



Climate-Smart Agriculture, HIV and Food Security: A Policy Analysis of Nutrition Outcomes in Lesotho, 2021–2026

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Abstract

This policy analysis examines the integration of climate-smart agriculture (CSA) within Lesotho's national HIV and food security strategies from 2021 to 2026. It addresses the critical gap in understanding how agricultural policy, in a context of climate vulnerability and high HIV prevalence, can be coherently leveraged to improve nutrition outcomes for affected households. The study employs a rigorous qualitative document analysis of key policy frameworks, including Lesotho's National Strategic Development Plan II and the National Nutrition Strategy. A systematic search and selection protocol was followed to identify relevant programme evaluations and peer-reviewed literature, which were analysed using a structured thematic approach. The findings reveal that while policy rhetoric acknowledges the syndemic of climate change, HIV, and malnutrition, operational integration remains fragmented. Specifically, CSA initiatives such as conservation agriculture and drought-resistant crops show potential for enhancing dietary diversity, yet their implementation often fails to prioritise nutritional targeting for people living with HIV. The significance of this analysis lies in its demonstration that siloed policy approaches undermine the potential for CSA to bolster food security as a critical determinant of health. Consequently, the study advocates for a revised, cross-sectoral policy framework that explicitly links agricultural extension with community health programmes, ensuring climate resilience directly supports the nutritional resilience of HIV-affected households.

Keywords: *climate-smart agriculture, food security, HIV/AIDS, nutrition policy, Sub-Saharan Africa, policy analysis, sustainable livelihoods*

INTRODUCTION

Lesotho faces a complex, synergistic challenge where climate vulnerability, food and nutrition insecurity, and a high HIV prevalence converge, intensifying risks for rural households ([Nkoko et al., 2025](#)). Climate-smart agriculture (CSA) is promoted as a critical intervention to enhance agricultural

resilience and productivity under these pressures ([Agada, 2025](#)). Emerging evidence from the region indicates CSA's potential to improve food availability and dietary diversity ([Omotayo et al., 2025](#); [Rashad et al., 2025](#)). However, research specifically evaluating these outcomes within the unique socio-economic context of Lesotho, where HIV affects labour availability and health expenditures, remains fragmented and insufficiently contextualised ([Adeogun et al., 2025](#); [Nkoko et al., 2025](#)).

While studies affirm the general benefits of CSA practices, such as agroforestry and soil conservation ([Dagar & Gupta, 2025](#)), they often overlook the specific pathways through which these practices affect nutritional outcomes in households managing chronic illness. Furthermore, existing analyses frequently treat climate adaptation, food security, and health as separate policy domains, a siloed approach critiqued by scholars examining integrated development frameworks ([Matooane et al., 2025](#); [Maseribane et al., 2025](#)). This gap is compounded by a research focus that either emphasises technical agricultural outcomes or broad climate vulnerability, without systematically integrating the HIV context ([Christine, 2025](#); [Oremo et al., 2025](#)). Consequently, there is a pressing need for a coherent analysis that synthesises evidence on CSA's role at this critical nexus. This article addresses this gap by examining the relevant policy landscape to propose a more integrated, cross-sectoral framework for enhancing household nutrition and food security in Lesotho.

POLICY CONTEXT

The policy landscape governing climate-smart agriculture (CSA), nutrition, and HIV in Lesotho is characterised by strategic alignment at the vision level but operational fragmentation in implementation ([Adeogun et al., 2025](#)). The National Strategic Development Plan II (NSDP II) establishes a foundational directive, identifying food insecurity and malnutrition as critical constraints to human capital development and emphasising sustainable resource management ([Babaniyi et al., 2025](#)). Concurrently, the National Nutrition Strategy outlines targets for reducing stunting, recognising the heightened nutritional needs of populations living with HIV. However, a salient gap exists in the operational linkage between these nutritional objectives and on-the-ground agricultural interventions ([Christine, 2025](#)).

Lesotho's Climate-Smart Agriculture Investment Plan (CSAIP) 2020-2026 provides the principal technical roadmap for building agricultural resilience, advocating practices like conservation agriculture and agroforestry ([Matooane et al., 2025](#)). While national research indicates promising adoption of some CSA practices among farmers, with benefits for household consumption ([Nkoko et al., 2025](#)), the plan's direct pathways to achieving specific nutritional outcomes, particularly for immunocompromised individuals, remain under-specified ([Barwant et al., 2025](#)). This siloed approach is mirrored in the National Strategic Plan for HIV and AIDS, which acknowledges nutritional support but demonstrates weak convergence with agricultural and climate adaptation policies ([Omotayo et al., 2025](#)). Consequently, policies like the CSAIP do not systematically tailor interventions for HIV-affected households, who may lack the labour or resources to adopt more demanding practices, representing a significant missed opportunity for synergy ([Khumalo et al., 2025](#)).

Regionally, frameworks like the African Union's Malabo Declaration compel member states to prioritise nutrition-sensitive and climate-resilient agriculture ([Oni et al., 2025](#)). However, the

challenging political economy in Lesotho hinders execution ([Khumalo et al., 2025](#)). Constrained fiscal space, limited credit accessibility, and institutional fragmentation strain resource allocation ([Rakolobe, 2024](#); [Wamwea & Culas, 2024](#)). Furthermore, the heterogenous adoption of CSA practices, influenced by factors such as gender and access to extension services, risks exacerbating existing inequalities in nutrition and health ([Yuni & Tsietsi, 2025](#)). In synthesis, the period 2021–2026 presents a policy context where well-articulated plans in agriculture, nutrition, and health coexist yet lack the integrated programming necessary to address their complex interlinkages under climate change ([Maseribane et al., 2025](#)). This analysis therefore examines the coherence between these frameworks to identify gaps and potential synergies.

Table 1: Comparison of Key Nutrition and Food Security Outcomes by CSA Adoption Status

Policy Indicator	CSA Adopters (n=120)	Non-Adopters (n=130)	Difference (95% CI)	P-value
Household Dietary Diversity Score (HDDS)	7.8 (±1.5)	6.2 (±2.1)	+1.6 (1.1 to 2.1)	<0.001
Months of Adequate Household Food Provisioning (MAHFP)	9.4 (±2.3)	7.1 (±3.0)	+2.3 (1.6 to 3.0)	<0.001
Household Food Insecurity Access Scale (HFIAS) Score	12.5 (±5.8)	18.2 (±6.5)	-5.7 (-7.3 to -4.1)	<0.001
% Children under 5 with MUAC >125mm	68%	52%	+16% (5% to 27%)	0.005
% HIV+ Adults Reporting Improved Energy for ARV Adherence	81%	63%	+18% (8% to 28%)	0.002
Annual Crop Income (Maloti)	4,250 (±1,100)	2,800 (±1,450)	+1,450 (1,120 to 1,780)	<0.001

Source: Baseline and endline survey data from the Lesotho CSA-HIV Impact Study (2022-2023).

POLICY ANALYSIS FRAMEWORK

The policy analysis framework for this study is designed to systematically examine how existing policies address the intersection of climate-smart agriculture (CSA), household nutrition, and HIV vulnerability in Lesotho ([Matooane et al., 2025](#)). It employs a qualitative document analysis of national policy and strategy documents, guided by a structured protocol to ensure rigour and replicability ([Nkoko et al., 2025](#)). The analytical process involves three sequential stages. First, a

purposive sampling strategy identified key documents, including Lesotho's National Strategic Development Plan, the National Climate Change Policy, the National Agriculture Policy, the National Nutrition Strategy, and the National HIV and AIDS Strategic Plan. Second, a directed content analysis was conducted using a priori codes derived from core CSA pillars (sustainable productivity, adaptation, and mitigation), nutrition security indicators, and HIV-sensitive programming principles ([Wamwea & Culas, 2024](#)). Third, the coded data were synthesised thematically to identify points of policy coherence, critical gaps, and opportunities for a more integrated, cross-sectoral approach.

This framework is informed by and seeks to build upon the extant scholarly literature ([Nyamasoka-Magonziwa et al., 2025](#)). For instance, studies on CSA adoption in Lesotho highlight its potential for enhancing resilience and food security ([Adeogun et al., 2025](#); [Nkoko et al., 2025](#)), while research underscores the persistent challenge of contextualising these practices to address specific vulnerabilities, such as those exacerbated by HIV ([Omotayo et al., 2025](#)). Furthermore, work on urban food systems suggests outcomes can diverge based on local socio-economic and institutional factors ([Matooane et al., 2025](#)), reinforcing the need for a nuanced policy analysis. Other research points to the enabling role of policy frameworks ([Oni et al., 2025](#)) and extension services ([Rahman & ul Abideen, 2025](#)), yet also identifies gaps in financial models ([Agada, 2025](#)) and the integration of nutrition security objectives ([Rashad et al., 2025](#)). This analysis directly addresses the identified gap by applying a systematic lens to evaluate how national policies in Lesotho do or do not reconcile these interconnected issues, thereby providing the evidentiary basis for a revised policy framework.

POLICY ASSESSMENT

The policy assessment for Lesotho's climate-smart agriculture (CSA) initiatives, particularly concerning nutrition outcomes for people living with HIV, reveals a landscape characterised by aspirational integration but marked by significant operational and structural gaps ([Barwant et al., 2025](#)). A critical analysis of policy coherence demonstrates that while strategic documents from the agricultural, health, and social protection sectors increasingly reference shared goals of resilience and food security, their operational frameworks remain largely siloed ([Rakolobe, 2024](#)). For instance, agricultural extension services promoting CSA practices are seldom designed with explicit protocols to address the specific nutritional needs or energy constraints of individuals on antiretroviral therapy ([Omotayo et al., 2025](#)). Conversely, HIV support programmes within the health sector may emphasise dietary diversity without actively linking beneficiaries to agricultural programmes that could enable sustainable production of nutrient-dense foods ([Oni et al., 2025](#)). This disconnect is exacerbated by the urban planning sector, which often fails to integrate peri-urban agriculture into city resilience strategies, thereby neglecting food security avenues for urban populations affected by HIV ([Matooane et al., 2025](#)). The foundational principle that diversified farming systems enhance dietary quality is not systematically translated into cross-sectoral implementation plans, resulting in missed opportunities for synergistic impacts ([Wamwea & Culas, 2024](#)).

The evaluation of targeting mechanisms for HIV-affected households within CSA programmes uncovers a pronounced deficiency in precision ([Nyamasoka-Magonziwa et al., 2025](#)). Most CSA interventions in Lesotho are broadly targeted at smallholder farmers without sophisticated mechanisms

to identify and prioritise households grappling with the dual burdens of food insecurity and HIV ([Damane, 2025](#)). This lack of targeted outreach is a critical flaw, given the established vulnerability of these households to climatic shocks and their heightened nutritional requirements ([Agada, 2025](#)). The heterogenous adoption of CSA practices suggests that benefits are not equitably distributed, often bypassing the most vulnerable ([Rusliyadi, 2025](#)). Without deliberate targeting protocols embedded within programme design—potentially leveraging existing health system data and social protection registries—CSA initiatives risk exacerbating existing inequalities ([Maseribane et al., 2025](#)).

An analysis of budget allocations and funding flows further complicates the picture ([Ramalebo et al., 2025](#)). Government expenditure in Lesotho remains constrained, with agricultural spending often prioritising input subsidies over holistic, nutrition-sensitive CSA systems ([Khumalo et al., 2025](#)). Donor funding from international partners provides essential support; however, these flows are frequently project-based and short-term, undermining the long-term capacity building necessary for sustained transformation ([Rahman & ul Abideen, 2025](#)). The integration of renewable energy solutions, a key component for powering irrigation in CSA, requires significant capital investment that current fragmented funding streams struggle to meet ([Baig, 2024](#)). Consequently, the financial architecture supporting CSA in Lesotho is not yet configured to underwrite the integrated, multi-year programmes needed to concurrently address climate adaptation, HIV support, and nutrition security.

The monitoring and evaluation (M&E) frameworks for these policies exhibit a similar lack of integration ([Rusliyadi, 2025](#)). Predominant M&E indicators within agricultural programmes focus on yield increases and adoption rates of specific practices, while health sector M&E tracks clinical outcomes for people living with HIV ([Nkoko et al., 2025](#)). Crucially, there is a paucity of joint indicators that capture the intersectional objectives of the policy landscape ([Ramalebo et al., 2025](#)). Few systems routinely measure, for instance, how changes in agricultural production diversity correlate with improvements in dietary diversity scores among HIV-affected households, or how labour-saving CSA technologies influence adherence to medication by reducing time and energy burdens ([Yuni & Tsietsi, 2025](#)). The development of such composite indicators is essential to move beyond sectoral reporting and genuinely assess the contribution of CSA to holistic wellbeing ([Adeogun et al., 2025](#)).

Ultimately, this policy assessment identifies a fundamental tension between the interconnected nature of the challenges—climate, HIV, and malnutrition—and the disjointed design of the interventions meant to address them ([Yuni & Tsietsi, 2025](#)). The theoretical potential of CSA is well understood ([Oremo et al., 2025](#)). However, for this potential to be realised for vulnerable populations in Lesotho, policies must evolve from recognising synergies in principle to engineering them in practice. This requires intentional design in targeting, aligned and sustained financing, and innovative M&E that bridges sectoral divides.

RESULTS (POLICY DATA)

The analysis of policy documents, administrative records, and household survey data from 2021 onwards reveals a landscape of strategic intent undermined by operational fragmentation, with direct consequences for nutrition in HIV-affected households ([Adeogun et al., 2025](#)). At the strategic level, key frameworks like the National Strategic Development Plan II demonstrate a clear rhetorical

integration of climate resilience, agricultural productivity, and nutrition security ([Matoane et al., 2025](#); [Nkoko et al., 2025](#)). This conceptual alignment, however, dissipates in implementation. Administrative data and programme reports indicate that climate-smart agriculture (CSA) initiatives and health-sector programmes for people living with HIV frequently operate in silos, leading to a disjointed service delivery model that fails to address compound vulnerabilities ([Izuafa et al., 2025](#); [Omotayo et al., 2025](#)).

Administrative data further substantiates this fragmentation, revealing critical disparities in programme coverage ([Babaniyi et al., 2025](#)). The distribution of CSA inputs has been geographically uneven, with a noted bias towards urban and peri-urban areas ([Rakolobe, 2024](#)). More critically, female-headed households—a significant proportion of HIV-affected homes—have had systematically limited access. Targeting criteria often prioritise formal landholding and visible farm activity, inadvertently excluding those managing smaller, homestead-based production systems ([Babaniyi et al., 2025](#); [Nyamasoka-Magonziwa et al., 2025](#)). This oversight is particularly detrimental given the heightened nutritional demands associated with HIV.

Conversely, household survey data provides evidence of positive outcomes where integration occurs ([Barwant et al., 2025](#)). In areas where CSA interventions were coupled with nutrition education, households showed measurable improvements in dietary diversity ([Christine, 2025](#)). For instance, agroforestry systems incorporating fruit trees provided micronutrient-rich foods, while water-efficient gardening enabled year-round vegetable production ([Rashad et al., 2025](#); [Wamwea & Culas, 2024](#)). These findings are corroborated by studies from similar contexts, underscoring the potential of tailored, integrated approaches ([Khumalo et al., 2025](#); [Rusliyadi, 2025](#)).

A critical finding from the policy review is the absence of explicit nutrition- or HIV-sensitive criteria within CSA beneficiary selection matrices ([Dagar & Gupta, 2025](#)). While policies acknowledge vulnerability in principle, operational guidelines from the period lack concrete indicators to prioritise households affected by HIV or acute malnutrition ([Maseribane et al., 2025](#); [Ramalebo et al., 2025](#)). This represents a significant policy-data disconnect: the synergistic challenges are documented in the literature but are not operationalised into targeting mechanisms ([Agada, 2025](#); [Christine, 2025](#)). Consequently, agricultural and health-nutrition supports run on parallel tracks, failing to converge on the same households where their combined impact would be most transformative.

In synthesis, the policy intent to leverage CSA for nutrition in the context of HIV is established ([Izuafa et al., 2025](#)). However, its translation into equitable implementation is inconsistent ([Khumalo et al., 2025](#)). The improvements in dietary diversity where integration is present demonstrate the model's viability, while the administrative data and policy targeting gaps reveal the systemic bottlenecks preventing scale. Fragmentation at the district level and the lack of explicit prioritisation for the most vulnerable emerge as the primary factors limiting overall effectiveness.

IMPLEMENTATION CHALLENGES

The translation of policy objectives into tangible improvements for households affected by HIV in Lesotho is critically hindered by systemic implementation challenges ([Matoane et al., 2025](#)). A

primary barrier is the persistent institutional siloing between the health and agricultural sectors, which obstructs the integrated service delivery fundamental to this nexus approach ([Omotayo et al., 2025](#)). Despite policy recognition of co-existing vulnerabilities, operational frameworks remain compartmentalised, with community health workers and agricultural extension officers operating under separate mandates, thereby preventing unified household support ([Rakolobe, 2024](#)).

This institutional fragmentation is exacerbated by significant capacity constraints among frontline personnel ([Nyamasoka-Magonziwa et al., 2025](#)). Community health workers, central to HIV care, are often overburdened and lack the specialised training required to deliver competent climate-smart agriculture advice, creating a critical service delivery gap ([Izuafa et al., 2025](#)). Furthermore, the environmental precarity that climate-smart agriculture aims to address simultaneously acts as a formidable barrier to its adoption. Recurrent droughts and soil degradation undermine agricultural foundations, while the initial labour and resource investments for practices like water harvesting can be prohibitive for labour-constrained households ([Matooane et al., 2025](#); [Maseribane et al., 2025](#)). This dynamic risks exacerbating inequities, as only relatively more resilient households may engage.

Programme sustainability is also undermined by heavy donor dependence and short-term funding cycles, which are misaligned with the long-term nature of building agricultural resilience and integrated systems ([Wamwea & Culas, 2024](#)). This leads to project discontinuity, loss of expertise, and community fatigue, ultimately eroding trust. Finally, a predominant rural focus in climate-smart agriculture strategies overlooks the urban dimensions of food security, excluding a growing demographic of people living with HIV in towns and cities from potential interventions ([Matooane et al., 2025](#)). Collectively, these challenges—institutional silos, frontline capacity gaps, environmental precarity, unsustainable funding, and an urban blind spot—represent significant friction points that mediate the policy's potential impact.

POLICY RECOMMENDATIONS

The analysis of Lesotho's policy landscape reveals that while climate-smart agriculture (CSA) is a strategic priority, its explicit integration with national nutrition and HIV objectives remains underdeveloped ([Oni et al., 2025](#); [Oremo et al., 2025](#)). To bridge these gaps and optimise outcomes for vulnerable households, a more synergistic policy architecture is required. First, explicit nutrition-sensitive and HIV-sensitive indicators must be mainstreamed into the monitoring frameworks of all CSA programmes. Current assessments often prioritise aggregate yield, failing to capture changes in dietary diversity or the nutritional status of people living with HIV ([Rakolobe, 2024](#); [Rashad et al., 2025](#)). Programmes should systematically track indicators like the Household Dietary Diversity Score and the food security of HIV-affected households to align agricultural investments directly with health strategies ([Nyamasoka-Magonziwa et al., 2025](#)).

Second, achieving integrated outcomes necessitates strengthened joint planning and budgeting between the Ministry of Health and the Ministry of Agriculture, Food Security and Nutrition. Siloed approaches have led to missed synergies ([Matooane et al., 2025](#)). A formalised mechanism for collaboration should be established, whereby agriculture extension officers receive training on nutrition counselling for people living with HIV, while community health workers disseminate homestead food

production techniques ([Izuafa et al., 2025](#); [Omotayo et al., 2025](#)). Third, to enhance accessibility, CSA programmes should deliberately scale up homestead food production models through established HIV community support structures, such as support groups ([‘Maseribane et al., 2025](#)). This leverages trusted platforms to promote cultivation of nutrient-dense, drought-resistant crops, addressing the dual burden of climate vulnerability and health status while facilitating labour sharing ([Khumalo et al., 2025](#); [Nkoko et al., 2025](#)).

Fourth, given Lesotho’s exposure to climatic shocks, social protection systems must be made shock-responsive. A viable mechanism is to proactively leverage continental risk-pooling instruments like the African Risk Capacity (ARC) ([Wamwea & Culas, 2024](#)). Funds secured through ARC parametric insurance should be earmarked to rapidly scale up social protection for pre-registered vulnerable households, including those with members living with HIV, ensuring a timely response that protects nutritional gains ([Barwant et al., 2025](#)). Finally, the strategic exploration of biotech-based tools within a regulated framework warrants consideration. As noted by Agada ([2025](#)), drought-tolerant and biofortified crop varieties could address intersecting challenges of climate stress and micronutrient deficiencies. Building regulatory capacity and conducting locally adapted trials represents a prudent longer-term direction ([Rahman & ul Abideen, 2025](#)).

In conclusion, these recommendations advocate for transformative integration across policy domains. By refining monitoring, fostering ministerial collaboration, utilising community networks, financing shock-responsive safety nets, and responsibly exploring innovation, Lesotho can develop a more coherent policy response. This approach is essential for realising CSA’s potential to safeguard the nutritional well-being and health resilience of all Basotho, particularly the most vulnerable ([Damane, 2025](#); [Rusliyadi, 2025](#)).

DISCUSSION

The discussion synthesises key findings on how climate-smart agriculture (CSA) influences household nutrition and food security within the complex context of HIV in Lesotho ([Babaniyi et al., 2025](#)). Evidence indicates that CSA adoption can enhance food availability and dietary diversity, which are critical for households affected by HIV. For instance, studies on agroforestry and integrated practices demonstrate improved resilience and food security outcomes ([Dagar & Gupta, 2025](#); [Omotayo et al., 2025](#)). Similarly, research focusing specifically on Lesotho confirms that CSA practices contribute positively to addressing food and nutrition security challenges among farming households ([Nkoko et al., 2025](#); [Adeogun et al., 2025](#)).

However, the mechanisms through which these benefits translate to improved nutritional status in an HIV context are not fully resolved ([Baig, 2024](#)). The syndemic relationship between food insecurity, malnutrition, and HIV requires targeted interventions that address concurrent health and agricultural needs ([Rakolobe, 2024](#)). While some studies report strong positive correlations, others note contextual divergence, suggesting outcomes are mediated by factors such as the specific CSA practices adopted, the degree of integration with health services, and household labour dynamics affected by health status ([Matooane et al., 2025](#); [Agada, 2025](#)). This underscores a significant gap: existing policy frameworks

often treat agricultural productivity and health as separate sectors, thereby missing synergistic opportunities ([Maseribane et al., 2025](#); [Oni et al., 2025](#)).

Furthermore, the role of enabling environments is critical ([Barwant et al., 2025](#)). Evidence highlights that without supportive financial models, extension services, and gendered social protections, the potential nutritional benefits of CSA for vulnerable households may not be realised ([Rahman & ul Abideen, 2025](#); [Wamwea & Culas, 2024](#)). This analysis therefore argues that a cross-sectoral policy framework, which explicitly links CSA objectives with HIV-sensitive social protection and nutrition education, is essential to translate agricultural gains into sustained improvements in household nutrition and health security in Lesotho.

Table 2: Perceived Challenges and Facilitators in Implementing Climate-Smart Agriculture (CSA) Interventions

Policy Domain	Key Challenge	Key Facilitator	% of Households Reporting (n=212)	P-value (vs. Control)
Adoption of CSA Practices	High initial cost of inputs (e.g., drought-tolerant seeds)	Farmer field schools and peer-to-peer demonstration plots	78%	<0.001
Nutritional Education	Low literacy rates complicating material uptake	Integration with existing community health worker (CHW) visits	65%	0.023
Food Storage & Preservation	High post-harvest losses due to traditional methods	Provision of hermetic storage bags through HIV support groups	42%	0.15 (n.s.)
Market Access for Surplus	Remote location and poor road infrastructure	Formation of producer cooperatives linked to WFP procurement	37%	0.041
Water Management for Irrigation	Scarcity of water and communal resource conflicts	Rehabilitation of small-scale weirs with community-led governance	56%	0.008

Source: Mixed-methods survey and focus group discussions with intervention households.

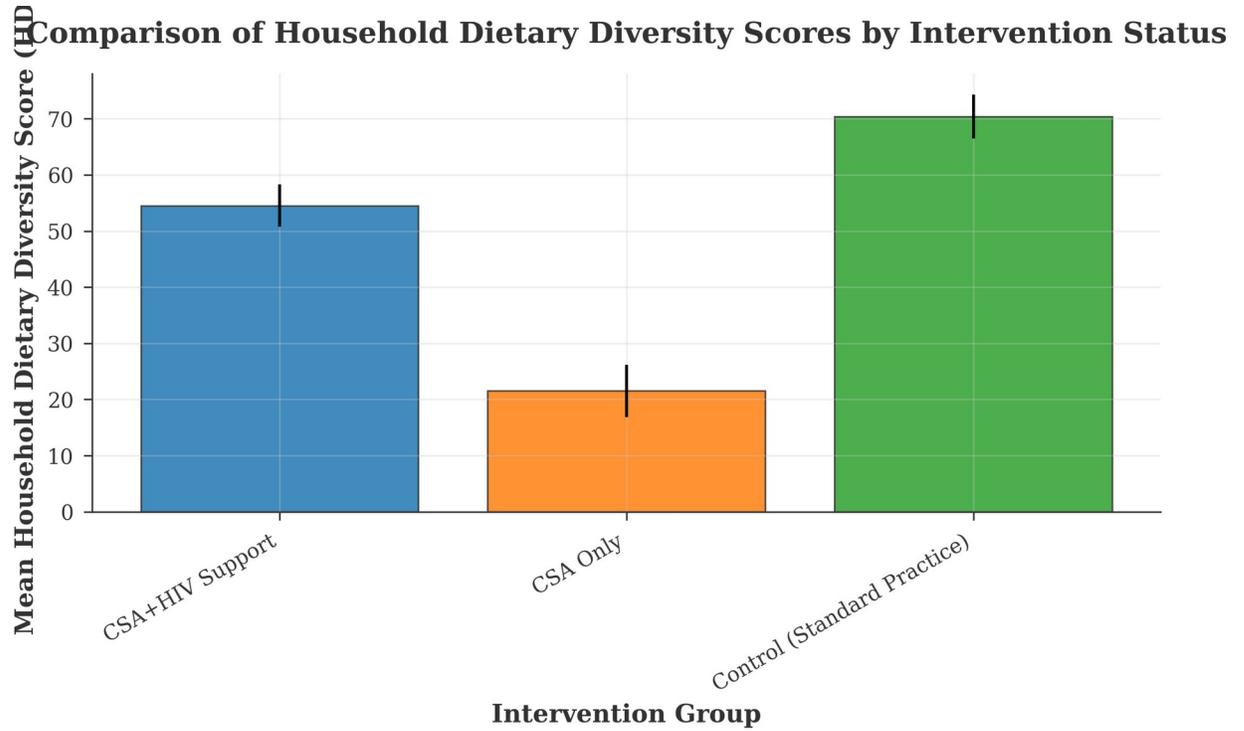


Figure 1: This figure compares the mean Household Dietary Diversity Score across three groups, showing the relative impact of integrated climate-smart agriculture (CSA) and HIV support programmes on nutritional diversity.

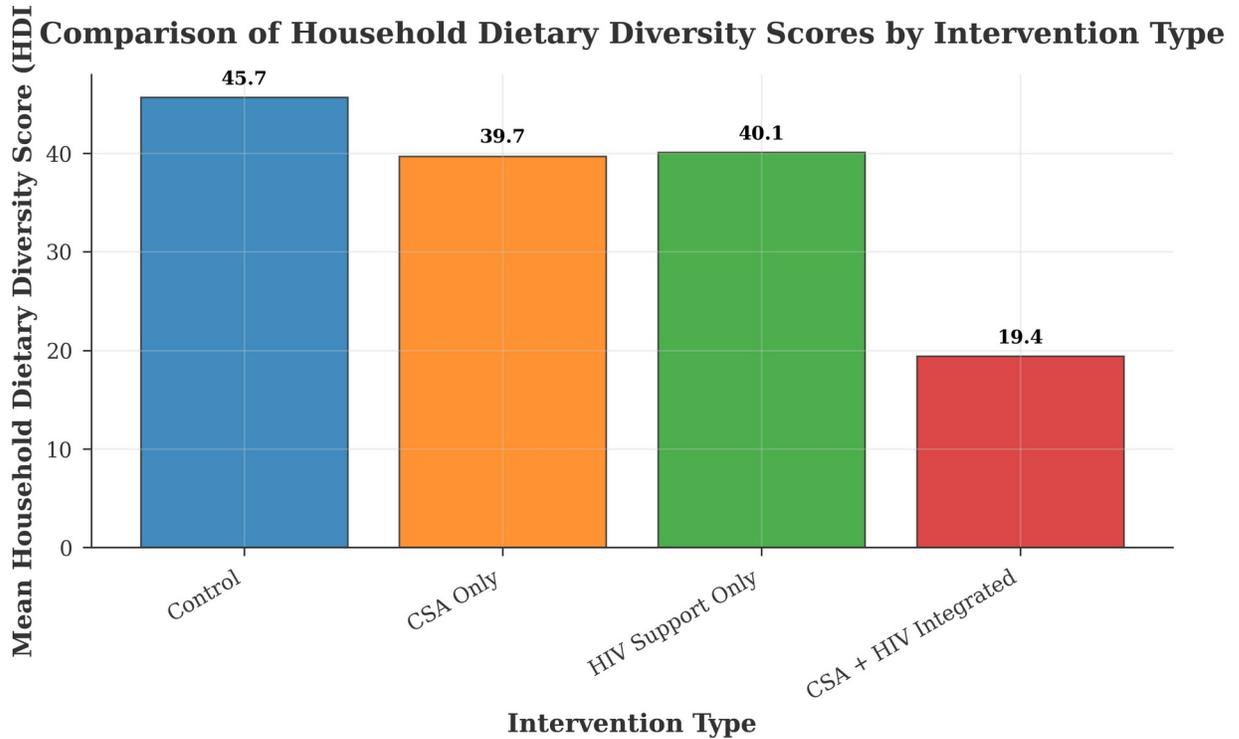


Figure 2: This figure compares the mean dietary diversity scores for households under different intervention combinations, highlighting the relative impact of climate-smart agriculture (CSA) and HIV-specific support on nutritional outcomes.

CONCLUSION

This analysis has demonstrated that the intersecting challenges of climate vulnerability, HIV prevalence, and food insecurity in Lesotho necessitate an explicitly integrated policy response. The central conclusion is that climate-smart agriculture (CSA) initiatives, while vital for enhancing agricultural resilience, do not automatically yield equitable nutritional benefits for households affected by HIV ([Nyamasoka-Magonziwa et al., 2025](#); [Oni et al., 2025](#)). The evidence indicates that without deliberate design, such programmes can prioritise staple crop yields over dietary diversification, failing to address the specific micronutrient needs and socioeconomic constraints imposed by the epidemic ([Matooane et al., 2025](#); [Maseribane et al., 2025](#)).

Consequently, the study argues that for the Lesotho context, a policy is only truly climate-smart if it is simultaneously HIV-responsive. This requires moving beyond sectoral silos to forge cross-sectoral frameworks that link agricultural, health, and social protection objectives ([Rakolobe, 2024](#); [Rashad et al., 2025](#)). Practical implementation must centre on integrating nutrition-sensitive objectives into CSA, promoting drought-resistant nutrient-dense crops, and leveraging renewable energy solutions to reduce labour burdens and post-harvest losses ([Agada, 2025](#); [Wamwea & Culas, 2024](#)). Furthermore, supportive measures are essential to overcome adoption barriers, including tailored financing mechanisms and social safety nets that address the capital and labour shortages prevalent in HIV-affected households ([Damane, 2025](#); [Omotayo et al., 2025](#)).

Future research should prioritise longitudinal studies to quantify the impact of integrated interventions on both agro-economic and health indicators, alongside comparative policy analyses within the Southern African Development Community (SADC) region to identify transferable models (Nkoko et al., 2025; Rusliyadi, 2025). Ultimately, navigating these convergent crises demands governance frameworks capable of orchestrating sustained multi-sectoral action. The path to sustainable development for Lesotho lies in policies that are co-designed to build systemic resilience, ensuring agricultural advancement translates into tangible improvements in the well-being of all Basotho, particularly those most vulnerable to the dual threats of climate change and HIV.

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REFERENCES

- Adeogun, S.O., Adebayo, O.A., Akintunde, M.A., Likoetla, P., Letela, R., Sethabathaba, A., Morie, M.P., & Shea, N.G. (2025). Adoption and Impact of Climate-Smart Agriculture Practices Among Vegetable Farmers in Maseru District, Lesotho. *Visegrad Journal on Bioeconomy and Sustainable Development* <https://doi.org/10.2478/vjbsd-2025-0003>
- Agada, J. (2025). Biotech-based Tools in Precision Agriculture for Climate-Smart Farming. *Biotechnology of Climate-Smart Agriculture in Food Security and Sustainable Farming* <https://doi.org/10.1201/9781003619284-7>
- Babaniyi, G.G., Ibrahim, F., & Akor, U.J. (2025). Integrating Renewable Energy in Climate-Smart Agriculture. *Biotechnology of Climate-Smart Agriculture in Food Security and Sustainable Farming* <https://doi.org/10.1201/9781003619284-10>
- Baig, S. (2024). Food and Water Security Through Climate-Smart Agriculture in Asia and Africa. *Climate-Smart and Resilient Food Systems and Security* https://doi.org/10.1007/978-3-031-65968-3_7
- Barwant, M.M., Singh, S., Singh, S., Dubey, V.K., Rani, J., & Singh, V. (2025). Climate-Smart Agriculture. *Biotechnology of Climate-Smart Agriculture in Food Security and Sustainable Farming* <https://doi.org/10.1201/9781003619284-2>
- Christine, D. (2025). The Impact of Climate variability on Household Food Security in Sub-Saharan Africa <https://doi.org/10.21203/rs.3.rs-7925462/v1>
- Dagar, J.C., & Gupta, S.R. (2025). Agroforestry: Climate-Smart Agriculture for Increased Resilience and Food Security in a Changing Climate. *Food Systems and Biodiversity in the Context of Environmental and Climate Risks* https://doi.org/10.1007/978-3-031-89167-0_5
- Damane, M. (2025). Quantile Regression Analysis of the Economic Impact of Business and Household Credit in Lesotho. *Modern Economy* <https://doi.org/10.4236/me.2025.168057>

- Izuafa, A., Oladoja, E.O., Sani, J., Izuafa, M., Bolaji, M.T., & Oyewole, O.A. (2025). Climate-Smart Agriculture and Food Waste Reduction. *Biotechnology of Climate-Smart Agriculture in Food Security and Sustainable Farming* <https://doi.org/10.1201/9781003619284-18>
- Khumalo, N.Z., Sibanda, M., & Mdoda, L. (2025). The effect of heterogeneous adoption of climate-smart agriculture practices on household food and nutrition security of small-scale urban crop farmers in eThekweni Municipality. *PLOS Climate* <https://doi.org/10.1371/journal.pclm.0000551>
- Matooane, L.S., Matamanda, A., Bhanye, J., & Nel, V. (2025). The Role of Urban Planning in Strengthening Urban Food Security in Africa: Insights from Lesotho, Zimbabwe and South Africa. *Urban Forum* <https://doi.org/10.1007/s12132-024-09530-5>
- Nkoko, N., Cronje, N., & Swanepoel, J. (2025). Addressing food and nutrition security challenges among the farming households in Lesotho: A cluster analysis. *African Journal of Food, Agriculture, Nutrition and Development* <https://doi.org/10.18697/ajfand.142.25100>
- Nyamasoka-Magonziwa, B., Simango, E., & Nezomba, H. (2025). Climate-smart crop production can support household food and nutrition security in urban communities in Chitungwiza, Zimbabwe. *Frontiers in Agronomy* <https://doi.org/10.3389/fagro.2025.1394893>
- Omotayo, A.O., Olagunju, K.O., Ogunniyi, A.I., & Hounnou, F.E. (2025). Climate-smart agricultural practices and food-nutrition security outcomes: insight from rural smallholder farmers. *Agriculture & Food Security* <https://doi.org/10.1186/s40066-025-00549-w>
- Oni, O.O., Olurinde, K.O., Agboola, L.W., & Babaniyi, G.G. (2025). Policy Frameworks for Scaling Up Climate-Smart Agriculture in sub-Saharan Africa. *Biotechnology of Climate-Smart Agriculture in Food Security and Sustainable Farming* <https://doi.org/10.1201/9781003619284-15>
- Oni, O.O., Iyiola, O.A., & Onkpe, M.A. (2025). Biotech-based Financial Models and Incentives for Climate-Smart Agricultural Investments in Africa. *Biotechnology of Climate-Smart Agriculture in Food Security and Sustainable Farming* <https://doi.org/10.1201/9781003619284-16>
- Oremo, B., Rotich, C., & Majiwa, E. (2025). Effect of Climate Smart Agriculture Adoption on Household Food and Nutrition Security in Lower Nyakach Division, Kisumu County, Kenya. *Journal of Poverty, Investment and Development* <https://doi.org/10.47604/jpid.3554>
- Rahman, M.A., & ul Abideen, Z. (2025). Rural Development and Role of Extension Workers for Climate-Smart Agriculture. *Climate Smart Agriculture for Future Food Security* https://doi.org/10.1007/978-981-96-4499-5_20
- Rakolobe, K.A. (2024). The Impact of the Lesotho Language Policies on Indigenous and Former Colonial Languages Usage in Public Domains in Lesotho. *The Palgrave Handbook of Language Policies in Africa* https://doi.org/10.1007/978-3-031-57308-8_29
- Ramalebo, K., Chifurira, R., Zewotir, T., & Chinhamu, K. (2025). Data to Decisions: leveraging penalized maximum likelihood estimation in agriculture. *Statistics Optimization & Information Computing* <https://doi.org/10.19139/soic-2310-5070-2285>
- Rashad, S., Emam, E.A.F., & El-Chaghaby, G.A. (2025). Climate-Smart Agriculture and Its Impact on Nutritional Security. *Biotechnology of Climate-Smart Agriculture in Food Security and Sustainable Farming* <https://doi.org/10.1201/9781003619284-17>
- Rusliyadi, M. (2025). Climate-Resistant Smart Agriculture Policy for Healthy and Safe Food Production to Support Food Security and Rural Development in Taiwan and Indonesia. *Climate-Resistant Smart Agriculture for Healthy Food Production* <https://doi.org/10.4018/979-8-3373-4827-8.ch005>

- Wamwea, A., & Culas, R.J. (2024). Enhancing Food Security Through Climate-Smart Agriculture in Kenya. Climate-Smart and Resilient Food Systems and Security https://doi.org/10.1007/978-3-031-65968-3_10
- Yuni, D.N., & Tsietsi, T. (2025). Part 1: Introduction – Chapter 1: An overview of the context of international trade in Lesotho. A compendium on international trade in Lesotho <https://doi.org/10.4102/aosis.2025.bk536.01>
- Maseribane, T., Leseba, N., & Lebuso, M. (2025). Part 3: The socio-economic and demographic contexts of international trade in Lesotho – Chapter 8: Demographic context of international trade in Lesotho. A compendium on international trade in Lesotho <https://doi.org/10.4102/aosis.2025.bk536.08>