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Barriers to Youth Adoption of Climate-Smart Agriculture in Liberia: A Socio-Technical Systems Approach

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Abstract

Liberia, a fragile, post-conflict West African nation of approximately 5.8 million people, faces escalating climate-induced livelihood barriers among disadvantaged, war-affected, and at-risk youth whose agricultural prospects are increasingly threatened by drought, unpredictable rainfall, and eroding soil fertility. Although the Government of Liberia has sustained interventions in climate-smart agriculture (CSA), these efforts have not translated into measurable gains in youth productivity, and young people remain largely excluded from CSA frameworks. Using a convergent parallel mixed-methods design, the study examined climate-related, selected personal/knowledge and skills, and social barriers to CSA adoption among disadvantaged youth across urban, peri-urban, and rural Liberia, complemented by an assessment of existing stakeholder support mechanisms and the perceived applicability of innovative empowerment approaches. From a target population of 68,194 disadvantaged youth and 110 developmental stakeholder organisations across Liberia's 15 counties, the study sampled 399 youth and 25 developmental stakeholder organisations, with 391 youth (98.0% response rate) and 21 stakeholder representatives (saturation) selected through stratified random and purposive multiphase techniques. Quantitative data were analysed using descriptive statistics and one-way ANOVA; qualitative data were thematically analysed. All five climate-related barrier items were rated severe ($\bar{x}$ = 5.14-5.38) and did not differ significantly by location (p = 0.15-0.94), indicating that climate risk is a universal constraint. Existing stakeholder mechanisms were rated less effective ($\bar{x}$ = 1.78-2.17), whereas youth rated digital, financial, and renewable-energy innovations as very applicable ($\bar{x}$ = 4.34-5.23), with rural youth reporting significantly greater unmet capacity-building needs (p < 0.05). The study proposes integrating social and technical systems into a coordinated, youth-inclusive CSA framework, with a youth-led biodigester enterprise identified as a potential application requiring further feasibility assessment.

Keywords: climate-smart agriculture; disadvantaged youth; socio-technical systems; economic empowerment; Liberia; youth-led biodigester enterprise

Introduction

Liberia is a predominantly youthful, post-conflict West African country of approximately 5.6-5.8 million people, roughly 75% of whom are below 35 years of age (Beaman et al., 2021). Agriculture remains central to rural livelihoods, but heavy dependence on rain-fed production leaves farming communities highly exposed to climate variability. West Africa's surface temperature has risen by about 1-3°C since the mid-1970s, and Liberia is experiencing rising temperatures, more variable rainfall, and prolonged dry spells that directly threaten youth-dependent farm production, income, and food security (Bah & Ulibarri, 2026). Climate-smart agriculture (CSA) offers a potential response, yet disadvantaged youth remain inadequately represented in CSA programming, and existing interventions have not translated into measurable productivity gains. Among the 391 disadvantaged youth surveyed for this study, only 1.0% owned agricultural land, and existing stakeholder mechanisms were perceived as less effective, illustrating interconnected barriers that research on isolated adoption factors has not adequately captured. This paper assesses the climate-related, selected personal/knowledge-and-skills, and social barriers constraining CSA

adoption among disadvantaged youth across urban, peri-urban, and rural Liberia, and proposes a climate-resilient socio-technical empowerment framework, anchored in a youth-led biodigester enterprise, for youth-led agricultural transformation.

Material and Methods

The study adopted a pragmatist philosophy and a convergent parallel mixed-methods design, in which quantitative and qualitative data were collected concurrently, analysed independently, and integrated through triangulation (Figure 1). It covered all 15 counties of Liberia. The study used the available sampling frame of 68,194 disadvantaged youth aged 15–35 years reported in LISGIS-derived estimates cited by Weiner and Kulczycki (2013), together with 110 developmental stakeholder organisations. Using Slovin's (1960) formula (5% margin of error), 399 questionnaires were administered through stratified-random, county-proportional sampling; 391 valid responses were retained (98.0% response rate). Twenty-one stakeholder representatives were purposively interviewed until thematic saturation was reached. (Table 1).

Table 1: Population, sample and response rate by data-collection phase

Phase	Target population	Sample drawn	Achieved sample	Response rate
Quantitative survey	68,194	399	391	98.0%
Qualitative interviews	110	25	21	84.0% (saturation)

Source: Field survey (2025).

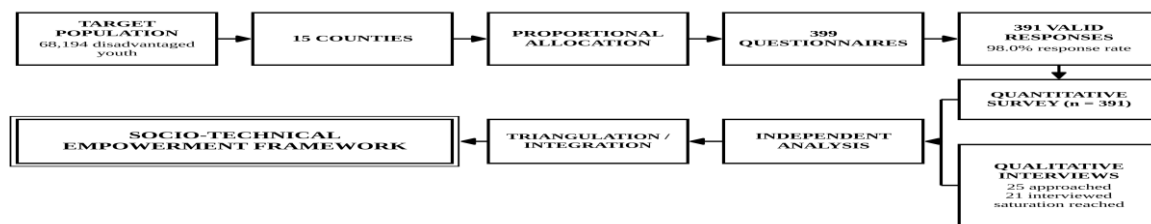


Figure 1: Study sampling and mixed-methods design

Quantitative data were collected with a researcher-developed questionnaire covering demographics, CSA barriers, stakeholder support mechanisms, and innovative empowerment approaches; qualitative data were collected with a semi-structured interview guide. Barriers were rated on a six-point severity scale (1 = not a barrier, 6 = very severe; cut-off $\bar{x} \geq 3.50$); mechanism effectiveness and innovation applicability were rated on six-point real-limit scales. The overall instrument's Cronbach's alpha was 0.93. Quantitative data were analysed in SPSS v20 using descriptive statistics and one-way ANOVA with Fisher's LSD post-hoc tests ($\alpha = 0.05$); qualitative data were analysed thematically through open coding.

Results and Discussion

Respondents ($N = 391$) were predominantly male (56.5%), aged 25-29 (54.0%), and resident in peri-urban areas (69.8%); 62.7% were household heads engaged mainly in casual labour (53.5%). Farming was the leading income source (56.3%), yet only 1.0% owned land outright (54.7% farmed family land), and 70.0% had a parent or guardian who was a farmer. All four reported climate-related barrier items were rated severe ($\bar{x} = 5.23$ – 5.38) and did not differ significantly by location ($p = 0.15$ – 0.94), indicating consistently severe climate-related constraints across locations. (Table 2) with no significant difference across urban, peri-urban, and rural youth ($p = 0.15$ - 0.94); climate-related barriers were consistently severe across the three settlement categories, with no statistically significant differences by location. Within the personal-barrier domain, lack of financial-literacy skill was the highest-rated barrier ($\bar{x} = 4.63$); by contrast, low self-confidence, fear of failure, and lack of interest in agribusiness all fell below the 3.50 cut-off. This suggests that capability and access constraints may be more prominent than the measured motivational barriers (Zenker et al., 2025). Cultural restriction on land ownership was the single most severe social barrier ($\bar{x} = 5.33$; Table 2), while gender discrimination as a standalone item did not meet the threshold ($\bar{x} = 2.48$), suggesting that land-related barriers may be a more prominent reported pathway of

gender-related disadvantage than the measured interpersonal discrimination item (Martin de Almagro, 2022).

Table 2: Selected climate-related and social barriers to CSA adoption (N = 391)

Barrier item	Domain	Mean ($\bar{x}$)	SD	Decision
Drought effects on farming	Climate	5.38	0.70	Severe
Limited access to weather forecasting	Climate	5.31	0.75	Severe
Unpredictable weather patterns	Climate	5.29	0.82	Severe
Limited access to climate information	Climate	5.23	0.66	Severe
Lack of financial literacy skills	Personal	4.63	-	Barrier
Cultural restriction on land ownership	Social	5.33	0.65	Severe
Limited family support for agribusiness	Social	5.29	0.58	Severe
Gender discrimination in agriculture	Social	2.48	1.69	Not a barrier

Scale: 1 = not a barrier to 6 = very severe barrier; cut-off $\bar{x} \geq 3.50$. Source: Field survey (2025).

One-way ANOVA showed rural youth reporting significantly greater knowledge barriers ($\bar{x} = 4.28$ vs 3.82 peri-urban; $F = 3.07$, $p = 0.048$) and significantly weaker CSA training, extension, information dissemination, and awareness mechanisms ($p = 0.038$ - 0.048), confirming a rural-urban capacity divide layered on top of a uniformly severe climate barrier. Every existing stakeholder mechanism examined was rated Less Effective ($\bar{x} = 1.78$ - 2.17 ; Table 3), with gender-inclusion mechanisms the lowest of all ($\bar{x} = 1.78$), despite years of government, NGO, and faith-based investment (Fiedler, 2020). In sharp contrast, every category of innovative empowerment mechanism drawn from other contexts was rated Very Applicable or higher ($\bar{x} = 4.34$ - 5.23 ; Table 3), with youth farmer help-desks, mobile-based micro-savings, affordable greenhouse technology, and organic-farming certification rated most highly (Ogunleke & Idowu, 2025). This gap suggests that weaknesses in the design or targeting of existing support mechanisms may be more prominent than resistance to the proposed innovations.

Table 3: Effectiveness of existing mechanisms vs. applicability of innovative approaches (N = 391)

Category	Mean range ($\bar{x}$)	Interpretation
Existing stakeholder mechanisms (5 domains)	1.78 - 2.17	Less effective
Innovative empowerment mechanisms (8 domains)	4.34 - 5.23	Quite/very applicable

Scale (0.50-6.00): 1.50-2.49 Less Effective; 3.50-4.49 Quite Applicable; 4.50-5.49 Very Applicable. Source: Field survey (2025).

These findings support a Climate-Resilient Socio-Technical Empowerment Framework (Figure 2) built on three complementary pillars: Enable (finance, land, policy, institutions), Equip (extension, training, technology, climate information), and Connect (markets, cooperatives, value chains) - through which CSA-adoption capacity converts into youth economic empowerment and climate resilience (Thorpe & Gaventa, 2020). Renewable-energy adoption ($\bar{x} = 5.14$) and waste-to-wealth farming schemes ($\bar{x} = 5.08$) were rated Very Applicable with no significant location effect, providing a basis for exploring a youth-led biodigester enterprise model, whose technical, economic, and institutional feasibility should be evaluated through subsequent research.: upstream waste collection and logistics, midstream installation and maintenance, and downstream bio-slurry and fertiliser retailing, that directly targets the least-effective existing mechanism (climate-variability response support, $\bar{x} = 2.17$) while building the technical capacity youth report lacking (Sarnoh, 2024; Simpson, 2026).

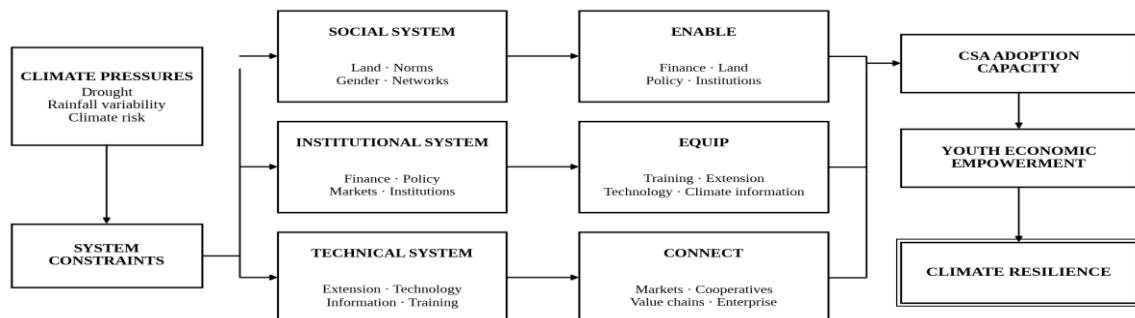


Figure 2: Climate-resilient socio-technical empowerment framework for disadvantaged youth in Liberia

Conclusions and Outlook

Disadvantaged youth in Liberia are not primarily constrained by disinterest in farming or in climate-smart practice: motivational items fell below the barrier threshold, while capability and access items (knowledge, skills, land, finance, extension) did not. Climate risk is a uniformly severe, non-discriminating barrier, whereas the capacity to cope with it is spatially unequal among disadvantaged rural youth. Existing stakeholder mechanisms are consistently rated less effective, while digital, financial, land-access, technological, and environmental-sustainability innovations are perceived by youth as highly applicable, pointing to a design and targeting problem rather than youth resistance to change. Integrating social and technical systems into a coordinated, youth-inclusive CSA framework, anchored by a youth-led biodigester enterprise hub for further feasibility testing, may provide a promising pathway for sustainable economic empowerment and climate resilience. Priority actions include treating climate-information and early-warning systems as universal infrastructure, spatially weighting CSA extension and training toward rural youth. In addition, pursuing customary land-tenure reform ahead of generic gender-sensitization programming and redesigning climate-financing mechanisms around terms accessible to collateral-poor youth serves as a viable option (Arouna et al., 2025; George, 2024). Being cross-sectional, the study cannot establish long-term causal intervention effects; future research should pursue longitudinal and gender-disaggregated analyses, cross-country comparisons, and a quasi-experimental evaluation of the proposed youth-led biodigester enterprise hub.

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