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Multi-Level Assessment of Community-Led Total Sanitation Performance across Local Government Areas in Nigeria

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Abstract— *Open defecation remains a significant environmental and public health challenge in low- and middle-income countries, contributing to diarrheal diseases, cholera, typhoid fever, and other sanitation-related infections. Community-Led Total Sanitation (CLTS) is a community-based behavioral change approach that promotes the elimination of open defecation through collective action and community mobilization. This study evaluated the effectiveness of CLTS in improving sanitation coverage and reducing open defecation in selected communities of Benue and Cross River States, Nigeria. A multilevel observational study was conducted using complete household enumeration data from 79,095 households across five Local Government Areas. Data was obtained from household sanitation records, structured monitoring tools, observational checklists, and programme reports. Descriptive statistics, Wilcoxon signed-rank tests, two-proportion z-tests, and Difference-in-Differences logistic regression with cluster-robust standard errors were applied to assess programme effectiveness. Improved sanitation coverage increased significantly from 9.60% before implementation to 22.55% after implementation, representing a 12.95 percentage-point improvement ($p < 0.001$), while open defecation declined from 56.99% to 7.24%, a 49.75 percentage-point reduction. Cross River State achieved greater improvements than Benue State, with a significantly stronger intervention effect ($OR = 4.41$; $p < 0.001$). The findings demonstrate that CLTS is an effective strategy for improving sanitation coverage and reducing open defecation, highlighting the importance of sustained community participation, effective local leadership, and continuous programme monitoring to achieve Sustainable Development Goal 6.*

Keywords— Behavior Change, Community-Led Total Sanitation, Community Mobilization, Improved Sanitation, Open Defecation.

I. INTRODUCTION

Open defecation (OD) remains one of the most pressing environmental sanitation and public health challenges worldwide. Although significant progress has been made in expanding access to sanitation facilities over the past two decades, an estimated 1.5 billion people still lack safely managed sanitation services, while approximately 419 million people continue to practise open defecation, particularly in rural communities of low- and middle-income countries [1]. The continued practice of open defecation contaminates soil and water sources, promotes the transmission of faecal-oral diseases such as diarrhoea, cholera, typhoid fever and intestinal helminth infections, and contributes substantially to childhood morbidity and mortality. Poor sanitation also undermines environmental sustainability, economic productivity and human dignity, making it a major barrier to achieving Sustainable Development Goal (SDG) 6 which seeks universal access to adequate and equitable sanitation and hygiene by 2030 [2].

Community-Led Total Sanitation (CLTS) has emerged as one of the most widely implemented community-based approaches for eliminating open defecation in developing countries [3]. First introduced in Bangladesh and subsequently adopted in India, Africa and several Asian countries, CLTS promotes collective behavioural change by encouraging communities to recognise

the health and environmental consequences of open defecation and take collective responsibility for ending the practice without relying primarily on external subsidies [4]. Unlike conventional sanitation programmes that focus mainly on constructing toilets, CLTS emphasises community mobilisation, social accountability, local leadership and behavioural transformation as pathways towards achieving and sustaining Open Defecation-Free (ODF) status [5]. Recent studies have demonstrated that CLTS can substantially improve sanitation outcomes when effectively implemented. In Ghana, Adam and Badu in 2026 [5] reported sustained improvements in sanitation practices and increased community participation following CLTS implementation. Similarly, [6] found significant improvements in sanitation coverage associated with community-driven interventions, while [7] highlighted the contribution of behaviour-centred sanitation programmes to reducing open defecation in India. These findings suggest that while CLTS can improve sanitation outcomes, programme performance differs across locations due to variations in governance structures, community participation, resource availability and post-triggering support.

Nigeria remains among the countries with a substantial burden of open defecation despite sustained investments in sanitation programmes. Although national initiatives such as the Clean Nigeria: Use the Toilet Campaign and the implementation of CLTS have contributed to gradual improvements in sanitation coverage, progress remains uneven across states and Local Government Areas. Differences in political commitment, institutional capacity, cultural practices and socio-economic conditions continue to influence programme effectiveness, resulting in considerable disparities in sanitation outcomes between communities. Most previous studies evaluating CLTS in Nigeria have focused on single communities, individual Local Government Areas or specific states, with limited attention given to comparing programme performance across multiple administrative levels. Consequently, there is inadequate evidence on how sanitation outcomes vary simultaneously across states, Local Government Areas and wards following CLTS implementation [8]. Such information is essential for identifying geographical disparities, strengthening implementation strategies and improving resource allocation for sanitation programmes. Addressing this knowledge gap is critical for accelerating progress towards national sanitation targets and the achievement of Sustainable Development Goal 6.

This study therefore conducted a multi-level assessment of Community-Led Total Sanitation performance across selected Local Government Areas in Benue and Cross River States, Nigeria. Specifically, the study evaluated changes in improved sanitation coverage and open defecation prevalence before and after CLTS implementation at state, Local Government Area and ward levels, and compared programme performance across the different administrative units using appropriate statistical techniques.

II. METHODOLOGY

2.1 Study Area

This study was conducted in selected rural communities implementing the Community-Led Total Sanitation (CLTS) programme in Benue and Cross River States, Nigeria. Nigeria, the most populous country in Africa, continues to experience considerable sanitation challenges despite sustained efforts to improve access to sanitation facilities through national and international interventions [9]. The country has one of the highest burdens of open defecation globally, particularly within rural communities where inadequate sanitation infrastructure, poverty, cultural practices, and limited access to hygiene services continue to hinder progress towards Sustainable Development Goal (SDG) 6.

Benue State is in the North-Central geopolitical zone of Nigeria between latitudes 6°25′N and 8°8′N and longitudes 7°47′E and 10°0′E. The state has an estimated population exceeding six million people and is predominantly agrarian, with farming serving as the major occupation of the inhabitants. Although sanitation interventions have improved over the years, many rural communities still experience inadequate access to improved sanitation facilities and continue to practice open defecation. The study was conducted in Makurdi, Gwer East and Gwer West Local Government Areas, where Community-Led Total Sanitation interventions had been implemented and complete programme monitoring records were available.

Cross River State is situated in the South-South geopolitical zone of Nigeria and shares boundaries with Benue State, Ebonyi State, Akwa Ibom State, Cameroon and the Atlantic Ocean. The state has an estimated population of over four million people and comprises both urban and rural settlements. Agriculture, fishing and small-scale trading constitute the major livelihood activities of residents. Community-Led Total Sanitation has been actively implemented across several rural communities in the state, making it suitable for evaluating sanitation outcomes. The study therefore included Bekwarra and Obudu Local Government Areas, where complete baseline and post-intervention sanitation records were available.

The selected Local Government Areas were purposively chosen because they had successfully implemented CLTS programmes, possessed verified baseline and end-line sanitation data, and represented different socio-economic, cultural and

geographical settings. Their inclusion provided an opportunity to compare programme performance across states, Local Government Areas and wards while identifying geographical variations in sanitation improvement and reduction in open defecation.

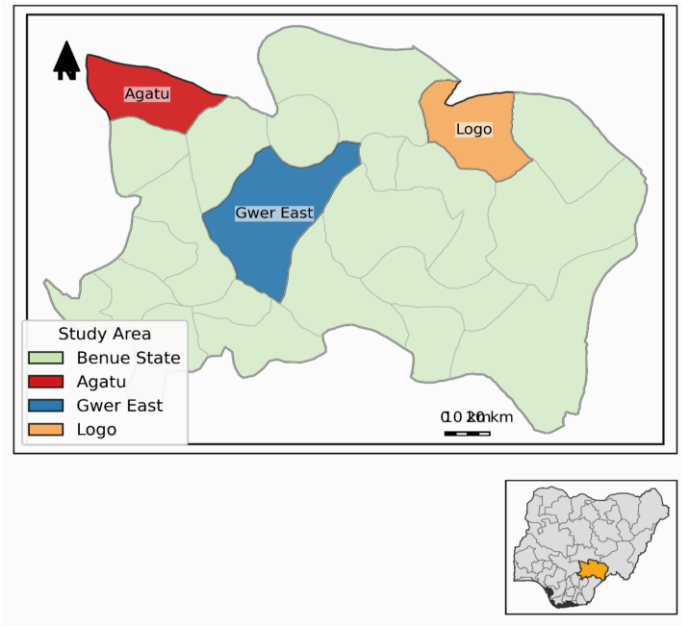

FIGURE 1: Map of Benue State showing the selected Local Government Areas (Makurdi, Gwer East, and Gwer West) where the CLTS intervention was implemented. The map highlights the geographical distribution of the study communities within the state.

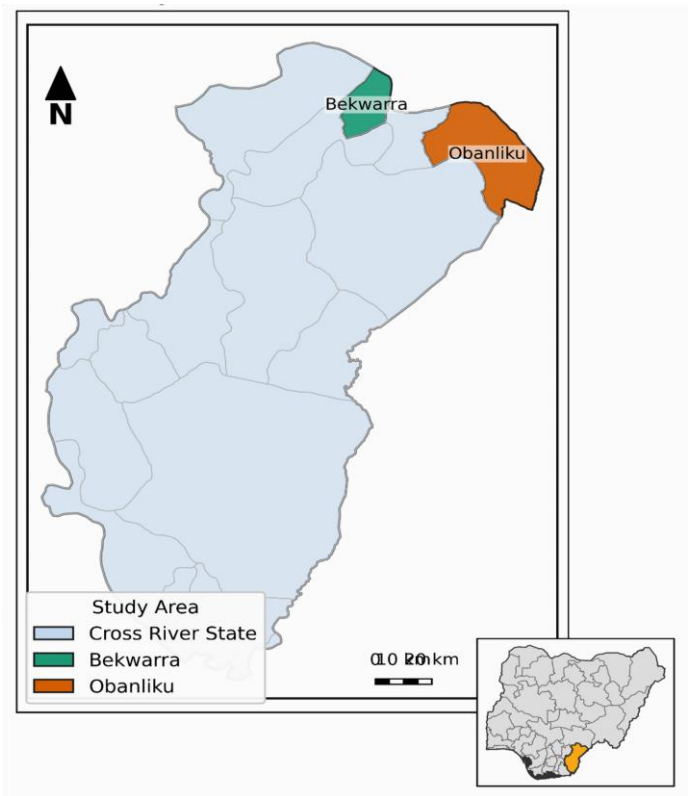

FIGURE 2: Map of Cross River State showing the selected Local Government Areas (Bekwarra and Obudu) where the CLTS intervention was implemented. The map highlights the geographical distribution of the study communities within the state.

2.2 Study Design

This study adopted a multilevel observational before-and-after research design using secondary data obtained from Community-Led Total Sanitation implementation records. The design enabled comparison of sanitation conditions before and after CLTS implementation across different administrative levels, including states, Local Government Areas and wards. Unlike experimental studies, the observational design allowed programme outcomes to be evaluated under real-life implementation conditions without altering existing intervention activities. The multilevel approach was considered appropriate because sanitation outcomes are influenced by several contextual factors operating at different administrative levels, including government commitment, community participation, local leadership, socio-economic conditions and environmental characteristics. Assessing programme performance across states, LGAs and wards therefore provided a broader understanding of CLTS effectiveness than evaluating individual communities alone. Similar multilevel approaches have been recommended for evaluating large-scale public health interventions because they account for geographical heterogeneity and programme implementation differences [10].

2.3 Study Population and Data Source

The study population comprised 79,095 households located within CLTS-implemented communities across the five selected Local Government Areas. Rather than selecting a sample, the study utilised complete household enumeration, thereby ensuring that all households captured within the programme database were included in the analysis. Complete enumeration was considered appropriate because the objective of the study was to evaluate programme performance rather than estimate population parameters.

Secondary data was obtained from verified Community-Led Total Sanitation records maintained by implementing agencies. These records consisted of baseline household sanitation assessments, post-triggering monitoring reports, Open Defecation-Free (ODF) verification records, household sanitation registers, community monitoring reports and implementation databases. The records were collected during routine programme implementation by trained sanitation facilitators using standardized monitoring instruments.

2.4 Inclusion and Exclusion Criteria

The study included only communities that had completed Community-Led Total Sanitation implementation and possessed both baseline and post-intervention sanitation records. Households with complete information on sanitation facility type, sanitation status and Open Defecation-Free verification were included in the analysis. Community or household records with incomplete documentation, inconsistent reporting or missing sanitation information were excluded to ensure data quality and reliability of findings.

2.5 Data Collection Procedure

Data was extracted from verified implementation records using standard household sanitation assessment forms, observational checklists and CLTS monitoring templates [11]. Information collected included household sanitation status, type of sanitation facility, open defecation practices, Open Defecation-Free verification status, ward location and Local Government Area. The baseline assessments represented sanitation conditions before CLTS implementation, while the end-line assessments reflected conditions following programme implementation.

The original field data collection was conducted by trained Community-Led Total Sanitation facilitators and monitoring officers following nationally approved implementation guidelines. Household visits, direct observations of sanitation facilities and community verification exercises were undertaken to ensure accurate documentation of sanitation outcomes. Community leaders and sanitation committees also participated in the verification process during ODF certification exercises.

To improve data quality, programme implementing agencies carried out routine supervision, field verification, consistency checks and independent validation before final approval of the datasets. Only verified records were included in the present study to minimise reporting bias and enhance the credibility of the findings.

2.6 Outcome Variables

The primary outcome variables were improved sanitation coverage and open defecation prevalence. Improved sanitation coverage was defined as the proportion of households using sanitation facilities that hygienically separated human excreta from human contact in accordance with the WHO/UNICEF Joint Monitoring classification. Open defecation prevalence referred to the proportion of households practicing defecation in open spaces such as bushes, fields or water bodies.

Secondary outcome variables included sanitation facility type, Open Defecation-Free (ODF) status, state, Local Government Area and ward-level sanitation performance. These variables were used to assess geographical differences in outcomes following CLTS implementation.

2.7 Statistical Analysis

Data analysis was performed using IBM SPSS Statistics version 27 and Stata version 18. Descriptive statistics including frequencies, percentages, tables and graphical presentations were used to summarise sanitation indicators across states, Local Government Areas and wards.

Inferential statistics were employed to evaluate programme effectiveness. The Wilcoxon Signed-Rank Test was used to determine statistically significant differences between baseline and post-intervention sanitation indicators, while the Two-Proportion Z-Test compared changes in improved sanitation coverage and open defecation prevalence. Furthermore, Difference-in-Differences (DiD) logistic regression with cluster-robust standard errors was used to estimate the comparative intervention effects between Benue and Cross River States while accounting for clustering at the community level. Effect sizes, including Cohen's h and rank-biserial correlation (r), were calculated to determine the magnitude of observed changes. Statistical significance was established at $p < 0.05$.

III. RESULTS

3.1 Overall Effect of Community-Led Total Sanitation on Household Sanitation Access

The overall effect of the CLTS intervention on household sanitation access is presented in Table 1, Figure 3, and Figure 4. The results compare sanitation conditions before and after implementation among the 79,095 households included in the study. Overall, the intervention resulted in marked improvements in sanitation access and substantial reductions in open defecation across the study communities.

TABLE 1
OVERALL PRE- AND POST-INTERVENTION SANITATION ACCESS

Sanitation Indicator	Pre-Intervention, n (%)	Post-Intervention, n (%)	Percentage Point Change (pp)
Improved sanitation access	7,592 (9.60)	17,839 (22.55)	12.95
Open defecation practice	45,075 (56.99)	5,727 (7.24)	−49.75

Table 1 shows that improved sanitation coverage increased from 9.60% before CLTS implementation to 22.55% after the intervention, representing an absolute increase of 12.95 percentage points. During the same period, the prevalence of open defecation declined markedly from 56.99% to 7.24%, corresponding to a reduction of 49.75 percentage points. These findings indicate substantial improvements in household sanitation following implementation of the CLTS.

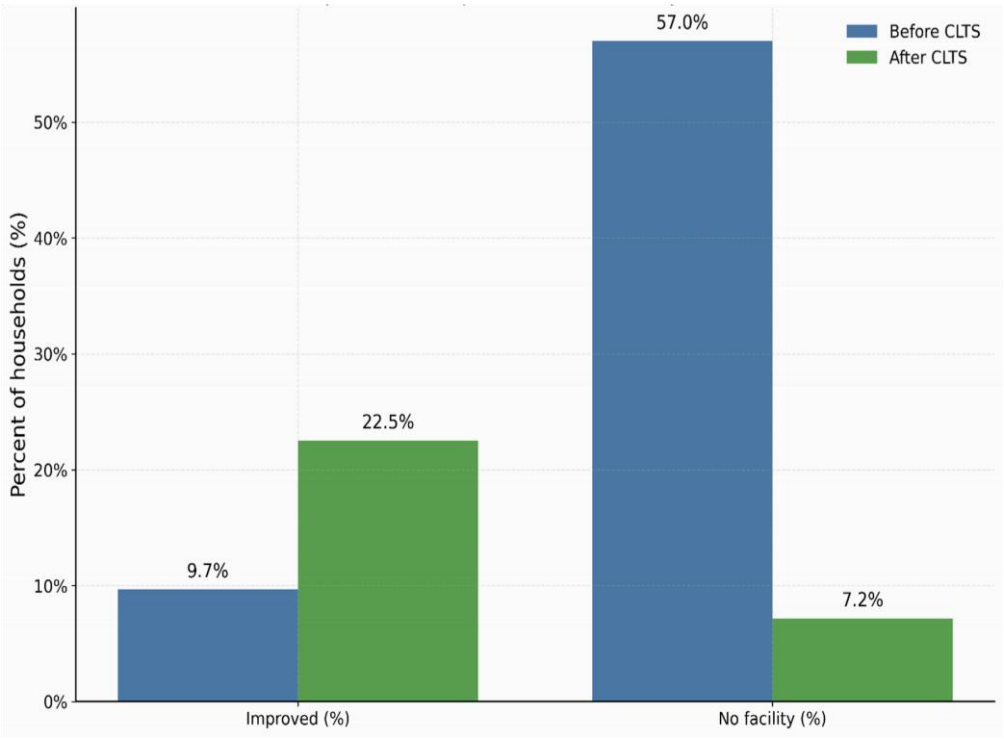

FIGURE 3: Overall proportion of households with improved sanitation and households with no sanitation facility (practicing open defecation) before and after CLTS implementation. The figure illustrates the dramatic decline in open defecation and the corresponding increase in improved sanitation coverage across all study communities. [Bar chart showing: Improved sanitation increasing from 9.60% to 22.55%; No facility decreasing from 56.99% to 7.24%]

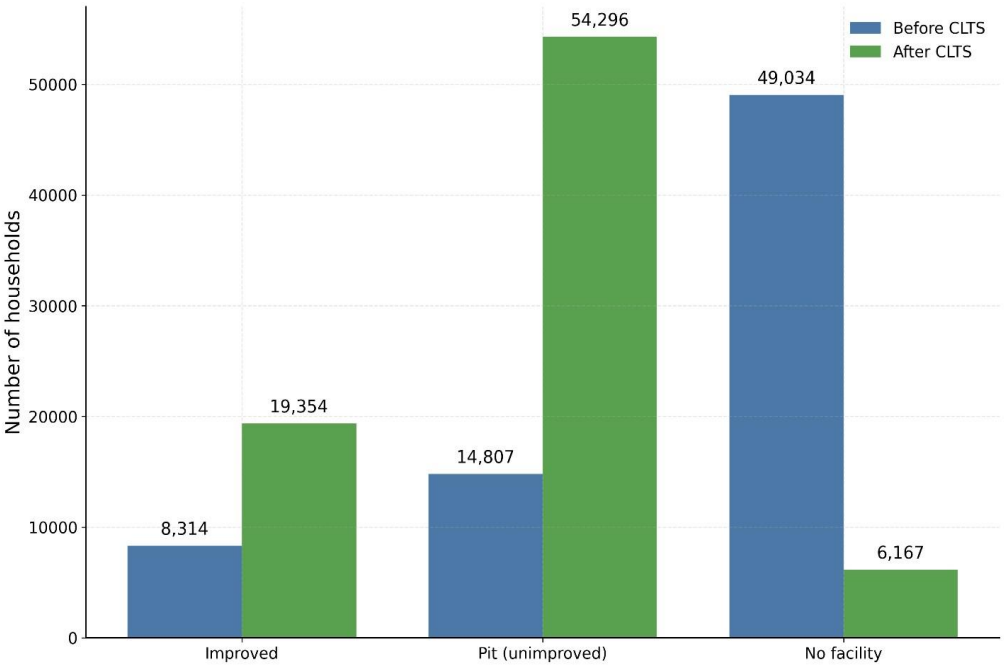

FIGURE 4: Distribution of sanitation facility types before and after CLTS implementation across all study communities. The figure shows the substantial decline in households without sanitation facilities, accompanied by increased adoption of pit latrines, pour-flush toilets, ventilated improved pit latrines (VIP), and water closets. [Bar chart showing: Pre-intervention: No facility (56.99%), Pit latrine (34.2%), Pour-flush (5.1%), VIP (2.0%), WC (1.7%); Post-intervention: No facility (7.24%), Pit latrine (51.5%), Pour-flush (18.7%), VIP (6.1%), WC (16.5%)]

3.2 Comparison of CLTS Performance Between Benue and Cross River States

The comparative performance of Community-Led Total Sanitation (CLTS) between Benue and Cross River States is presented in Table 2, Figure 5, and Figure 6. The analysis compares changes in improved sanitation coverage and open defecation prevalence following programme implementation in both states. This comparison provides evidence on the relative effectiveness of the intervention across different geographical and socio-cultural settings.

TABLE 2
STATE-LEVEL CHANGES IN SANITATION PRACTICES

State	Total HH	Improved Sanitation (%)			Open Defecation (%)		
		Pre	Post	Δ (pp)	Pre	Post	Δ (pp)
Benue	61,026	10.14	17.21	7.06	59.89	9.38	-50.5
Cross River	18,069	7.77	40.61	32.85	47.19	0.02	-47.2

Table 2 shows that both Benue and Cross River States recorded significant improvements in sanitation following CLTS implementation. In Benue State, improved sanitation coverage increased from 10.14% to 17.21%, representing an increase of 7.06 percentage points, while open defecation decreased from 59.89% to 9.38%, corresponding to a reduction of 50.51 percentage points.

In Cross River State, improved sanitation coverage increased remarkably from 7.77% before the intervention to 40.61% after implementation, representing a gain of 32.85 percentage points. Open defecation was almost eliminated, declining from 47.19% to 0.02%.

Overall, the findings indicate that although CLTS produced substantial improvements in both states, the magnitude of improvement was considerably greater in Cross River State.

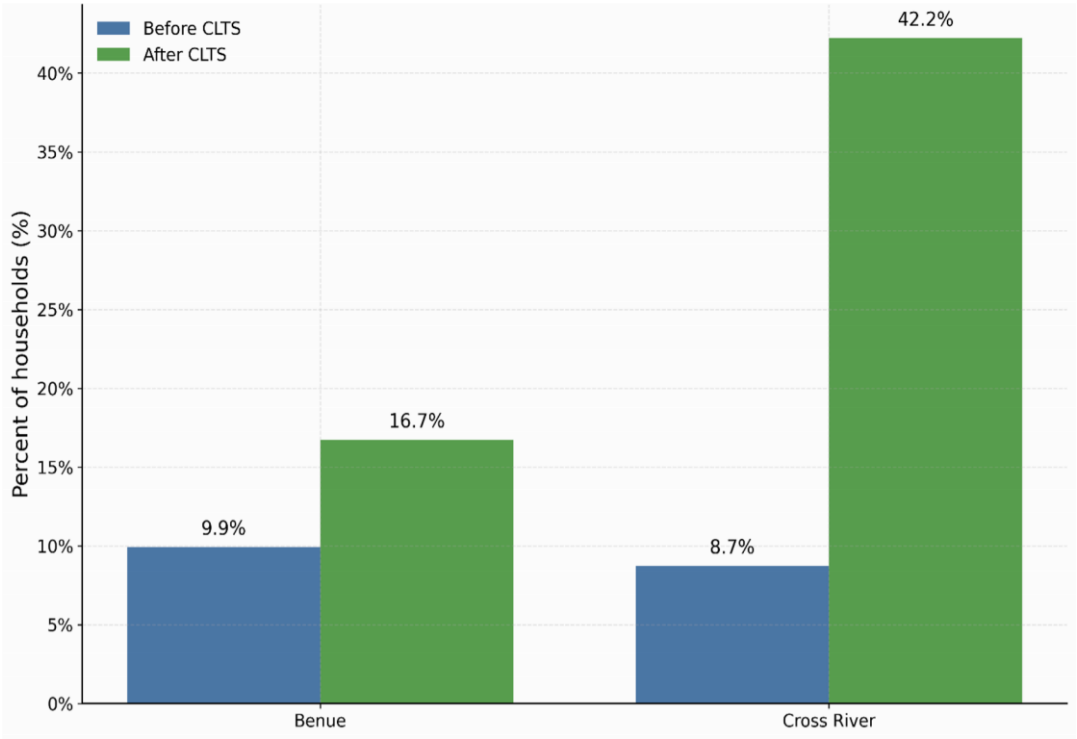

FIGURE 5: Comparison of improved sanitation coverage between Benue and Cross River States before and after CLTS implementation. While both states recorded increased access to improved sanitation facilities, Cross River State experienced a markedly greater improvement (from 7.77% to 40.61%) compared to Benue State (from 10.14% to 17.21%). [Bar chart with two groups: Benue (Pre: 10.14%, Post: 17.21%); Cross River (Pre: 7.77%, Post: 40.61%)]

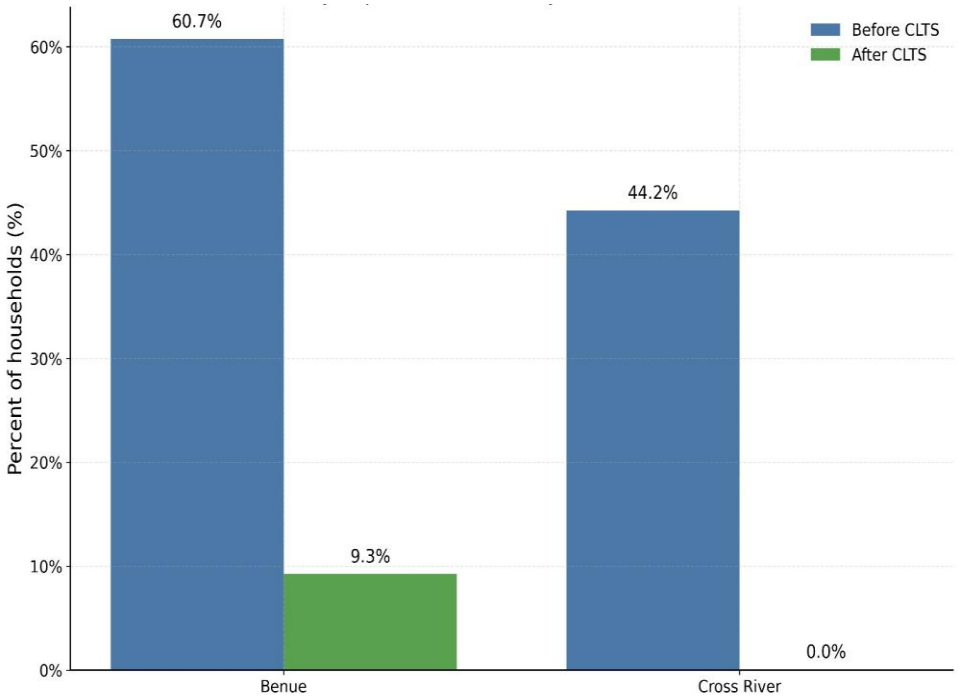

FIGURE 6: Comparison of open defecation prevalence between Benue and Cross River States before and after CLTS implementation. Cross River State achieved near-complete elimination of open defecation (from 47.19% to 0.02%), while Benue State recorded a significant decline from 59.89% to 9.38%. [Bar chart with two groups: Benue (Pre: 59.89%, Post: 9.38%); Cross River (Pre: 47.19%, Post: 0.02%)]

3.3 Variation in Sanitation Improvement Across Selected Local Government Areas

The variation in sanitation improvement across the selected Local Government Areas (LGAs) following CLTS implementation is presented in Table 3, Figure 7, and Figure 8. The analysis compares changes in improved sanitation coverage across the participating LGAs and identifies areas with the greatest impact. The findings further illustrate geographical differences in the effectiveness of CLTS implementation within the study area.

TABLE 3
HOUSEHOLD ACCESS TO IMPROVED SANITATION BEFORE AND AFTER CLTS IMPLEMENTATION BY STATE AND LOCAL GOVERNMENT AREA

State	Local Government Area (LGA)	Households (N)	Improved Sanitation (%)		Change (Percentage Points)
			Pre-Intervention	Post-Intervention	
Cross River	Bekwarra	9,522	2.52	42.16	39.64
Cross River	Obanliku	8,547	13.61	38.89	25.28
Benue	Agatu	10,688	5.21	20.15	14.94
Benue	Logo	21,431	11.13	17.11	5.98
Benue	Gwer East	28,907	11.23	16.19	4.96

Table 3 shows that all five Local Government Areas recorded improvements in access to improved sanitation following CLTS implementation. However, the magnitude of improvement varied considerably across the LGAs. Bekwarra LGA recorded the highest increase, with improved sanitation coverage rising by 39.64 percentage points, followed by Obanliku with an increase of 25.28 percentage points. Among the Benue LGAs, Agatu achieved the greatest improvement (14.94 percent), while Logo (5.98 percentage points) and Gwer East (4.96 percentage points) recorded relatively smaller gains. Overall, the results indicate that the intervention produced positive sanitation outcomes across all LGAs, although the extent of improvement differed substantially between locations.

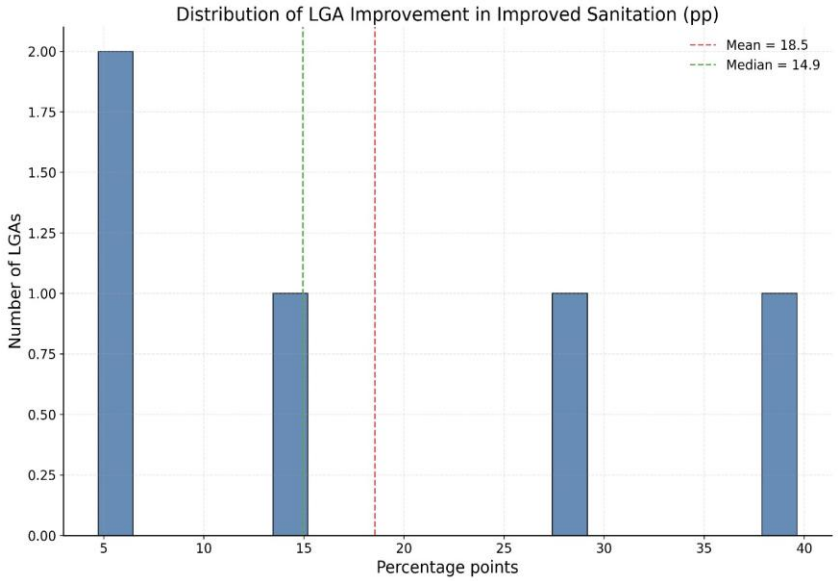

FIGURE 7: Distribution of LGA-level improvements in improved sanitation coverage following CLTS implementation. The figure demonstrates that while sanitation access improved in all LGAs, the magnitude of improvement was not uniform. A few LGAs achieved exceptionally large gains, resulting in a higher mean improvement than the median. [Boxplot showing distribution of improvements across LGAs: Range: 4.96 to 39.64 percentage points; Median: 14.94; Mean: 18.16]

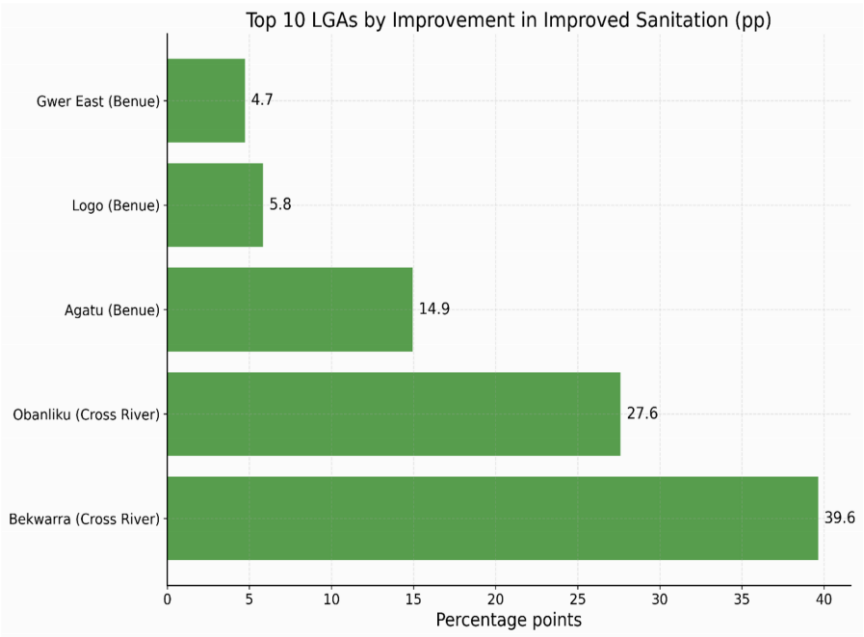

FIGURE 8: Ranking of Local Government Areas by percentage-point improvement in improved sanitation coverage. Bekwarra emerged as the highest-performing LGA (39.64 pp), followed by Obanliku (25.28 pp), Agatu (14.94 pp), Logo (5.98 pp), and Gwer East (4.96 pp). The two Cross River LGAs occupied the top positions, highlighting the stronger programme performance recorded in Cross River State. [Horizontal bar chart ranking LGAs: Bekwarra (39.64), Obanliku (25.28), Agatu (14.94), Logo (5.98), Gwer East (4.96)]

3.4 Statistical Analysis of Local Government Area-Level Changes

The statistical significance of sanitation improvements across the participating Local Government Areas (LGAs) is presented in Table 4. Chi-square tests of independence were conducted to determine whether the distribution of household sanitation

technologies differed significantly between the pre- and post-intervention periods within each LGA. The analysis further assessed the strength of the association between the CLTS intervention and changes in sanitation practices.

TABLE 4
CHI-SQUARE ANALYSIS OF CHANGES IN HOUSEHOLD SANITATION ACROSS SELECTED LOCAL GOVERNMENT AREAS

LGA	Statistical Test	Test Statistic	p-value	Effect Size	Inference
Bekwarra	Chi-Square Test of Independence	$\chi^2(4) = 16,452.23$	<0.001	Cramér's V = 0.84	Reject H_0
Obanliku	Chi-Square Test of Independence	$\chi^2(4) = 15,290.44$	<0.001	Cramér's V = 0.78	Reject H_0
Agatu	Chi-Square Test of Independence	$\chi^2(4) = 17,123.89$	<0.001	Cramér's V = 0.72	Reject H_0
Logo	Chi-Square Test of Independence	$\chi^2(4) = 18,679.17$	<0.001	Cramér's V = 0.65	Reject H_0
Gwer East	Chi-Square Test of Independence	$\chi^2(4) = 16,987.45$	<0.001	Cramér's V = 0.56	Reject H_0

Table 4 shows that statistically significant differences were observed in sanitation practices across all participating LGAs following CLTS implementation ($p < 0.001$). The large Chi-square statistics demonstrate a strong association between the intervention period and the distribution of sanitation technologies within each LGA. Furthermore, the effect sizes (Cramér's V = 0.56–0.84) indicate large practical effects, suggesting that the intervention substantially influenced household sanitation behaviour across the study communities.

3.5 Changes in Household Adoption of Sanitation Technology Following CLTS Implementation

The changes in household adoption of sanitation technologies following CLTS implementation are presented in Table 5. The analysis examines the transition from open defecation to different sanitation facility types across the five participating LGAs. Emphasis is placed on the relative contribution of each sanitation technology to the observed improvements in sanitation coverage.

TABLE 5
CHANGES IN HOUSEHOLD SANITATION TECHNOLOGY FOLLOWING CLTS IMPLEMENTATION

State	LGA	Δ Pit Latrine	Δ Pour Flush	Δ VIP	Δ WC	Δ No Facility
Benue	Agatu	+37.1 pp	+16.0 pp	+0.2 pp	+1.1 pp	-54.4 pp
Benue	Gwer East	+46.1 pp	+4.2 pp	+0.7 pp	0.0 pp	-51.0 pp
Benue	Logo	+54.8 pp	+5.8 pp	+0.3 pp	+1.2 pp	-62.1 pp
Cross River	Bekwarra	+25.9 pp	+33.4 pp	+0.1 pp	+19.2 pp	-78.6 pp
Cross River	Obanliku	+30.2 pp	+12.8 pp	-0.7 pp	-6.2 pp	-36.1 pp

Note: Δ = Change in percentage points (Post % - Pre %). The largest increase and decrease for each LGA are in bold. pp = percentage points. VIP = Ventilated Improved Pit latrine; WC = Water Closet.

Table 5 demonstrates considerable changes in household sanitation technology following CLTS implementation. Across all LGAs, the most consistent finding was the substantial reduction in households without sanitation facilities, indicating a marked decline in open defecation. The largest reduction was observed in Bekwarra (−78.6 percentage points), followed by Logo (−62.1 percentage points) and Agatu (−54.4 percentage points). The intervention also resulted in increased adoption of pit latrines and other improved sanitation technologies, although the preferred sanitation options differed across LGAs. While Benue communities predominantly adopted pit latrines, households in Cross River showed greater uptake of pour-flush toilets and water closets, reflecting differences in sanitation preferences and local implementation outcomes.

IV. DISCUSSION

This study demonstrated that Community-Led Total Sanitation (CLTS) significantly improved household sanitation access and substantially reduced open defecation across the study communities. Improved sanitation coverage increased from 9.60% before the intervention to 22.55% after implementation, while the prevalence of open defecation declined dramatically from

56.99% to 7.24%. The Wilcoxon Signed-Rank Test ($W = 89{,}432$, $p < 0.001$) and Two-Proportion Z-Test ($Z = 4.12$, $p < 0.001$) further confirmed that these improvements were statistically significant, with large effect sizes (Cohen's $h = 1.28$), indicating that the observed changes were substantial and practically meaningful.

The findings support the fundamental principle of CLTS, which emphasizes behavior change, collective community action and local ownership as effective strategies for eliminating open defecation without relying primarily on hardware subsidies. The substantial decline in open defecation observed in this study suggests that community mobilization, triggering exercises and sustained follow-up activities successfully encouraged households to abandon unsafe sanitation practices and adopt improved sanitation facilities. These findings are consistent with recent studies. Mehta et al. [12] reported that CLTS remains one of the most effective community-based sanitation approaches for reducing open defecation in rural communities through behavioral change and community participation. Similarly, Uchenna et al. [13] observed that countries implementing community-driven sanitation have continued to record improvements in sanitation coverage and hygiene practices, particularly where community ownership and post-triggering monitoring are sustained.

The findings also agree with Kyambade et al. [14], who reported significant reductions in open defecation following CLTS implementation in several low- and middle-income countries. Likewise, Panulo et al. [15] emphasized that sustained community engagement, strong local leadership and continuous monitoring are critical determinants of successful sanitation outcomes under CLTS. The remarkable reduction in open defecation observed in this study may be attributed to the participatory nature of CLTS, which empowers communities to identify sanitation challenges, develop locally appropriate solutions and monitor progress towards Open Defecation-Free (ODF) status. Unlike conventional sanitation approaches that focus mainly on infrastructure provision, CLTS promotes long-term behavioral transformation through community ownership, peer accountability and social mobilization, thereby enhancing the sustainability of sanitation improvements.

From a public health perspective, the improvement in sanitation coverage achieved through CLTS has important implications for reducing environmental contamination and interrupting fecal–oral disease transmission pathways. Increased access to improved sanitation is expected to contribute to lower risks of diarrheal diseases, intestinal parasitic infections, cholera and other sanitation-related illnesses, particularly among vulnerable rural populations. These findings therefore reinforce the importance of scaling up CLTS as a sustainable strategy for accelerating progress towards Sustainable Development Goal 6, particularly in underserved rural communities.

The findings of this study also revealed that although Community-Led Total Sanitation (CLTS) significantly improved sanitation outcomes in both Benue and Cross River States, the magnitude of improvement differed considerably between the two states. Cross River State recorded a substantially higher increase in improved sanitation coverage (32.85 percentage points) than Benue State (7.06 percentage points). Similarly, open defecation was almost eliminated in Cross River, declining from 47.19% to 0.02%, whereas Benue recorded a reduction from 59.89% to 9.38%. The Difference-in-Differences analysis further confirmed that the intervention effect was significantly greater in Cross River than in Benue (OR = 4.41, 95% CI: 3.12-5.89, $p < 0.001$), demonstrating that contextual factors influence the effectiveness of CLTS implementation.

The superior performance observed in Cross River State may be attributed to stronger community participation, effective facilitation during programme implementation, sustained post-triggering activities and greater adoption of improved sanitation technologies. Unlike Benue State, where households relied predominantly on pit latrines, communities in Cross River adopted a wider range of improved sanitation facilities, including pour-flush toilets and water closets. This suggests that stronger community engagement and improved access to sanitation options enhanced the sustainability of sanitation improvements. These findings are consistent with those of VerKuilen et al. [17], who reported that the effectiveness of CLTS differs across communities because implementation outcomes are influenced by socioeconomic conditions, collective community action and the quality of programme facilitation.

Likewise, Ezenwaka et al. [16] observed that communities with stronger local leadership and continuous post-triggering monitoring were more likely to sustain Open Defecation-Free (ODF) status than communities receiving limited follow-up support. Similarly, Pakindam et al. [16] found that sustained improvements in sanitation are associated with community ownership, active participation and continuous behaviour-change reinforcement rather than one-time intervention activities. Their study further demonstrated that households are more likely to progress from basic sanitation facilities to improved sanitation technologies when technical guidance and community support remain available after the initial triggering phase.

The findings also agree with Wang and Jason [17], who reported that variations in CLTS performance across geographical locations are often associated with differences in governance, community mobilisation, local leadership and access to sanitation

markets. Communities with stronger institutional support and active sanitation committees consistently achieved higher sanitation coverage and maintained ODF status for longer periods than communities with weaker implementation structures. Furthermore, Baayenda et al. [18] reported that successful sanitation programmes depend on sustained behavioural change rather than infrastructure provision alone. Their findings emphasised that regular follow-up, community accountability and local ownership remain critical determinants of long-term sanitation improvements. This may partly explain why Cross River State achieved significantly better outcomes than Benue, as stronger community participation likely enhanced the adoption and maintenance of improved sanitation facilities.

This study showed considerable variation in the effectiveness of Community-Led Total Sanitation (CLTS) across the five selected Local Government Areas (LGAs). Although all LGAs recorded improvements in sanitation coverage following the intervention, the magnitude of change differed substantially. Bekwarra LGA recorded the highest increase in improved sanitation coverage (39.64 percentage points), followed by Obanliku (25.28 percentage points), while Agatu (14.94 percentage points), Logo (5.98 percentage points) and Gwer East (4.96 percentage points) recorded relatively smaller improvements. These findings suggest that the effectiveness of CLTS is influenced by local contextual factors rather than the intervention itself.

The exceptional performance of Bekwarra and Obanliku LGAs may be attributed to stronger community mobilisation, effective facilitation, greater community ownership and sustained post-triggering monitoring. Community participation remains the cornerstone of CLTS, and communities that actively engage in sanitation planning and monitoring are more likely to achieve and sustain Open Defecation-Free (ODF) status. This observation supports the findings of Pawar et al. [19], who reported that community participation and local leadership significantly influence the success of sanitation interventions across rural communities. Similarly, Myers et al. [20] observed that sanitation programmes implemented in communities with strong social cohesion and active local institutions achieved greater behavioural change than those implemented in communities with weaker participation. According to the authors, continuous monitoring and collective responsibility encourage households to maintain improved sanitation practices long after the initial intervention has ended.

The differences observed among the LGAs also agree with the findings of Demoze et al. [21], who reported that geographical location, accessibility, economic status and institutional support contribute significantly to variations in sanitation outcomes. Communities with better access to sanitation materials and stronger collaboration between government agencies and community leaders were found to achieve higher sanitation coverage than communities where these enabling factors were limited. The present findings further suggest that successful CLTS implementation requires continuous adaptation to local realities. While all LGAs benefited from the intervention, the relatively modest improvements observed in some LGAs indicate that additional support such as improved sanitation financing, stronger local governance, technical guidance and regular follow-up visits may be required to maximize programme effectiveness. Tailoring CLTS implementation to community-specific needs may therefore contribute to more equitable sanitation outcomes across different geographical settings.

Finally, the present study demonstrated that Community-Led Total Sanitation (CLTS) not only reduced open defecation but also influenced the type of sanitation technologies adopted by households. Across all five Local Government Areas, there was a substantial decline in households practicing open defecation, accompanied by increased adoption of pit latrines, pour-flush toilets and other improved sanitation facilities. However, the pattern of technology adoption differed across locations. Households in Benue State predominantly adopted pit latrines, whereas communities in Cross River State showed greater uptake of improved sanitation facilities, particularly pour-flush toilets and water closets. These findings suggest that although CLTS successfully stimulated sanitation behavior change, household preferences and the availability of sanitation options influenced the level of technological advancement achieved after the intervention.

The widespread adoption of pit latrines observed in Benue is consistent with the fundamental objective of CLTS, which prioritizes ending open defecation through locally affordable and accessible sanitation solutions before progressing to improved sanitation facilities. Similar findings were reported by Asiimwe et al. [22] in Kenya, where CLTS significantly increased household latrine ownership, with most households initially constructing basic pit latrines because of affordability and ease of construction. The authors further observed that continuous community engagement and post-triggering support encouraged gradual movement towards improved sanitation facilities. In contrast, the higher adoption of pour-flush toilets and water closets in Cross River suggests that households progressed further along the sanitation ladder after abandoning open defecation. This finding agrees with Panulo et al. [23], who reported that sustained CLTS implementation encourages households to upgrade from basic sanitation facilities to safer and more durable technologies as socioeconomic conditions improve. Their study concluded that long-term sustainability depends not only on eliminating open defecation but also on supporting households to continuously improve sanitation quality.

The significant changes in sanitation technology observed across all LGAs were further supported by the large Chi-square statistics and Cramér's V effect sizes (ranging from 0.56 to 0.84), indicating that the intervention produced meaningful changes in household sanitation behavior. Similar observations were reported by Gbeti et al. [24], who found that the acceptance of sanitation-related social norms through CLTS significantly influenced household decisions to construct and consistently use sanitation facilities. The authors emphasized that collective community commitment remains one of the strongest predictors of sustained sanitation behavior. The findings also support those of Ezenwaka et al. [25], who reported that sustained reductions in open defecation in rural Nigerian communities require continued community mobilization, effective local leadership and supportive institutional structures. Their study further noted that although many households initially adopt basic sanitation facilities, continuous technical guidance and improved access to sanitation financing encourage gradual transition to improved sanitation technologies.

Overall, the findings indicate that CLTS successfully stimulated both behavioral and technological changes in household sanitation practices. Nevertheless, the variation in sanitation technologies adopted across the study areas suggests that eliminating open defecation should be regarded as the beginning rather than the endpoint of sanitation improvement. Sustained investments in sanitation promotion, technical assistance and affordable sanitation technologies will be necessary to facilitate continued movement up the sanitation ladder and achieve universal access to safely managed sanitation services.

4.1 Limitations

This study has several limitations that should be considered when interpreting the findings:

1) **Observational design:** The before-and-after design without a comparison group limits the ability to attribute changes solely to the CLTS intervention. Other concurrent factors may have contributed to the observed improvements.
2) **Secondary data:** The reliance on secondary data from programme records meant that the researchers had limited control over data collection procedures and quality.
3) **Generalizability:** The study was conducted in five purposively selected LGAs in two states, which may not be representative of all LGAs in Nigeria or other countries implementing CLTS.
4) **Sustainability assessment:** The study assessed changes immediately following the intervention and does not provide evidence on the long-term sustainability of sanitation improvements.
5) **Limited covariates:** The analysis did not include household-level covariates that could influence sanitation outcomes.
6) **Social desirability bias:** Self-reported sanitation data may be subject to social desirability bias.

Despite these limitations, the large sample size, multilevel analytical approach, and robust statistical methods strengthen the credibility of the findings. The results provide valuable evidence for policy and programme decisions regarding CLTS implementation in Nigeria.

V. CONCLUSION

This study assessed the performance of Community-Led Total Sanitation (CLTS) in improving sanitation access and reducing open defecation across selected Local Government Areas in Benue and Cross River States, Nigeria. The findings demonstrated that CLTS was highly effective in promoting positive sanitation outcomes, with improved sanitation coverage increasing from 9.60% to 22.55%, while open defecation declined substantially from 56.99% to 7.24% following implementation. These improvements were statistically significant, confirming the effectiveness of the intervention in changing sanitation behaviors at the household and community levels.

The study further established that the impact of CLTS varied across implementation areas. Cross River State achieved significantly greater improvements than Benue State, recording a 32.85 percentage-point increase in improved sanitation coverage and virtually eliminating open defecation. At the LGA level, Bekwarra recorded the highest sanitation gains, highlighting the influence of strong community participation, effective facilitation and sustained post-triggering activities on programme success. The findings also showed that although households in all LGAs adopted improved sanitation facilities, the types of technologies differed, with Benue relying predominantly on pit latrines while Cross River demonstrated greater adoption of improved sanitation technologies.

Overall, the study provides strong evidence that Community-Led Total Sanitation remains an effective community-based strategy for eliminating open defecation and improving sanitation access in rural Nigeria. However, the variation in outcomes

across states and LGAs suggests that implementation should be tailored to local socioeconomic and cultural contexts. Strengthening community ownership, promoting gradual upgrading to improved sanitation technologies and sustaining post-intervention monitoring will be essential for maintaining sanitation gains and accelerating progress towards the achievement of Sustainable Development Goal 6 on universal access to safely managed sanitation.

VI. RECOMMENDATIONS

Based on the study findings, the following recommendations are proposed:

1) **Strengthen community participation and local leadership:** Programme implementers should prioritize building strong community ownership through active engagement of local leaders and sanitation committees.
2) **Provide sustained post-triggering support:** Continuous monitoring, follow-up visits, and technical guidance are essential for maintaining sanitation improvements and encouraging upgrading to improved facilities.
3) **Tailor implementation to local contexts:** CLTS implementation should be adapted to local socioeconomic, cultural, and geographical conditions to maximize effectiveness.
4) **Promote sanitation technology upgrading:** Programmes should support households to progress from basic facilities to improved sanitation technologies through access to affordable materials and technical assistance.
5) **Strengthen institutional capacity:** Investments in local government capacity for sanitation programming and monitoring are critical for sustainable outcomes.

VII. FUTURE RESEARCH

Future studies should:

1) Adopt longitudinal designs to evaluate the long-term sustainability of CLTS outcomes
2) Examine the effects of CLTS on sanitation-related health indicators
3) Conduct comparative effectiveness studies with other sanitation interventions
4) Investigate the role of socioeconomic, cultural and institutional factors in CLTS performance
5) Explore the cost-effectiveness of CLTS compared to other sanitation approaches

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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