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Strengthening Community-Based Soil Erosion Adaptation through Education and Participatory Practices in Rural Areas

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ABSTRACT

Community-based adaptation plays a critical role in addressing environmental challenges and food insecurity in vulnerable rural areas. This study examines community-based responses to soil erosion and food insecurity through indigenous participation and locally driven adaptation practices. Using a mixed-method approach that integrates household surveys, food insecurity assessment, and participatory qualitative methods, the study analyzes how community engagement influences adaptive capacity and livelihood resilience. The findings indicate that indigenous participation enhances the effectiveness of soil erosion control measures and contributes to improved food security outcomes. Educational interventions and knowledge-sharing practices emerge as key components in sustaining community-based adaptation strategies. These results highlight the importance of integrating community service and education into environmental adaptation programs. The study contributes to community development discourse by emphasizing participatory approaches as practical pathways for strengthening resilience and sustainable livelihoods in erosion-prone regions.

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1. INTRODUCTION

Soil erosion remains one of the most pervasive and destructive forms of land degradation across Sub-Saharan Africa, undermining agricultural productivity, ecological stability, and rural food security. In erosion-prone agrarian systems, the loss of fertile topsoil reduces nutrient availability, weakens soil structure, and diminishes water-holding capacity, thereby constraining crop performance and increasing livelihood vulnerability in farming households (Lal, 2019). These impacts are particularly critical in rural settings where food access and income depend heavily on rain-fed production and the continued availability of cultivable land (Njoku *et al*., 2021).

In northern Nigeria, soil erosion has become a dominant environmental threat where fragile landscapes, limited vegetation cover, and land-use pressure interact with rainfall variability to accelerate runoff and sediment displacement (Abdulkadir *et al*., 2017; Adebayo & Tukur, 1999). Adamawa State, particularly Mubi North and Mubi South Local Government Areas (LGAs), has been widely identified as a hotspot of erosion vulnerability due to rugged topography, dissected hillslopes, and terrain characteristics that support the initiation and expansion of sheet, rill, and gully erosion (Musa *et al*., 2022; Nyako *et al*., 2020). Empirical observations from erosion-prone communities in the region show increasing soil loss, sedimentation of productive plots, damage to rural paths and roads, and recurring declines in crop output, which collectively intensify household exposure to food insecurity (Daniel *et al*., 2022; Umar & Birma, 2020).

Despite these challenges, rural communities have long relied on indigenous and locally organized soil management practices to reduce erosion risk and stabilize agricultural production. Common community-based strategies include contour farming, stone bunding, agroforestry, mixed cropping, and community-led terracing, which are sustained through shared labor arrangements and knowledge transmission within communities (Bunu *et al*., 2020; Mohammed *et al*., 2018). Evidence in the region further suggests that rainfall intensity and related erosive responses can worsen land degradation when conservation measures are weak or inconsistently maintained, making locally feasible conservation practices and continuous learning essential for long-term effectiveness (Suleiman *et al*., 2021). However, while these practices are widely reported, empirical work that quantitatively links specific community-based erosion-control strategies with household food security and yield outcomes across multiple communities remains limited, constraining policy design and the scaling up of proven community-led interventions (Adedeji et al., 2021; Umar & Nyako, 2022).

Therefore, this study assesses community-based soil erosion adaptation practices in Mubi North and Mubi South by integrating household survey evidence with participatory learning-based approaches to examine how community engagement and local education/knowledge-sharing strengthen adaptive capacity. The novelty of this work lies in linking specific community-driven practices to measured household food security outcomes (HFIAS) and crop yield performance using inferential analyses, while also contextualizing these relationships through participatory qualitative insights. The findings are expected to inform community service and education-oriented programming by identifying practical, locally grounded pathways for strengthening resilience, improving food security, and supporting scalable, sustainable land management strategies in erosion-prone rural settings.

2. LITERATURE REVIEW

2.1. Soil Erosion and Land Degradation in Northern Nigeria

Soil erosion represents a major environmental challenge in Northern Nigeria, resulting from the interaction of fragile soil structures, steep slopes, and long-term land-use pressure. The Mubi region is particularly vulnerable due to its undulating terrain, dissected hillslopes, and shallow soil profiles, which promote the development of sheet, rill, and gully erosion processes (Tukur & Musa, 2017; Abdulkadir *et al*., 2018). These geomorphological conditions accelerate surface runoff and sediment transport, leading to progressive land degradation.

Empirical evidence from Adamawa State indicates that erosion severity has intensified over time due to population growth, deforestation, overcultivation, and the expansion of settlements into marginal lands. The combined effects of topography, land-use dynamics, and socio-economic pressure create a high-risk environment for soil degradation in the Mubi area (Adebayo *et al*., 2014). As a result, agricultural productivity declines, land availability is reduced, and rural livelihoods become increasingly vulnerable to environmental stress.

2.2. Community-Based Adaptation (CBA) Approaches

Community-Based Adaptation (CBA) has been increasingly recognized as a locally appropriate approach for addressing soil erosion in vulnerable rural environments. CBA emphasizes indigenous knowledge systems, collective action, and community participation in the design and implementation of conservation practices. In erosion-prone areas such as Mubi North and Mubi South, common adaptation measures include contour farming, stone bunding, agroforestry, mixed cropping, and community-led terracing.

Studies conducted in Northern Nigeria demonstrate that farmer-led conservation practices can significantly reduce erosion impacts when consistently applied. Although topography remains a dominant determinant of erosion risk, locally driven conservation measures are effective in moderating runoff and stabilizing cultivated slopes (Tukur & Musa, 2017). Similarly, indigenous soil conservation practices improve soil moisture retention and support more stable crop production (Abdulkadir *et al*., 2018). These findings highlight the importance of community participation and local knowledge in sustaining erosion control efforts.

2.3. Soil Erosion and Food Security Nexus

Soil erosion and food security are closely interconnected in agrarian communities where land quality directly determines household welfare. The loss of fertile topsoil reduces soil nutrient availability, weakens soil structure, and diminishes crop productivity. In erosion-prone environments, these processes contribute to declining yields, reduced household income, and increased vulnerability to food shortages.

Evidence from Northern Nigeria indicates that erosion-induced land degradation constrains the productive capacity of staple crops and undermines household food access. Declining soil fertility and land degradation intensify livelihood insecurity among smallholder farmers (Abdulkadir *et al*., 2018; Adebayo *et al*., 2014). This relationship underscores the importance of soil conservation as a foundational component of food security strategies in rural communities.

2.4. Empirical Gaps in Erosion-Food Security Linkages

Despite extensive documentation of erosion drivers and conservation practices in Northern Nigeria, important empirical gaps remain. Existing studies have largely focused on identifying physical determinants of erosion and describing indigenous land management

strategies (Tukur & Musa, 2017; Abdulkadir *et al*., 2018; Adebayo *et al*., 2014). However, relatively few studies have empirically examined how specific community-based adaptation practices influence household food security outcomes.

Most available research relies on descriptive assessments, limiting the ability to quantify the effectiveness of adaptation measures or compare outcomes across communities. This gap constrains evidence-based policy development and weakens the integration of community-led erosion control strategies into formal agricultural extension and land management frameworks. Addressing this limitation requires systematic analysis linking local adaptation practices with measurable food security indicators**.**

3. METHOD

3.1. Study Area

This study was conducted in Mubi North and Mubi South Local Government Areas (LGAs), located in the northern part of Adamawa State, Nigeria. The area is characterized by rugged and undulating terrain, including dissected hills, steep slopes, and shallow valleys, which make it highly susceptible to sheet, rill, and gully erosion, particularly during the rainy season. Rainfall in the region is typically intense and concentrated between May and October, contributing to rapid surface runoff and accelerated land degradation.

The population of Mubi North and Mubi South depends predominantly on rain-fed agriculture, with major crops including maize, sorghum, millet, cowpea, and groundnut. Subsistence farming represents the primary livelihood activity, and soil erosion poses a significant threat to agricultural productivity, food availability, and household economic stability. Communities in the study area exhibit strong traditional ecological knowledge and rely on indigenous land management practices to cope with environmental stressors.

3.2. Research Design

This study adopted a mixed-methods research design, integrating quantitative and qualitative approaches to provide a comprehensive understanding of community-based soil erosion adaptation practices and their implications for household food security.

(i) Quantitative Component. Household surveys were administered to 420 respondents across ten erosion-prone communities. The survey collected data on socio-demographic characteristics, farming practices, experiences of soil erosion, adaptation strategies, and household food security conditions. The Household Food Insecurity Access Scale (HFIAS) was used to assess food security levels among sampled households.

(ii) Qualitative Component. Qualitative data were collected through Focus Group Discussions (FGDs) conducted in the ten selected communities. These discussions explored community perceptions of soil erosion, indigenous conservation practices, collective adaptation strategies, and local learning processes. In addition, Key Informant Interviews (KIIs) were conducted with village heads, traditional leaders, agricultural extension officers, environmental officers, and local agricultural desk officers.

(iii) Field observations and Global Positioning System (GPS) mapping were employed to document erosion hotspots, gully locations, and existing soil conservation structures. The integration of these methods ensured triangulation, depth, and reliability of the findings.

3.3. Sampling Procedure

A multistage sampling technique was employed to ensure adequate representation of erosion-prone communities and farming households within the study area.

(i) Selection of Communities. Ten communities were purposively selected based on documented severity of soil erosion and consultations with local authorities and community leaders.
(ii) Selection of Households. Within each selected community, households were chosen using a systematic sampling technique. Every nth household was selected based on community size and population distribution.
(iii) Selection of Respondents. Eligible respondents were adults aged 18 years and above who were actively involved in farming activities and possessed adequate knowledge of household food production and soil erosion challenges. This approach ensured that respondents were well-positioned to provide reliable information relevant to the study objectives.

3.4. Data Collection Instruments

Multiple data collection instruments were utilized to capture diverse dimensions of soil erosion, community-based adaptation practices, and household food security.
(i) Structured Questionnaire. Used to collect data on demographic characteristics, farming systems, erosion experiences, adaptation strategies, and food security indicators.
(ii) Household Food Insecurity Access Scale (HFIAS). Applied to categorize households into four food security levels: food secure, mildly food insecure, moderately food insecure, and severely food insecure.
(iii) Focus Group Discussion Guide. Designed to explore indigenous soil conservation practices, community perceptions of erosion, historical changes, and adaptation challenges.
(iv) Key Informant Interview Checklist. Used to obtain expert insights from community leaders, extension officers, and environmental officials regarding land degradation and adaptation interventions.
(v) Field Observation Checklist. Employed to verify the presence, condition, and extent of physical conservation structures such as terracing, stone bunds, contour bunds, and vegetative strips.
(vi) GPS Devices. Used to map erosion hotspots, gully extents, and conservation sites for spatial documentation and analysis.

3.5 Data Analysis

Both quantitative and qualitative analytical techniques were applied.
(i) Quantitative Analysis. Descriptive statistics, including frequencies, percentages, and means, were used to summarize socio-economic characteristics, erosion experiences, adaptation strategies, and food security status. Inferential statistical analyses were conducted to examine relationships and differences among variables. The Chi-square test was used to assess associations between erosion-control practices and household food security categories. Logistic regression analysis was employed to identify determinants of household food security, while Analysis of Variance (ANOVA) was applied to compare mean crop yields across communities with and without community-based adaptation interventions. All quantitative analyses were performed using SPSS software.
(ii) Qualitative Analysis. Qualitative data obtained from FGDs and KIIs were transcribed and thematically analyzed. Coding was conducted to identify recurring themes related to indigenous knowledge, community adaptation practices, learning processes, barriers to

adoption, and resilience strategies. Field observation data and GPS information were used to contextualize and validate qualitative and quantitative findings.

3.6. Ethical Considerations

Ethical approval for the study was obtained from relevant academic and local authorities. All participants were informed about the purpose of the study, and participation was entirely voluntary. Informed consent was obtained before data collection, anonymity of respondents was ensured, and all information collected was treated with strict confidentiality.

4. RESULTS AND DISCUSSION

This section presents and discusses the empirical findings on community-based soil erosion adaptation and household food security in Mubi North and Mubi South Local Government Areas. The results integrate quantitative survey data with qualitative insights to examine the effectiveness of indigenous adaptation strategies and their implications for food security and agricultural productivity.

4.1. Community-Based Soil Erosion Adaptation Practices

The analysis reveals widespread adoption of community-based soil erosion adaptation strategies across the study area. As shown in **Table 1**, contour farming and stone bunding represent the most frequently practiced measures, adopted by 67.4% of respondents, followed by agroforestry (52.1%) and mixed cropping (48.9%). Community terracing (33.6%) and grass strip planting (21.5%) are less prevalent but remain important in areas with steep slopes.

Table 1 highlights the dominance of low-cost, labor-intensive practices that rely on indigenous knowledge and communal labor arrangements. These findings are consistent with previous studies indicating that farmer-led soil conservation practices are widely applied in erosion-prone regions of Northern Nigeria due to their feasibility and compatibility with local farming systems (Tukur & Musa, 2017; Abdulkadir et al., 2018).

Table 1. Community-based erosion adaptation measures.

Adaptation Method	Percentage of Respondents
Contour farming & stone bunding	67.4%
Agroforestry	52.1%
Mixed cropping	48.9%
Community terracing	33.6%
Grass strip planting	21.5%

Qualitative evidence from focus group discussions supports these findings. Participants consistently described contour farming and stone bunding as long-established practices used to slow runoff, retain soil moisture, and prevent gully expansion. These practices are often implemented through communal labor systems, reflecting strong social cohesion and shared responsibility for land management. Such locally organized adaptation aligns with observations that community-driven conservation practices remain effective when embedded within indigenous knowledge systems (Abdulkadir *et al*., 2018).

4.2. Food Security Status of Households

Household food security was assessed using the Household Food Insecurity Access Scale (HFIAS). Results indicate that food insecurity remains widespread across the study area.

Approximately 41.2% of households were classified as moderately food insecure, while 27.6% were severely food insecure. Only 8.3% of households were categorized as food secure.

These findings underscore the persistent vulnerability of rural households whose livelihoods depend on rain-fed agriculture and degraded land resources. Land degradation in Adamawa State contributes directly to declining agricultural productivity and heightened livelihood insecurity (Adebayo *et al*., 2014). The high prevalence of food insecurity observed in this study further reinforces the need for effective soil conservation strategies as part of broader food security interventions.

4.3. Relationship Between Adaptation Practices and Food Security

Statistical analysis confirms a significant association between community-based adaptation practices and household food security outcomes. The Chi-square test revealed a significant relationship between contour farming adoption and household food security status ($\chi^2 = 18.37$, $p < 0.01$). Households practicing contour farming were significantly more likely to report better food access than non-adopters.

Logistic regression analysis further demonstrates the predictive role of adaptation strategies. As presented in **Table 2**, agroforestry emerged as the strongest determinant of food security, increasing the likelihood of food security by more than twofold. Stone bunding also showed a positive effect, while mixed cropping reduced vulnerability to food shortages.

These results confirm that erosion-control practices not only reduce land degradation but also translate into tangible livelihood benefits. Similar findings (Abdulkadir *et al*., 2018) observed that farmer-led conservation practices improve soil moisture retention and stabilize crop production in semi-arid environments.

Table 2. Logistic regression results on determinants of household food security.

Variable	Odds Ratio	Interpretation
Agroforestry	2.34	Increases likelihood of food security
Mixed cropping	0.64	Reduces vulnerability to food insecurity
Stone bunding	1.87	Enhances yield stability

4.4. Effects of Adaptation Practices on Crop Yield Performance

Analysis of variance (ANOVA) was conducted to compare crop yields between communities practicing terracing and those without such interventions. The results show a statistically significant difference in mean maize and sorghum yields. Terraced communities recorded an average yield of 2.74 t/ha, compared to 1.89 t/ha in non-intervention communities ($F = 9.46$, $p < 0.01$).

This yield difference represents an approximate 45% increase in productivity in terraced landscapes, demonstrating the effectiveness of slope stabilization in erosion-prone areas. These findings corroborate earlier research indicating that topography-driven erosion can be significantly moderated through farmer-led conservation measures, resulting in improved agricultural outcomes (Tukur & Musa, 2017).

4.5. Implications for Community-Based Adaptation and Food Security

The findings of this study demonstrate that community-based adaptation strategies play a critical role in mitigating soil erosion and strengthening household food security. Practices such as agroforestry, contour farming, and stone bunding function through multiple

mechanisms, including runoff reduction, soil moisture conservation, and enhancement of soil fertility. Their effectiveness is reinforced by community participation, indigenous knowledge, and collective action.

Importantly, the results highlight that locally driven adaptation strategies are not merely traditional coping mechanisms but empirically effective interventions with measurable impacts on food security and crop productivity. This aligns with observations that conservation practices rooted in local knowledge systems are more sustainable than externally imposed interventions that lack community ownership (Abdulkadir *et al*., 2018).

The persistence of high food insecurity levels, however, indicates that adaptation practices alone are insufficient without broader institutional support. Strengthening agricultural extension services, enhancing community learning platforms, and integrating erosion management into local development planning are essential for scaling up successful practices. Adebayo *et al*. (2014) emphasize that without such support, land degradation will continue to undermine rural livelihoods despite local adaptation efforts.

4.6. Synthesis

The results provide robust evidence that community-based soil erosion adaptation strategies significantly enhance agricultural productivity and household food security in Mubi North and Mubi South. By combining indigenous knowledge with collective action, rural communities are able to mitigate erosion impacts and strengthen livelihood resilience. These findings reinforce the importance of embedding community service and education within environmental adaptation initiatives to achieve sustainable land management and food security outcomes.

4.7. Recommendations

Based on the findings of this study, several practical recommendations are proposed to strengthen community-based soil erosion adaptation and improve household food security in erosion-prone rural areas.

(i) Community-based soil conservation practices should be formally integrated into local agricultural extension programs. Extension services should prioritize participatory training that builds on indigenous knowledge, particularly for practices such as contour farming, stone bunding, agroforestry, and terracing, which have demonstrated measurable benefits for crop productivity and food security.

(ii) Local governments and development agencies should support community-led initiatives through technical guidance and facilitation rather than top-down interventions. Providing simple tools, training support, and coordination mechanisms can enhance the sustainability of existing community adaptation efforts without undermining local ownership.

(iii) Farmer-to-farmer learning and community education platforms should be strengthened. Demonstration plots, peer learning groups, and collective work programs can accelerate knowledge sharing, improve adoption rates, and reinforce collective responsibility for land management.

(iv) Special attention should be given to youth involvement in land management activities. Engaging young people in terracing, agroforestry, and erosion monitoring can support long-term sustainability while creating opportunities for skills development and community service.

(v) Soil erosion management should be embedded within broader rural development and food security strategies. Addressing erosion as a standalone environmental issue is insufficient; integrated approaches that link land management, agricultural productivity, and household welfare are essential for building resilient rural livelihoods.

5. CONCLUSION

This study demonstrates that community-based soil erosion adaptation strategies play a critical role in enhancing agricultural productivity and household food security in Mubi North and Mubi South Local Government Areas of Adamawa State, Nigeria. Empirical evidence shows that locally driven practices (particularly contour farming, stone bunding, agroforestry, and terracing) significantly reduce erosion impacts, stabilize crop yields, and improve food security outcomes.

The findings confirm that indigenous knowledge and collective action are not merely traditional coping mechanisms but effective and sustainable solutions to land degradation when supported by participatory learning and community engagement. However, the persistence of food insecurity highlights the need for stronger institutional support and integration of community-based adaptation into formal agricultural and rural development frameworks.

Overall, the study underscores the importance of aligning community service, education, and environmental management to strengthen resilience and promote sustainable livelihoods in erosion-prone rural settings.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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