
Effect of Urban Informal Settlement Sanitation Improvement on Household Climate Change Adaptation: Evidence from Langas Ward, Uasin Gishu County, Kenya

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Abstract

Climate change increasingly threatens sanitation systems in urban informal settlements, yet sanitation improvement remains an underexplored pathway for building household climate resilience. This study examined the effect of sanitation improvement on household climate change adaptation in Langas Ward, Uasin Gishu County, Kenya, focusing on non-sewered toilet installation, hygiene training, institutional collaboration, and the moderating role of community participation. Anchored on the “How Tough is WASH” framework and Arnstein’s Ladder of Citizen Participation, an explanatory sequential mixed-methods design was adopted, combining a structured survey of 347 households (91.3% response rate) with 12 key informant interviews. Quantitative data were analysed using descriptive statistics, Pearson correlation, multiple regression, and hierarchical regression; qualitative data were analysed thematically. Non-sewered toilet installation emerged as the strongest predictor of adaptation (Beta = 0.487, $p < 0.001$), followed by hygiene training (Beta = 0.401, $p < 0.001$) and institutional collaboration (Beta = 0.389, $p < 0.001$), together with education and income as significant covariates. Community participation did not significantly moderate the sanitation–adaptation relationship ($B = 0.089$, $p = 0.056$), reflecting predominantly tokenistic participation. Qualitative findings showed that interventions strengthened resilience but were constrained by affordability, flood vulnerability, patchy training coverage, weak institutional coordination, and limited decision-making power for communities. The study concludes that sanitation improvement is an effective, though incomplete, strategy for climate adaptation in informal settlements and recommends flood-resilient sanitation design, strengthened inter-institutional coordination, climate-responsive hygiene education, and a shift from tokenistic to substantive community participation.

Keywords: *Sanitation Improvement, Climate Change Adaptation, Informal Settlements, Non-Sewered Sanitation, Community Participation, Kenya*

INTRODUCTION

Sanitation interventions have traditionally focused on disease prevention, but climate change has introduced new pressures, flooding, erratic rainfall, and rising temperatures, that compromise sanitation infrastructure and heighten exposure to environmental hazards, particularly in urban informal settlements (Howard et al., 2021). Contemporary frameworks such as climate-resilient sanitation, Citywide Inclusive Sanitation, and the Tracking Adaptation and Measuring

Development framework increasingly recognise sanitation as a pillar of climate adaptation, yet interventions remain narrowly focused on infrastructure provision, with limited attention to how they strengthen household-level adaptive capacity (UNICEF, 2020; Schrecongost et al., 2020). In sub-Saharan Africa, inadequate sanitation combined with climate variability significantly undermines household resilience: flooding damages latrines and spreads waste into living environments, while drought limits water available for hygiene (Okesanya et al., 2024; WSUP, 2020). In Kenya, and specifically in Langas Ward, Uasin Gishu County, rapid urbanisation has produced densely populated settlements with inadequate sanitation infrastructure, where heavy rainfall and flooding routinely cause latrine collapse, waste overflow, and contamination of water sources (County Government of Uasin Gishu, 2023). Although national and county policies such as Kenya Vision 2030 and the Uasin Gishu County Climate Change Action Plan (2023–2027) acknowledge the need for climate-resilient sanitation, implementation gaps persist. Existing research tends to emphasise access to sanitation facilities without examining how such improvements translate into household-level adaptation outcomes, and rarely integrates measurable adaptation indicators or the moderating role of community participation. This study addresses these gaps.

The main objective was to examine the effect of urban informal settlement sanitation improvement on household climate change adaptation in Langas Ward. The specific objectives were to: (i) examine the effect of non-sewered toilet installation on household climate change adaptation; (ii) establish the effect of hygiene training on household climate change adaptation; (iii) establish the effect of institutional collaboration on household climate change adaptation; (iv) determine the moderating effect of community participation on the relationship between sanitation improvement and household climate change adaptation; and (v) explore the experiences, barriers, and contextual factors explaining how sanitation improvement influences adaptation. Correspondingly, four null hypotheses were tested:

- i. H_{01} : Non-sewered toilet installation has no significant effect on household climate change adaptation.
- ii. H_{02} : Hygiene training has no significant effect on household climate change adaptation.
- iii. H_{03} : Institutional collaboration has no significant effect on household climate change adaptation.
- iv. H_{04} : Community participation has no significant moderating effect on the relationship between sanitation improvement and household climate change adaptation.

Theoretical Framework

The study was anchored on an integrated framework combining the “How Tough is WASH” framework (Howard et al., 2021) as the primary lens for assessing sanitation system resilience, with Arnstein’s (1969) Ladder of Citizen Participation used to theorise the moderating role of community participation. The “How Tough is WASH” framework defines resilience as the ability of sanitation systems to anticipate, withstand, and recover from climate-induced shocks while maintaining safe service delivery, and organises resilience across infrastructure, environmental, management, governance, institutional, and supply-chain domains. Arnstein’s ladder distinguishes tokenistic forms of participation (informing, consultation, placation) from substantive forms (partnership, delegated power, citizen control), providing a lens for interpreting whether community involvement is likely to strengthen intervention outcomes. Complementary theoretical perspectives — Social-Ecological Systems Resilience Theory, the COM-B Framework, the RANAS Behavioural Model, the Adaptive Governance and Multi-Level

Governance Framework, and the Action Theory of Adaptation — were drawn upon in interpreting the mechanisms linking specific interventions to household adaptation outcomes.

MATERIALS AND METHODS

Research Design and Study Area

The study adopted a pragmatist research philosophy and an explanatory sequential mixed-methods design, in which a quantitative phase was conducted first and a subsequent qualitative phase was used to explain, elaborate on, and contextualise the quantitative results (Creswell & Plano Clark, 2018). The study was conducted in Langas Ward, Kapsaret Constituency, Uasin Gishu County, a densely populated informal settlement of approximately 127,167 residents (KNBS, 2019) marked by rapid urbanisation, inadequate sanitation infrastructure, and heightened vulnerability to flash floods from River Langas. Data were collected between June and July 2026, coinciding with Kenya's long rainy season, to capture real-time household experiences under climate stress.

Population and Sampling

The target population comprised approximately 3,500 households in Langas Ward. Using the Krejcie and Morgan (1970) formula for a 95% confidence level and 5% margin of error, a base sample of 346 households was calculated and adjusted upward for an anticipated 10% non-response rate, yielding a final sample of 380 households, selected through systematic random sampling across settlement zones. A secondary population of 12 key informants — comprising county officials from Water, Environment and Natural Resources (3) and Health (2), ward administrators (2), community health volunteers (2), and NGO/CBO representatives (3) — was purposively selected, with data collection continuing until thematic saturation was reached.

Instruments, Reliability, and Trustworthiness

A structured, five-point Likert-scale questionnaire was administered to households, organised into sections covering socio-demographics and the three independent variables (non-sewered toilet installation, hygiene training, institutional collaboration), the moderating variable (community participation), and the dependent variable (household climate change adaptation, comprising community preparedness, coping capacity, and resource sustainability). A semi-structured key informant interview guide covering parallel thematic sections was used for the qualitative phase. Both instruments were pilot tested with 30 households and two key informants in Huruma estate, a comparable neighbouring settlement. Content, face, and construct validity were established through literature-based item development, expert review, and pilot feedback. Cronbach's alpha coefficients for all constructs ranged from 0.71 to 0.85, exceeding the conventional 0.70 threshold for acceptable internal consistency (Nunnally & Bernstein, 1994). Trustworthiness of the qualitative data was established through credibility, transferability, dependability, and confirmability procedures, including member checking and a reflexive research journal.

Data Analysis

Quantitative data from 347 returned questionnaires were analysed in SPSS Version 28 using descriptive statistics, Pearson correlation, and multiple regression to test H01–H03. The moderating effect of community participation (H04) was tested using hierarchical multiple regression via the PROCESS macro (Hayes, 2018), entering control variables (gender, education, income), the three independent variables, the moderator, and the sanitation improvement × community participation interaction term in four sequential steps. Statistical significance was set at $p < 0.05$. Qualitative data from key informant interviews were analysed thematically following Braun and Clarke's (2006) six-phase framework using NVivo software, and integrated with the

quantitative findings at the interpretation stage to explain and contextualise statistical relationships.

Ethical Considerations

Ethical clearance was obtained from The Catholic University of Eastern Africa and a research permit from the National Commission for Science, Technology and Innovation (NACOSTI). Informed consent was obtained from all participants, with identification numbers used in place of personal names to preserve anonymity. Participation was voluntary, and participants could withdraw at any point without penalty. Data were stored on password-protected devices, and audio recordings were deleted after transcription and verification.

RESULTS

Response Rate and Respondent Profile

Of 380 questionnaires administered, 347 were completed and returned, a response rate of 91.3%, exceeding the commonly accepted 70% threshold for survey research (Mugenda & Mugenda, 2012). All 12 targeted key informant interviews were completed, with saturation achieved. The majority of respondents were female (57.3%), reflecting women's primary role in household sanitation management. The largest age group was 25–34 years (28.2%), most respondents had secondary education (35.7%), and the predominant occupations were casual labour (32.3%) and self-employment (28.2%). Over half of respondents (57.4%) earned below KES 10,000 per month, indicating widespread economic vulnerability, and 55.0% had not benefited from any sanitation intervention in the preceding two years, revealing significant coverage gaps.

Descriptive Statistics of Study Variables

All study variables were rated at a moderate level, with overall construct means ranging from 2.88 to 3.28 (Table 1). Reliability of sanitation facilities under climate stress ($M = 2.87$) and access to institutional support services ($M = 2.76$) were the lowest-rated constructs, while household involvement in sanitation use ($M = 3.45$) was the highest-rated.

Table 1: Descriptive Statistics of Study Variables

Variable	Construct	Mean	SD	Interpretation
Non-Sewered Installation (IV1)	ToiletAccess to improved toilets	3.12	0.94	Moderate
	Reliability under climate stress	2.87	1.02	Moderate-Low
	Safe waste containment	3.01	0.97	Moderate
	Overall IV1	3.00	0.91	Moderate
Hygiene Training (IV2)	Frequency of training	2.45	1.10	Low
	Knowledge of sanitation practices	3.34	0.89	Moderate-High
	Adoption of hygienic behaviours	3.21	0.92	Moderate
	Overall IV2	3.00	0.87	Moderate
Institutional (IV3)	CollaborationPartnerships with NGOs/Government	2.98	0.99	Moderate
	Access to support services	2.76	1.05	Moderate-Low
	Community–institution	2.89	1.01	Moderate

Variable	Construct	Mean	SD	Interpretation
	engagement			
	Overall IV3	2.88	0.95	Moderate-Low
Community (MV)	ParticipationHousehold involvement	3.45	0.88	Moderate-High
	Participation in maintenance/decisions	3.12	0.96	Moderate
	Local ownership	3.28	0.90	Moderate
	Overall MV	3.28	0.85	Moderate
Household Climate Change Adaptation (DV)	Community preparedness	3.08	0.95	Moderate
	Coping capacity	2.95	1.01	Moderate
	Resource sustainability	3.14	0.92	Moderate
	Overall DV	3.06	0.89	Moderate

Source: Field data (2026). Interpretation scale: 1.00–1.80 = Very Low; 1.81–2.60 = Low; 2.61–3.40 = Moderate; 3.41–4.20 = High; 4.21–5.00 = Very High.

Effects of Sanitation Improvement Variables on Household Climate Change Adaptation

Pearson correlation analysis showed that all three sanitation improvement variables were significantly and positively associated with household climate change adaptation: non-sewered toilet installation ($r = 0.487$, $p < 0.01$), hygiene training ($r = 0.401$, $p < 0.01$), and institutional collaboration ($r = 0.389$, $p < 0.01$). Education and income were also significantly correlated with adaptation across all three models (r ranging from 0.13 to 0.20, $p < 0.01$), while gender showed no significant association ($p > 0.05$).

Separate multiple regression models, controlling for gender, education, and income, confirmed these relationships (Table 2). Non-sewered toilet installation was the strongest predictor of adaptation ($\beta = 0.487$, $t = 9.40$, $p < 0.001$), with the model explaining 26.2% of variance in adaptation ($R^2 = 0.262$; $F(4,342) = 30.45$, $p < 0.001$). Hygiene training was a significant predictor ($\beta = 0.401$, $t = 7.42$, $p < 0.001$; $R^2 = 0.186$; $F(4,342) = 19.56$, $p < 0.001$), as was institutional collaboration ($\beta = 0.389$, $t = 6.98$, $p < 0.001$; $R^2 = 0.177$; $F(4,342) = 18.45$, $p < 0.001$), which had the lowest explanatory power of the three. Education and income were significant positive predictors in all three models, while gender was not significant in any model. These results led to the rejection of the null hypotheses H01, H02, and H03.

Table 2. Summary of regression models controlling for gender, education, and income

Predictor	β (IV1 model)	β (IV2 model)	β (IV3 model)	t range	Sig.
Non-Sewered Toilet Installation	0.487	—	—	9.40	$p < 0.001$
Hygiene Training	—	0.401	—	7.42	$p < 0.001$
Institutional Collaboration	—	—	0.389	6.98	$p < 0.001$
Education	0.145	0.131	0.137	2.69–3.11	$p < 0.05$
Income	0.156	0.142	0.134	2.55–2.97	$p < 0.05$
Gender	0.023 (ns)	0.026 (ns)	0.024 (ns)	0.53–0.58	$p > 0.05$
R²	0.262	0.186	0.177		
F (4, 342)	30.45*	19.56*	18.45*		

Source: Field data (2026).

Moderating Effect of Community Participation

Hierarchical multiple regression was used to test the moderating role of community participation (Table 3). Control variables explained 5.5% of variance in adaptation (Step 1: $R^2 = 0.055$, $p < 0.001$); adding the three sanitation improvement variables increased explained variance to 26.2% (Step 2: $\Delta R^2 = 0.207$, $p < 0.001$); adding community participation increased explained variance to 28.5% (Step 3: $\Delta R^2 = 0.023$, $p = 0.001$), indicating a significant independent effect of participation on adaptation ($B = 0.245$, $p = 0.001$). However, the sanitation improvement $\times$ community participation interaction term added in Step 4 explained only an additional 0.8% of variance and was not statistically significant ($\Delta R^2 = 0.008$; $B = 0.089$, $t = 1.93$, $p = 0.056$; 95% CI $[-0.002, 0.180]$). The null hypothesis H04 was therefore not rejected, although the p-value approached the conventional significance threshold.

Table 3: Hierarchical multiple regression

Model Step	R	R ²	ΔR^2	F Change	Sig. F Change
Step 1: Control variables	0.234	0.055	0.055	6.67	0.000
Step 2: Independent variables	0.512	0.262	0.207	31.89	0.000
Step 3: Moderating variable	0.534	0.285	0.023	11.01	0.001
Step 4: Interaction term	0.541	0.293	0.008	3.67	0.056

Source: Field data (2026).

Summary of Hypothesis Testing

Table 4: Summary of Hypothesis Testing

Hypothesis	Statement	Decision	Basis
H01	Non-sewered toilet installation has no significant effect on household climate change adaptation.	Rejected	$\beta = 0.487$, $p < 0.001$
H02	Hygiene training has no significant effect on household climate change adaptation.	Rejected	$\beta = 0.401$, $p < 0.001$
H03	Institutional collaboration has no significant effect on household climate change adaptation.	Rejected	$\beta = 0.389$, $p < 0.001$
H04	Community participation has no significant moderating effect on the sanitation improvement–adaptation relationship.	Not rejected	$B = 0.089$, $p = 0.056$

Source: Field data (2026).

Qualitative Insights

Thematic analysis of key informant interviews contextualized the statistical findings. On infrastructure, informants described improved toilets as beneficial but constrained by affordability and flood vulnerability: a county official noted that container-based toilets have helped but that “many households cannot afford them” and that facilities are “washed away or become unusable” during floods (KI-001). On hygiene training, an NGO representative explained that coverage is patchy; reaching only 20–30% of households, with almost no follow-up, and that training rarely addresses climate-specific risks such as flood-time sanitation management (KI-009; KI-003). On institutional collaboration, informants consistently described fragmentation: county government, NGOs, and community-based organisations “don’t coordinate well,” producing duplication in some areas and unfilled gaps in others, with support that is reactive rather than proactive (KI-002; KI-010). On community participation, informants reported active household-level involvement in using and maintaining facilities, but limited influence over decisions on technology choice or siting, which are typically made by NGOs and

government before community meetings occur (KI-007; KI-004). Informants also linked persistent poverty directly to constrained adaptation, describing climate-resilient sanitation as “a luxury that many cannot afford” (KI-012).

Discussion

The finding that non-sewered toilet installation was the strongest predictor of household climate change adaptation ($\beta = 0.487$) is consistent with global evidence that non-sewered systems enhance climate resilience by reducing flood-related contamination and sustaining functionality during extreme weather (Oishi et al., 2026; World Health Organization, 2022). This is consistent with Social-Ecological Systems Resilience Theory’s emphasis on redundancy and buffer capacity: non-sewered systems provide an alternative to centralized sewer infrastructure, yet the low mean for reliability under climate stress (2.87) indicates that current buffer capacity remains insufficient, and qualitative accounts of toilets being washed away during floods corroborate this gap.

Hygiene training had a smaller, though still significant, effect ($\beta = 0.401$) than infrastructure, consistent with the RANAS Behavioural Model’s proposition that knowledge and skills must be complemented by self-regulation and coping planning to sustain behavior under stress (Mosler, 2012). The gap between moderate knowledge outcomes ($M = 3.34$) and low training frequency ($M = 2.45$) suggests that training is effective where delivered but too infrequent and insufficiently climate-focused to achieve widespread impact, corroborating calls to integrate climate considerations into WASH programme design (Iyer & Kohlitz, 2024).

Institutional collaboration had the smallest effect size among the three predictors ($\beta = 0.389$) and the lowest overall construct mean (2.88), reflecting the fragmented, reactive institutional landscape described by key informants. This is consistent with the Adaptive Governance and Multi-Level Governance Framework’s emphasis on coordination and institutional learning as prerequisites for effective adaptation (Folke et al., 2005), and echoes findings that citywide sanitation coordination in comparable Kenyan contexts is undermined by siloed, linear planning approaches (Ogendi & Marende, 2026). Across all three models, education and income were significant positive predictors, indicating that wealthier and more educated households are better positioned to invest in, access, and sustain climate-resilient sanitation, a pattern with clear equity implications for programme targeting.

The near-significant but non-significant moderation result for community participation ($p = 0.056$) is best interpreted through Arnstein’s (1969) Ladder of Citizen Participation. Qualitative evidence indicated that participation in Langas is concentrated at the lower rungs of informing and consultation; households implement and maintain facilities but are largely excluded from decisions on technology and siting. This is consistent with the interpretation that the *level* of participation, rather than its mere presence, determines whether it strengthens intervention outcomes, and is broadly aligned with evidence that meaningful WASH participation requires genuine ownership and accountability rather than symbolic involvement (Nelson et al., 2021; Samaddar et al., 2021). The finding contrasts with Ombwayo et al. (2026), who found a strong moderating effect of stakeholder involvement in Nairobi slum-upgrading projects, a difference plausibly explained by the narrower, tokenistic form of participation measured in this study relative to the more substantive project-management involvement examined in that context.

Conclusion

This study concludes that sanitation improvement is an effective strategy for strengthening household climate change adaptation in urban informal settlements, with non-sewered toilet installation, hygiene training, and institutional collaboration each exerting a statistically

significant, positive effect on adaptation. Non-sewered toilet installation is the most influential lever, though its impact is constrained by inadequate reliability under flooding; hygiene training is effective when delivered but limited by inconsistent coverage and a lack of climate-specific content; and institutional collaboration, while beneficial, is undermined by fragmentation and weak coordination among county government, NGOs, and community actors. Community participation, although positively associated with adaptation in its own right, does not currently strengthen the effect of sanitation improvement because it remains tokenistic rather than substantive. Socio-economic status, education and income, consistently shapes households' ability to benefit from sanitation interventions, raising equity concerns that warrant explicit attention in programme design.

Recommendations

County government: Prioritize climate-resilient, flood-resistant non-sewered sanitation designs, integrate climate risk assessment into sanitation planning, establish subsidies for low-income households, and strengthen formal inter-departmental coordination between health, water, environment, and disaster management units.

National government and policymakers: Embed sanitation-specific indicators within national climate adaptation policy, and provide fiscal incentives and technical guidelines for climate-resilient non-sewered sanitation, given that 55% of surveyed households had not benefited from any recent sanitation intervention.

NGOs and development partners: Scale up hygiene training coverage beyond the current 20–30%, incorporate climate-specific content (flood-time sanitation management, disaster preparedness) using a RANAS-informed approach emphasizing coping planning, and ensure consistent follow-up support.

Communities and community-based organisations: Move participation beyond informing and consultation toward genuine partnership in decision-making on sanitation technology and siting, and strengthen community-based sanitation committees and collective flood-preparedness mechanisms.

Limitations and Future Research

This study is cross-sectional and confined to a single ward, which limits causal inference and generalizability. Future research should employ longitudinal designs to establish whether observed effects persist over time; conduct comparative studies across informal settlements with differing infrastructure, climate risk, and governance contexts; evaluate the comparative cost-effectiveness of specific non-sewered technologies under flood conditions; test participatory models ranging from consultation to citizen control to clarify how participation might be strengthened into a genuine moderator of adaptation outcomes; and examine gendered dimensions of sanitation-related climate adaptation, given qualitative evidence that women disproportionately manage household sanitation despite gender showing no independent statistical effect in this study.

Declarations

Ethics approval: This study received ethical clearance from The Catholic University of Eastern Africa and a research permit from the National Commission for Science, Technology and Innovation (NACOSTI), Kenya. Informed consent was obtained from all participants.

Conflict of interest: The author declares no conflict of interest.

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Data availability: The datasets generated during this study are available from the corresponding author upon reasonable request, subject to participant confidentiality protections.

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