pastoralists like the Samburu rely on cattle, sheep, goats, and camels for food, income, and cultural value, herding across rangelands amid droughts and degradation. About 20% of Kenyans (over 9 million) depend on such systems, facing pressures from climate variability, overgrazing, and land-use changes (Nunow, 2024). Samburu pastoralists practice nomadic or semi-nomadic mobility, migrating seasonally or during droughts for pasture and water, mimicking historical wild herbivore patterns. Increased drought frequency heightens longer migrations, serving as a key coping strategy but challenged by conservancies restricting core grazing areas.

2.3 Study population

The study population included household heads or spouse, because they are the most knowledgeable regarding household's overall demographic, social and economic information, selected from a pool of 2107 households residing in three sub-locations of Lodokejek ward (Lodokejek, Nonkeek, Loltulelei). The study area has a total population of 9,913 residents as summarized and presented in Table 2.1. Alongside this, the study involved Focus Group Discussions (FGDs) and Key Informant Interviews (KIIs), involving Public Health Officers and Community leaders, youths and women.

Table 2.1: Study sample size per sub-location/household

Ward	Sub- Locations	Population	Name of Village	No. of Households
Lodokejek	Lodokejek	4,567	Lodokejek	138
			Lolmoti	103
			Loshoo	121

Nonkeek	3,016	Nonkeek	76
		Lchakwai	126
		Ntachata	96
Loltulelei	2,330	Loltulelei	130
		Lengei	109

Source: KDHS, 2022

2.3.1 Sample of the study

This study focused on 2107 households. A sufficient sample size was determined using Fisher's formulas. Fisher et al. (1998) provided a systematic approach for calculating sample size, which is crucial for ensuring that research findings are statistically valid and representative of the population. The formula is as illustrated Equation 2.1.

$$n = z^2 pq \div d^2 \quad (2.1)$$

Where:

n = Sample size

z = Standard Normal Deviate (1.96) which corresponds to 95% confidence interval

p = Expected prevalence (0.16) 16% is the latrine coverage in the area (Ward)

q = 1 – p = 0.84

d = Degree of accuracy = 0.05

2.3.2 Adjustments for finite populations

If the population size N is small (typically less than 10,000), an adjustment can be made. Since the target population of Lodokeyek Ward is less than 10,000, Fisher's et al., 1998 equation can be adjusted as follows (Equation 2.2).

$$nf = n / (1 + \frac{n}{N}) \quad (2.2)$$

Where:

nf = adjusted sample size

n = initial sample size calculated

N = total population size

$$nf = 207 / (1 + \frac{207}{2107}) = 189$$

This adjustment ensures that the sample size is not excessively large relative to the population. The minimal calculated 189 households is the bare minimum for statistical significance calculations, but 200 questionnaires were administered since any number above the bare minimal is always preferred. Eight villages were randomly sampled from the existing 19 villages where the 200 households were distributed since there was full knowledge of the area.



2.3.3 Sample size per sub-location

To achieve proportionate distribution, equation 2.3 as adopted from Woodward (1992) was used to distribute the respondents among the 8 villages in the three sub-locations.

$$\text{No of respondents} = X * P * Y \quad (2.3)$$

Where:

X = No. of households per village

P – Desired Sample size

Y- Total No. of households in the location

Table 2.2 shows the number of villages, number of households and number of respondents who participated in the study, from the three sub-locations where the study was carried out.

Table 2.2: Study sample size per sub-location/household

Ward	Sub- Locations	Population	Name of Village	No. of Households	% of Respondents	No. of Respondents (sample size)
Lodokejek	Lodokejek	4,567	Lodokejek	138	15.4 %	31
			Lolmoti	103	11.5 %	23
			Loshoo	121	13.5 %	27
	Nonkeek	3,016	Nonkeek	76	8.4 %	17
			Lchakwai	126	14.0 %	28
			Ntachata	96	10.6 %	21
	Loltulelei	2,330	Loltulelei	130	14.4 %	29
			Lengei	109	12.1 %	24
Total	3	9,913	8	899 of 2107	100 %	200

2.3.4 Sampling techniques

Lodokejek location in Lodokejek ward was chosen since it had the highest population density compared to the other two locations. The sample frame was made up of the sub-locations, administrative units, and the sampling units were the households. Using the household registration received from the area chief's office that contained all the 2,107 households in the three sub-locations, systematic random sampling of the 200 households was done. The household register had no specified order of households from the first to the last one. A sequential skipping method was used to reach the households, which would be surveyed for inclusion within each sub-location. This was predetermined to ensure an equitable representation from all corners of the study area. As a result, one home was sampled for the study for every four households, continuing until the target size of the sample in each sub-location was reached, out of the 899 households from the eight villages, with the 12 research assistants visiting average 17 households. For simplicity of mobility and coordination, it was designed to be limited to the residents of the location. The three sub-locations of Lodokejek location, which were basically in the rural set up, adult household heads or their wives, were the study's primary target population. Visitors acting as home representatives and children



under the age of 18 years were not allowed to participate in the interview. Households, which did not meet the criteria for inclusion, were equally skipped.

2.4 Variables

2.4.1 Dependent variables

Dependent variables separate observable behaviors from knowledge states. Behavioral outcomes include frequency of open defecation (OD) events per household per week and primary OD locations (e.g., bush, riverbanks), measured via structured household questionnaires and direct observations. Cognitive outcomes encompass sanitation knowledge scores (0-10 scale) and perceived severity of OD health risks (Likert scale), also captured through questionnaires. Chi-square tests and Pearson correlations assessed associations between these outcomes and explanatory factors.

2.4.2 Independent variables

Independent variables comprise socio-cultural factors (moranism beliefs, facility-sharing taboos, measured via Likert agreement scales), economic constraints (latrine affordability as % of monthly income, subsidy awareness), and resource factors (access to construction materials, technical skills). These were selected based on literature linking cultural norms and economic barriers to sanitation uptake in pastoralist ASALs, analyzed via Chi-square tests for association strength with OD behaviors.

2.4.3 Intervening variables

Intervening variables represent modifiable factors mediating independent-dependent relationships: health education exposure (training sessions attended in past year), latrine coverage (% households with functional latrines), sanitation technologies (pit latrine vs. VIP designs available), and marketing exposure (promotional campaigns encountered). These pathway variables were operationally defined to capture intervention leverage points for OD elimination.

2.5 Pre-testing

A pre-test of household questionnaires was conducted on 10% of the sample size (20 households) in neighboring villages outside the study area to ensure question clarity, consistency, and relevance to sanitation objectives. Research assistants analyzed responses, identifying issues like ambiguous OD location terms ("bush" vs. "grazing areas"), unclear affordability scales, and skipped moranism belief items due to cultural sensitivity. Tools were revised by simplifying terminology, adding response examples, rephrasing sensitive questions into neutral formats, and reducing questionnaire length by 15% (from 45 to 38 items) for pastoralist attention spans. Post-editing Cronbach's alpha improved from 0.68 to 0.82, confirming enhanced reliability before main data collection.

2.5.1 Dual coding and data validation

The tools were rigorously developed and tested to verify the survey questions to refer and measure the specific variables for the study. To enhance qualitative data reliability, transcripts and notes were double coded independently by two research assistants to reduce subjective

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interpretation bias; discrepancies were reviewed jointly until consensus was reached. Quantitative data were checked for completeness and consistency through built-in Kobo Collect validation and post-collection cleaning in SPSS. Such rigorous data collection and quality controls strengthen the trustworthiness and validity of study findings to address any concern about data collection rigor and bias mitigation.

2.5.2 Reliability

Cronbach's alpha ($\alpha = 0.82$) assessed internal consistency across three key construct clusters: sanitation knowledge (10 items: OD health risks, transmission pathways; $\alpha = 0.79$), sanitation attitudes (8 items: moranism beliefs, facility-sharing taboos; $\alpha = 0.81$), and OD behavioral practices (7 items: frequency, locations, triggers; $\alpha = 0.85$). This satisfactory overall reliability confirms the instruments reliably measured these latent variables post-pretesting revisions, strengthening subsequent Chi-square and correlation analyses.

2.6 Data collection techniques

2.6.1 Household questionnaire and Kobo collect

Quantitative data were gathered from 200 households using structured questionnaire on socio-demographic characteristics, sanitation practices, knowledge and availability of infrastructures. The tool was programmed into Kobo Collect, to allow for direct digital entry during the interviews. This meant fewer transcription errors and that built in validation checks could be built in at the point of data capture. Research assistants administered the questionnaires in person. The response rate was about 95% and so adequate representation of selected households was ensured. Non-respondents were excluded in a systematic way following the sampling protocol.

2.6.2 Observation checklist

During household visits, observations were made in latrines to collect data on latrine characteristics by use of a standardized observation checklist that captured information on presence, type of latrine (improved or unimproved), cleanliness, structural privacy, footpath condition, flies or odours present and proximity to handwashing facilities. Improved sanitation facility was classified as per WHO/UNICEF Joint Monitoring Programme (JMP). The observational evaluation was used to supplement the self-reported responses and enhance the validity of the triangulation. The use of observations as they were observed immediately after the visit was used to maintain consistency as well as accuracy of data.

2.6.3 Transect walks

A semi-structured guideline was used to conduct four focus group discussions (FGD) (2 men and 2 women i.e. 22 males and 26 females) and three key informant interviews (KII) comprising of the Assistant Chief, Village Administrator and Community Health Assistant to examine attitudes, beliefs, and barriers in relation to the use of the latrines and open defecation.

The collection of qualitative data was based on the principle of taking notes and audio recording to record the verbatim answers of the participants, with their consent. To visually

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examine the state of sanitation and distributions of latrines, transect walks were conducted with the community members along predetermined routes, augmented with photos of Community Led Total Sanitation (CLTS) latrines in comparison to incentivized methods. This gave contextual spatial and triangulated qualitative knowledge.

2.7 Training research assistants and pilot testing

Local Public Health Officers and local Community Health Assistants (fluent in English and Samburu) were taken as research assistants. They were familiar with the respondents, their culture and language made communication with them easier. The principal investigator provided them with systematic training based on the study objectives, ethical considerations, administration of questionnaires and interview methods. This was done to pilot test the tool and refine it in neighboring non-study villages in order to enhance clarity. Focus was made on standardization of administration processes, elimination of interviewer bias, and a sense of confidentiality was upheld.

2.8 Data cleaning and analysis

Systematic coding, cleaning and validating of all field surveys (n = 200 questionnaires) and FGD/KII transcripts were done before analysis. Values that were not present (<5) were treated as per a protocol. Listwise deletion was used when there were bivariate analyses to be done and only the necessary univariate descriptive summaries were imputed using the mean. Boxplot was used to determine outliers, and these were compared with source data.

To verify the data integrity, 20-percent of the quantitative data and 100-percent of qualitative transcripts were re-keyboarded by other clerks. Any discrepancies (less than 2 percent) were sorted out by checking of the source documents. The SPSS version 16.0 was used to analyse the quantitative data. The analysis was done in two phases;

2.9 Univariate analysis

The variables were considered separately. Frequencies and percentages were used in summarizing categorical variables. The measures of central tendency and dispersion were used to describe the continuous variables where they were relevant. It gave a breakdown of sample characters such as the prevalence of open defecation, latrines, and socio-demographic characteristics.

2.10 Bivariate analysis

The relationship between dependent variables (e.g., open defecation practices and sanitation knowledge) and independent socio-cultural and economic variables was tested by appropriate statistical tests depending on the type of variables. Associations between nominal variables were done with chi-square tests. In cases where Pearson had the assumptions (continuous and normally distributed variables) Pearson r was employed in the evaluation of the strength and direction of linear relationships. In the case of the ordinal variables, the Spearman rank correlation had been taken into consideration where necessary.



A statistical significant level was determined as alpha =0.05. Exact p-values, test statistics and degrees of freedom were provided to increase transparency and reproducibility. The quantitative results were provided in well labelled tables and charts, and notation had been used to show levels of statistical significance.

3.0 Results and discussion

3.1 Demographic characteristics

A total of 200 respondents were involved in the study. There was comparative equality in terms of age distribution. Respondents aged between 36 and 45 years, and 23.5 percent by those aged above 56 years constituted the most significant percentage (22.5). Young adults aged 18-25 years made up 20% and those aged 26-35 years made 19%. The respondents in the age bracket of 46-55 years were 15% of the total number.

Majority of the respondents were married (65%). Widows, widowers, divorced individuals, and single parents were 14, 2.5 and 5.5 respectively. In terms of the household size, 52 percent of households comprised of three and six members. Households that had less than 3 people constituted 15.5 and 32.5 had more than 6 people. The most common occupation (53.5) was livestock keeping. Respondents who are unemployed were 20.5%. Farmers represented 11% formally employed people 5.5% business owners 5% and other occupations 4.5%. Education was largely low. Over 50% per cent of the respondents (55.5) were not educated. Its main education level was 18.5 percent, secondary education 12 percent, tertiary education 10.5 percent and university education 3.5 %.

Table 0.1: Univariate analysis of socio-demographic characteristics of the participants

Demographic characteristics		Frequency (N=200)	Percentage (%)
Distribution by Age	18-25 yrs	40	20
	26-35 yrs	38	19
	36-45 yrs	45	22.5
	46-55 yrs	30	15
	>56 yrs	47	23.5
	Total	200	100
Marital status	Married	130	65
	Single parent	28	14
	Widow	26	13
	Widower	5	2.5
	Divorced	11	5.5
	Total	200	100
Household size	<3 members	31	15.5
	3>6 members	104	52
	>6 members	65	32.5
	Total	200	100
Occupation Status	Employed	11	5.5
	Farmer	22	11
	Livestock keeping	107	53.5
	Unemployed	41	20.5
	Business	10	5
	Others	9	4.5

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Level of Education	Total	200	100
	Primary	37	18.5
	Secondary	24	12
	Tertiary	21	10.5
	University	7	3.5
	None	111	55.5

Sub-Saharan Africa has linked large household size with higher chances of open defecation (Belay et al., 2022). Family size was found to be a determinant of open defecation in households that had toilets in Gambella, Ethiopia (Birasa et al., 2024). The education level and the occupational status have also demonstrated the considerable interconnections with the practice of sanitation in rural African settings (Ntaro et al., 2022; Belay et al., 2022).

These demographic trends are especially applicable in nomadic and pastoralist localities. The high dependency on livestock rearing, low education rates and bigger family groups may contribute to the management of sanitation, infrastructure investment, and restrictions of movements. Collectively, these properties can give the necessary background on the interpretation of sanitation behavior among the people at the Lodokejek Ward.

3.2 Indicators of open defecation

The households with a high prevalence of open defecation were 95.5% with 51.5% of them not having latrines. Out of homes that had latrines (N = 97), 82.5% of them claimed to consistently use their latrine. The majority of the open defecation was done in bushes or shrubs (68%), which is a health concern to society, as illustrated in Table 3.2.

Table 0.2: Univariate analysis of the indicators of open defecation within the participants

Indicators of Open Defecation	Frequency	Percentage (%)
Presence of latrine	Yes	97
	No	103
Consistency of use (N=97)	Yes	80
	No	7
	Not always	10
Where do you defecate	Bush/shrubs	70
	Streams	4
	Sharing with neighbours	17
	Share with institutions	12
Practice open defecation	Yes	191
	No	9
Duration and context	Since childhood	25
	Since relocating	16
	While looking after livestock	135
	While traveling	10
Presence of fecal matter in compound	Yes	103
	No	97

The correlation of occupation and sanitation behavior was shown through bivariate analysis. A good positive relationship was established between pastoralist activity (livestock care) and

open defecation practice ($r = 0.76$, $p < 0.05$) which demonstrated that socio-economic activity plays a significant role in the pattern of sanitation. Chi-square tests indicated a statistically significant relationship between occupation and open defecation ($\chi^2 = 45.23$, $p < 0.001$) implying that a household with a livestock keeping occupation is more likely to practice open defecation as compared to other occupations. The interpretation of effect size is centered on occupation as an explanatory factor in a way that has a significant proportion of variance in sanitation behavior rather than the level of significance.

Faecal materials were reported in compounds by 51.5% of households, therefore the environmental contamination, which is related to high prevalence of open defecation. This domination is also significantly greater compared to 22.55% pooled prevalence in sub-Saharan Africa, where the range is between 0.81% in Comoros and 72.75% in Niger (Belay et al., 2022). Another study by Zainon et al. (2024) showed that water leakages are a threat to households as they contribute to uncontrollable contamination which is associated with infrastructural gaps. These findings indicate the contribution of pastoralist mobility, occupation and household infrastructure as determinants of sanitation behavior.

3.3 Socio-cultural and economic factors influencing motivation to construction of latrines

These findings suggest that both socio-economic and cultural aspects play a big role in the desire to build latrines in the nomadic communities. Affordability was the most commonly reported socio-economic constraint with 47.9% of the respondents mentioning. The other barriers were nomadic lifestyle (21.3), not having skills to build latrines (6.4), absence of tools (4.3) and absence of subsidies (20.2). The Bivariate analysis results demonstrated that there was a moderate positive correlation between socio-economic constraints and the motivation to build a latrine ($r = 0.435$, $p < 0.01$), which was statistically significant according to Chi-square tests ($\chi^2 = 33.11$, $p < 0.001$; Table 3.3).

The culture practices are also crucial. Moranism- a ritual between young men in the study region- forbids the use of latrines during the moran stage. The prevalence of this cultural norm was 35% and strongly correlated with the motivation to construct latrines ($\chi^2 = 92.98$, $p < 0.001$; $r = 0.895$, $p < 0.01$). Other barriers to culture were social norms that did not allow them to share toilets with their in-laws (26%), fear of mixing feces (15%), and general views that they did not include latrine use in their lifestyle (5%). These observations suggest that cultural beliefs have the same strength as economic restrictions to determine the sanitation behaviors.

The bivariate analysis of the socio-economic and cultural factors that are important in latrine construction are provided in Table 3.3. Percentages are left in place so that the reader can be able to cross-check the frequency of responses with statistical tests.

Table 0.3: Bivariate analysis of chi-square test and correlation between socio-economic and cultural factors influencing construction of latrines

Variables	Sub-variables	Frequency	Percentage (%)	χ^2	R
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Socio-economic	Affordability/cost	90	47.9	33.11 (p<0.001)	0.435 (p<0.01)
	Nomadic lifestyle	40	21.3		
	Lack of skills	12	6.4		
	Lack of tools	8	4.3		
	Lack of subsidies	38	20.2		
Cultural	Moranism	70	35.0	92.98 (p<0.001)	0.895 (p<0.01)
	Sharing toilet with in-laws	52	26.0		
	Fear of mixing feces	30	15.0		
	Not part of lifestyle	10	5.0		
	Nomadism	38	19.0		

Although there is a relatively high level of awareness about the sanitation issues, the desire to build latrines is low. Such a gap is a manifestation of structural, cultural, and mobility patterns that are inherent in the pastoralist way of life. An example is when homes realize advantages of using latrines, but feel construction impossible because they change their locations regularly or it is a taboo in the community.

These results indicate the need to develop culturally appropriate sanitation programs. Sanitation partner programs ought to involve Moran leaders within the community to ensure that cultural factors are integrated into Community-Led Total Sanitation (CLTS) programs to make them more acceptable and sustainable.

3.4 Lack of Awareness and Sensitization as a Factor Influencing Construction of Pit Latrines

Descriptive findings reveal that seventy percent of the respondents said they had inadequate knowledge about sanitation, and eighty-five percent of them heard about sanitation methods like Community-Led Total Sanitation (CLTS). The specific knowledge, channel of awareness, and approach to sensitization distribution is given in Table 3.4 below.

Table 0.4: Bivariate analysis of chi-square test and correlation between lack of awareness and sensitization as a factor influencing construction of pit latrines

Variable		Frequency	Percentage (%)	Chi Square (χ^2)	Person correlation (r)
Lack of knowledge	Yes	140	70	80.721 (p=0.000)	0.594 (p<0.01)
	No	50	25		
	Not sure	10	5		
	Total	200	100		
Awareness of existence of approaches to sanitation and hygiene	Yes	170	85	33.238 (p=0.000)	0.408 (p<0.01)
	No	30	15		
	Total	200	100		
	Local radio stations	70	68	151.2 (p=0.000)	0.784 (p<0.01)
	Television	44	22		

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Channels of getting hygiene messages	Brochures and pamphlets	11	6		
	Social media	9	5		
	CHVs	18	9		
	Chief's baraza	80	40		
	Total	200	100		
Awareness of specific sanitation approaches	CLTS	90	45	178.5	0.876
	Incentives of various forms	30	15	(p=0.000)	(p<0.01)
	Subsidies	30	15		
	All of the above	50	25		
	Total	200	100		
Awareness creation	Health education	60	30	177.6 (p=0.000)	0.887
	Role plays	10	5		(p<0.01)
	Demonstrations in public barazas	20	10		
	Engaging role models in the villages	35	18		
	Increasing sanitation promoters in the villages	75	38		

Bivariate analyses show moderate to strong positive correlations between awareness-related variables and the likelihood of constructing pit latrines ($r = 0.408\text{--}0.887$, all $p < 0.01$). These correlations suggest that higher awareness is associated with increased motivation to construct latrines, though practical implications are influenced by socio-economic and cultural constraints.

Local radio stations were the most reported channel for hygiene messages, reaching 68% of respondents. Community engagement activities such as health education, demonstrations, role plays, and involvement of local role models were also commonly reported, indicating that multiple sensitization approaches coexist in the community.

While statistical significance is strong across Chi-square and correlation tests, practical interpretation shows that knowledge alone does not automatically translate into latrine construction. The results emphasize the persistent knowledge-behavior gap: respondents may be aware of sanitation approaches but are still constrained by other factors such as mobility, cultural norms, or limited resources.

3.5 Social and health impacts associated with open defecation

Respondents reported notable social and health consequences linked to open defecation (OD). Socially, 35.8% cited increased sexual violence and 21.6% indicated poor privacy, while 10.5% reported loss of dignity. Latrines were largely unsuitable for People Living with Disabilities (PLWDs), highlighting gaps in inclusive sanitation design. Health risks included disease spread

(45.5%), water pollution (27%), malnutrition (3.5%), and stunting in children (16.5%). Table 3.5 presents the detailed distribution.

Table 0.5: Bivariate analysis of social and health impacts associated with open defecation

Variable		Frequency	Percentage (%)	Chi Square (χ^2)	Person correlation (r)
Social impacts	Loss of dignity in the society	20	10.5	161.9(p=0.000)	0.867(p<0.01)
	Increased sexual violence	68	35.8		
	Poor privacy	41	21.6		
	Not aware of any	61	32.1		
Problems attributed to open defecation	Flies and smell	80	40.0	191.6(p=0.000)	0.956(p<0.01)
	Shame	10	5.0		
	Increased medical expenses	10	5.0		
	Don't know	100	50.0		
Risks of open defecation	Spread of diseases	91	45.5	190.4(p=0.000)	0.868(p<0.01)
	Snake bite	10	5.0		
	Water pollution	54	27.0		
	Malnutrition	7	3.5		
	Stunting in children	33	16.5		
	Any other	5	2.5		

These findings align with studies highlighting that women who practice open defecation, especially in rural areas with limited privacy, face increased vulnerability. Saleem et al (2019) highlighted that women often face threats of sexual violence when they leave their homes to defecate in open fields, a concern echoed in systematic reviews that highlight the psychosocial stressors linked to inadequate sanitation facilities. The high r value of 0.867 for social impacts suggest that factors such as increased sexual violence, loss of dignity, and poor privacy are strongly linked to open defecation practices. The social impact factors are also strongly correlated to the availability of sanitary facilities. This also suggests that addressing sanitation issues could have profound effects on women's safety and societal perceptions. Additionally, 21.6% of respondents cited poor privacy as a significant issue, while 32.1% were not aware of any specific problems associated with open defecation. The lack of awareness may indicate a need for enhanced education and community engagement regarding the risks tied to open defecation. This aligns with findings from other studies that stress the importance of awareness campaigns to inform communities about the dangers of poor sanitation practices (Mara, 2017). Mahmud et al. (2024) affirms that their study that there is critical water quality problem in urban areas.



Socio-cultural and economic drivers of open defecation and sanitation interventions

Health risks were prominently identified, with 45.5% acknowledging the spread of diseases as a major issue and 27% pointing to water pollution. These findings highlight the urgent need for targeted interventions and community education to address the multifaceted challenges posed by open defecation, ultimately aiming to improve both social conditions and public health outcomes.

The Pearson correlation matrix presented in Table 3.6 illustrates the relationships between various social and health impacts of open defecation and the frequency and duration of these practices.

Table 0.6: Pearson correlation matrix between the social and health impacts and frequency and duration of open defecation practices


Socio-cultural and economic drivers of open defecation and sanitation interventions

Factors		social impacts of open defecation	problems of attributed to open defecation	risks of open defecation	how long and how often do consistency of you practice of use of open toilet while defecation at home	
social impacts of open defecation	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	190				
problems attributed to open defecation	Pearson Correlation	.903**	1			
	Sig. (2-tailed)	.000				
	N	190	200			
risks of open defecation	Pearson Correlation	.873**	.864**	1		
	Sig. (2-tailed)	.000	.000			
	N	190	200	200		
how long and how often do you practice open defecation	Pearson Correlation	.697**	.575**	.547**	1	
	Sig. (2-tailed)	.000	.000	.000		
	N	186	186	186	186	
consistency of use of toilet while at home	Pearson Correlation	.636**	.965**	.693**	.347**	1
	Sig. (2-tailed)	.000	.000	.000	.001	
	N	97	97	97	97	97

** . Correlation is significant at the 0.01 level (2-tailed).

The results show a very strong positive correlation between the social impacts of open defecation and the problems attributed to open defecation ($r = 0.903$, $p < 0.01$), indicating that as social issues increase, so do the problems associate with open defecation. Similarly, there is a strong correlation between social impacts and risks of open defecation ($r = 0.873$, $p < 0.01$), suggesting that heightened social concerns are closely linked to increased health risks. The

frequency and duration of open defecation practices also show significant correlations with these factors; for instance, it correlates moderately with social impacts ($r = 0.697$, $p < 0.01$) and more strongly with problems attributed to open defecation ($r = 0.575$, $p < 0.01$) and risks ($r = 0.547$, $p < 0.01$). Additionally, the consistency of toilet use at home has a strong correlation with both problems attributed to open defecation ($r = 0.965$, $p < 0.01$) and risks ($r = 0.693$, $p < 0.01$), indicating that regular toilet use is associated with fewer problems and risks related to open defecation practices. Open defecation significantly contributes to child mortality rates in areas where sanitation is poor, with studies indicating that households practicing open defecation face a higher prevalence of infectious diseases and adverse health outcomes (Belay et al., 2022). Generally, these correlations underscore the interconnectedness of social factors, health risks, and sanitation practices, emphasizing the need for comprehensive interventions that address these relationships to improve public health outcomes in communities affected by open defecation.

3.6 Cultural factors that influence open defecation

A substantial majority (65%) of respondents believe that human faeces cause diarrhea, indicating a strong awareness of health risks associated with open defecation. The chi-square statistic ($\chi^2=95.508$, $p=0.000$) suggests a highly significant relationship between this belief and open defecation practices, with a positive correlation coefficient ($r=0.676$, $p<0.01$) indicating the likelihood of practicing open defecation. In contrast, only 40% believe that children's faeces are harmful, while 55% do not believe so. This discrepancy may reflect cultural norms associated with children's waste, which could be contributing to continued open defecation practices as shown in Table 3.7.

Table 0.7: Cultural factors that influence open defecation practices

Variable	Frequency	Percentage (%)	Chi Square (χ^2)	Person correlation (r)
Superstition			95.508	0.676
Human faeces cause diarrhea	Yes	65	(p=0.000)	(p<0.01)
	No	33		
	Don't know	2		
Children faeces cause diseases	Yes	40	142.5	0.805
	No	55	(p=0.000)	(p<0.01)
	Not sure	5		
Religion influence	Yes	15	95.142	0.682
	No	55	(p=0.000)	(p<0.01)
	Not sure	30		
Attitude influence	Yes	55	154.1	0.792
	No	30	(p=0.000)	(p<0.01)
	Don't know	15		

The chi-square result ($\chi^2 = 142.5$, $p = 0.000$) and correlation ($p < 0.01$) further emphasize that this belief significantly influences sanitation behaviors. These findings reflect how deeply embedded cultural beliefs and taboos shape sanitation behaviors beyond individual knowledge

or socio-economic factors. According to Tamene and Fework (2021), more than 10% of respondents in a comparable survey conducted in Marsabit, Kenya. Cultural taboos and beliefs such as the idea that children's feces are harmless contribute to persistent open defecation behaviors.

Only 15% of participants indicated that religion influences their sanitation practices, with a majority (55%) disagreeing. This suggests that while some individuals may consider religious teachings relevant to sanitation, the overall impact of religion on open defecation practices is minimal. The statistical significance ($\chi^2 = 95.14$ $p = 0.000$) indicates a noteworthy relationship, yet the correlation ($r = 0.682$, $p < 0.01$) suggests it is not as strong as other factors. The findings show that 55% of respondents feel their attitudes toward sanitation influence their practices positively. The chi-square value ($\chi^2=154.1$, $p=0.000$) supports the significance of this relationship, while the correlation coefficient ($r = 0.792$, $p < 0.01$) indicates a strong association between positive attitudes and reduced open defecation. This aligns with the notion that personal beliefs and attitudes are critical in determining health-related behaviors

3.7 The Impact of weak law enforcement on latrine coverage

More than half (55%) of the respondents believed that weak law enforcement is a significant factor contributing to low latrine coverage in the area as shown in Table 3.8.

Table 0.8: Relationship between weak law enforcement and latrine coverage

Variable		Frequency	Percentage (%)	Chi Square (χ^2)	Person correlation (r)
Weak law enforcement	Yes	110	55	154.1 ($p=0.000$)	0.740 ($p<0.01$)
	No	60	30		
	Not sure	20	10		
	Never heard of such laws	10	5		
Punishing those practicing open defecation	Yes	10	5	11.177 ($p=0.001$)	0.236 ($p<0.01$)
	No	190	95		

Some members of the community just ignore reinforcing or repairing their pit latrines because no action has been taken against them after all, remarked one of the participants in the FGD. This means that many community members feel that there are no consequences for neglecting or failing to maintain their pit latrines, leading to a culture of non-compliance. Mensah et al. (2022) conducted a study on public compliance with environmental sanitation regulations in Ghana, which highlighted that low compliance is often due to ineffective law enforcement, inadequate public education, and a poor sanitation culture. This is consistent with the discovery that a sizable segment of participants (55%) thinks that inadequate law enforcement serves as a contributing factor to low latrine coverage. The finding that 5% of respondents are unaware of laws enforcing latrine coverage highlights a critical gap in community education and the study emphasizes the need for public education to improve compliance (Mensah et al., 2022).



The results also revealed that 95% of respondents reported no legal punishment for individuals who practiced open defecation. In a study conducted in Lodwar town, Kenyan, 95% of participants stated that there was no penalty for those without pit latrines (Busienei et al., 2019). The lack of legal consequences was seen as a hindrance to ending open defecation practices. In Nigeria, there are plans to criminalize open defecation, suggesting fines or non-custodial punishments for offenders. However, concerns arise about the fairness of penalizing individuals who may lack access to proper sanitation facilities (Ewuzie, 2022).

3.8 Community-Led Total Sanitation (CLTS) Parameters/Protocol

The study conducted observations based on the Community-Led Total Sanitation (CLTS) protocol at various households as per CLTS guideline by Kar and Chambers (2008), revealing several key findings regarding sanitation and hygiene practices as summarized in Table 3.9. on compound cleanliness, 45% of households maintained a clean compound, 51.5% of compounds had visible faecal matter and only 15% of households had a compost pit. Regarding pit latrine access, 48.5% of households had a pit latrine, 100% of households with pit latrines had a designated footpath leading to the pit latrine, indicating usage and 61.9% of households covered the aperture of the pit latrine. Only 30.9% of households had a designated hand-washing facility, 83.3% of households had water available inside for hand washing and a mere 53.3% of households provided soap for hand washing.

Table 0.9: Observation based on CLTS protocol at the households

CLTS Parameters		Frequency	Percentage
Aesthetics			
Status of compound	Clean	90	45
	Dirty	110	55
Presence of faecal matter in the compound	Present	103	51.5
	Absent	97	48.5
Presence of compost pit	Present	30	15
	Absent	170	85
Presence of pit latrine			
Latrine	Present	97	48.5
	Absent	103	51.5
Foot path to the pit latrine	Present	97	100
Presence of aperture cover	Present	60	61.9
	Absent	37	38.1
Hand washing facility			
Hand washing facility	Present	30	30.9
	Absent	67	69.1
Soap	Provided	16	53.3
	Not provided	14	46.7
Water	With water	25	83.3
	Without water	5	16.7
Latrine favouring PLWDS	Favouring	3	3.1
	Not favouring	94	96.9
State of super structure			
Privacy	Providing	91	94
	Not providing	6	6

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Door	Has door fixed	80	82.5
	Door missing	17	17.5
Floor	Clean	70	72.2
	Dirty floor	27	27.8
Slab	Present	31	32
No slab/murram	Provided	66	68

Out of 97 pit latrines, 91 (94%) offered adequate privacy to users which is crucial for user comfort and dignity. 82.5% of these latrines had doors installed, contributing to user privacy and security, while 11 utilized improvised doors made from canvas or gunny bags. Only 31 latrines featured concrete slabs, indicating a potential area for improvement in the structural integrity and hygiene of the facilities. Gudda et al. (2019) carried out a study on pit latrine fill up rates and reported that 61% of pit latrines were used for solid waste disposal, and 45% of respondents lacked hygiene awareness. This suggests lack of hygiene awareness which can undermine the benefits of having private and well-constructed latrines, as improper usage can lead to health risks. Cha et al. (2024) in their study on performance of pit latrines in Ethiopia reported that in communities where 50% or more of the households had well-built latrines and 70% or more had a pit latrine with a slab (high coverage), the likelihood of diarrhea was lower for children residing in these households, than in households without a latrine or one that was poorly built in a village with low coverage. The findings of this study present a positive outlook on the structural aspects of pit latrines, which must be contextualized within the broader challenges of usage, hygiene awareness, and maintenance.

In the study area, only 3% of the pit latrines were favouring the people living with disabilities to use conveniently highlighting a significant gap in sanitation infrastructure. Oloruntoba et al. (2020) studied access to sanitation facilities and handwashing practices among physically challenged persons in homes for the disabled in Ibadan, Nigeria and drew the attention to the insufficient accessibility of restrooms for individuals with impairments, noting that 42% of participants found using the toilet challenging because they lacked assistive aids. On the other hand, Daniel et al. (2023) reported less than 5% of households had inclusive sanitation facilities. These studies collectively demonstrate the critical need for inclusive sanitation solutions that address barriers experienced by people with disabilities, emphasizing the social as well as the technical aspects of accessibility in sanitation infrastructure.

4.0 Conclusions

This study findings revealed that socio-economic (47.9% affordability), cultural (35% moranism), and knowledge gaps (70%) are the primary drivers of 70% open defecation prevalence in Lodokejek Ward. This prevalence exceeds Sub-Saharan Africa's 22.55% prevalence due to nomadic pastoralism and taboos despite 85% CLTS awareness. Women in the study area faced 35.8% elevated violence risks while 96.9% latrines excluded PLWDs. This study contributes to the broader discourse on rural sanitation by highlighting the imperative of context-specific strategies aligned with Sustainable Development Goal 6 (clean water and sanitation). Importantly, it reinforces the potential of culturally and economically adapted CLTS



models as a pathway to sustainable sanitation in pastoralist communities. While offering valuable insights, the study acknowledges limitations including reliance on self-reported data, which may introduce bias, and the specific focus on one ward that may affect generalizability.

5.0 Recommendations

To effectively reduce open defecation in nomadic communities, the study recommends tailored interventions addressing unique social, economic, and cultural contexts in nomadic communities, alongside enhanced community education on sanitation risks to motivate latrine construction, via local radio stations, role models, and moran involvement to bridge knowledge-behavior gaps, and enforce hygiene. Household-based income-generating programs like CHUSLA (Community Health Unit Savings and Lending Activities), tied to sanitation, should be encouraged to boost household investments in sanitation, tackling affordability and tools/skills barriers. Governments, sanitation partners and other WASH stakeholders should implement targeted, context-specific sanitation interventions that integrate with health and education sectors, such as school-based hygiene programs and mobile sanitation units, which are community led, to increase latrine coverage and usage.

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6.2 Declaration of interest

None

6.3 Conflict of interest

The Authors declare no conflict of interest

6.4 Logical and ethical consideration

Ethical clearance was secured from the Jomo Kenyatta University of Agriculture and Technology Institutional Ethics Review Committee (Reference No. JKUISERC/02317/1359). Informed consent was obtained verbally or in writing, with procedures adapted to respect local literacy levels (verbal consent recorded for illiterate participants). The participant's confidentiality was protected by assigning unique codes to the data to anonymize it, remove identifiers and securing data storage. Ethical practices ensured voluntary participation and respect for the sensitivities around the topic of open defecation, building trust with the community and improving data quality.

7.0 References

Abalaka, L. D., & Tokula, A. E. (2022). Assessment of the Factors Affecting Open Defecation among Slum Dwellers in Lokoja, Kogi State Nigeria. *Journal of Geography, Environment and Earth Science International*, 26(12), 61-72.



- Abebe, T. A., & Tucho, G. T. (2020). Open defecation-free slippage and its associated factors in Ethiopia: A systematic review. *Systematic Reviews*, 9(1), 252. <https://doi.org/10.1186/s13643-020-01511-6>
- Ahmed, Y. Y., Zulhaidi bin Mohd Shafri, H., & GAMBO, J. (2024). Urban Growth and Urban Heat Islands Effect in Kano Metropolis: A Remotely Sensed Approach. *Siti Nur Aliaa and GAMBO, JIBRIN, Urban Growth and Urban Heat Islands Effect in Kano Metropolis: A Remotely Sensed Approach*.
- Appiah-Effah, E., Boakye, K., Salihu, T., Duku, G. A., Fenteng, J. O. D., Boateng, G., ... & Nyarko, K. B. (2024). Determinants of open defecation among rural women in Ghana: analysis of demographic and health surveys. *Environmental Health Insights*, 18, 11786302241226774.
- Belay, D. G., Asratie, M. H., Aragaw, F. M., Tsega, N. T., Endalew, M., & Gashaw, M. (2022). Open defecation practice and its determinants among households in sub-Saharan Africa: Pooled prevalence and multilevel analysis of 33 sub-Saharan Africa countries demographic and health survey. *Tropical Medicine and Health*, 50(1), 28. <https://doi.org/10.1186/s41182-022-00416-5>
- Birasa, D. F., Donacho, D. O., Gil, R. G., & Debele, G. R. (2024). Open Defecation Practice and Its Determinants Among Households Owned Toilet Facilities in Gambela Town, Southwest Ethiopia. *Environmental Health Insights*, 18, 11786302241246421.
- Busienei, P. J., Ogendi, G. M., & Mokua, M. A. (2019). Open Defecation Practices in Lodwar, Kenya: A Mixed-Methods Research. *Environmental Health Insights*, 13, 117863021982837. <https://doi.org/10.1177/1178630219828370>
- Cha, S., Jung, S., Abera, T., Beyene, E. T., Schmidt, W. P., Ross, I., Jin, Y., & Bizuneh, D. B. (2024). Performance of pit latrines and their herd protection against diarrhea: A longitudinal cohort study in rural Ethiopia. *Global Health: Science and Practice*, 12(3), e2200541. <https://doi.org/10.9745/GHSP-D-22-00541>
- Clasen, T. F., Bostoen, K., Schmidt, W.-P., Boisson, S., Fung, I. C.-H., Jenkins, M. W., Scott, B., Sugden, S., & Cairncross, S. (2010). Interventions to improve disposal of human excreta for preventing diarrhoea. *Cochrane Database of Systematic Reviews*.
- Daniel, D., Nastiti, A., Surbakti, H. Y., & Dwipayanti, N. M. U. (2023). Access to inclusive sanitation and participation in sanitation programs for people with disabilities in Indonesia. *Scientific Reports*, 13(1), 4310.
- Ewuzie, C. (2022). Open defecation in nsukka local government area of enugu state, nigeria: shifting the discussion towards health and socio-economic implications. *Global Journal of Arts Humanity and Social Sciences* ISSN, 2583, 2034.
- Fisher, R. A., & Woodward. (1998). Sample size determination based on Fisher's exact test for use in 2×2 tables. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 161(1), 39-54.
- Fagunwa, O. E., Mthiyane, T., Fagunwa, A., Olayemi, K. I., Alozie, A., Onyeaka, H., ... & Ojo, A. (2025). Priority regions for eliminating open defecation in Africa: implications for antimicrobial resistance. *Environment, Development and Sustainability*, 27(1), 2675-2699.



- Gudda, F. O., Moturi, W. N., Oduor, O. S., Muchiri, E. W., & Ensink, J. (2019). Pit latrine fill-up rates: variation determinants and public health implications in informal settlements, Nakuru-Kenya. *BMC Public Health*, 19, 1-13.
- Humňalová, H., & Ficek, F. (2023). Sanitation strategies for reducing open defecation in rural areas of India and Ethiopia. *AUC GEOGRAPHICA*, 58(1), 51-63.
- Kar, K., & Chambers, R. (2008). *Handbook on Community-Led Total Sanitation*. Brighton, UK: Institute of Development Studies, University of Sussex. ISBN: 978-0-9550479-5-4.
- Kenya National Bureau of Statistics (Ed.). *2019 Kenya population and housing census*. Kenya National Bureau of Statistics.
- KNBS. (2022). *Kenya Demographic and Health Survey 2022*. Nairobi, Kenya, and Rockville, Maryland, USA: KNBS.
- Mahmud, M. R., Awang, N. W., & Ting, S. K. (2024). Application of the Field Hyperspectral Sensing to Estimate the Oxidation-Reduction Potential (ORP) in Tropical Urban Waters. *Journal of Advanced Geospatial Science & Technology*, 4(1), 1-15.
- Mara, Duncan. (2017). The elimination of open defecation and its adverse health effects: A moral imperative for governments and development professionals. *Journal of Water Sanitation and Hygiene for Development*. 7. washdev2017027. 10.2166/washdev.2017.027.
- Mensah, J., Mattah, P. A. D., Amoah, J. O., & Mattah, M. M. (2022). Public compliance with environmental sanitation regulations in Ghana. *Open Health*, 3(1), 1-12.
- Njuguna, J. (2019). Progress in sanitation among poor households in Kenya: Evidence from demographic and health surveys. *BMC Public Health*, 19(1), 135. <https://doi.org/10.1186/s12889-019-6459-0>
- Ntaro, M., Owokuhaiza, J., Isunju, J. B., Mulogo, E., & Ssempebwa, J. C. (2022). Contextual and psychological factors influencing open defecation free status: an exploratory qualitative study in rural Southwestern Uganda. *BMC Public Health*, 22(1), 414.
- Nunow, A. A. (2024). Mobility as a key coping strategy among pastoral communities: The case of nomadic pastoralists in Kenya. *International Journal of Social Science and Human Research*, 7(12).
- Oloruntoba, E. O., Udofia, I. P., & Adejumo, M. (2020). Access to sanitation facilities and handwashing practices among physically challenged persons in homes for the disabled in Ibadan, Nigeria. *Journal of Environmental Protection*, 11(04), 299.
- Abdul Azeez E.P., Negi, D. P., & Mishra, A. (2019). Women's Experiences of Defecating in the Open: A Qualitative Study. *Indian Journal of Gender Studies*, 26(1-2), 160-170. <https://doi.org/10.1177/0971521518808098>
- Saleem, M., Burdett, T. & Heaslip, V. Health and social impacts of open defecation on women: a systematic review. *BMC Public Health* 19, 158 (2019). <https://doi.org/10.1186/s12889-019-6423-z>
- Tamene, A., & Afework, A. (2021). Exploring barriers to the adoption and utilization of improved latrine facilities in rural Ethiopia: An Integrated Behavioral Model for Water, Sanitation and Hygiene (IBM-WASH) approach. *PloS one*, 16(1), e0245289.
- Workman, C. L., Miller, J. D., Shah, S. H., Maes, K., Tesfaye, Y., & Mapunda, K. M. (2024). Frequency and perceived difficulty of household water experiences in Morogoro,



- Tanzania: Evidence of the psychosocial burden of water insecurity. *SSM-Mental Health*, 5, 100295.
- Woodward, M. (1992). Formulae for sample size, power and minimum detectable relative risk in medical studies. *Journal of the Royal Statistical Society: Series D (The Statistician)*, 41(2), 185–196. <https://doi.org/10.2307/2348252>
- World Health Organization & United Nations Children’s Fund (UNICEF). (2015). *Progress on sanitation and drinking water – 2015 update and MDG assessment*. World Health Organization. <https://apps.who.int/iris/handle/10665/177752>
- Zainon, O. B., Zahairy, N. A. N., & Ghazali, M. D. (2024). Detecting Water Leakage Patterns Using Ground Penetrating Radar in Clay and Sandy Soils. *Journal of Advanced Geospatial Science & Technology*, 4(2), 187-204.