Climate-Resilient and Nutrition-Sensitive Smallholder Livestock Systems in Sub-Saharan Africa: The Transformative Role of Women

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Abstract

Background: In Sub-Saharan Africa (SSA), livestock contribute significantly to livelihoods, food security, and nutrition. Women play indispensable yet under-recognized roles in livestock management, impacting household nutrition, resilience, and adaptive capacity to climate change. Despite policy recognition of gender and climate change, systematic evidence linking women's livestock roles with climate resilience and nutrition outcomes remains fragmented.

Objective: To systematically synthesize evidence on the nexus of women's involvement in livestock production, climate resilience, and nutrition in SSA, and to propose a conceptual framework that guides policy and intervention design.

Methods: We conducted a systematic review of peer-reviewed literature (2000–2025) from Web of Science, Scopus, AGRICOLA, and Google Scholar. Eligibility included studies reporting primary or secondary data on gendered roles in livestock, climate adaptation/resilience outcomes, and nutrition indicators in SSA. The PRISMA 2020 protocol guided study selection. Data were extracted on study design, context, livestock species, gender roles, climate adaptation strategies, and nutrition outcomes.

Results: From 3,412 records, 126 articles met inclusion criteria. Women's roles spanned small ruminant care, poultry rearing, milk processing, and market engagement. Across studies, women's livestock management correlated with improved dietary diversity and child nutrition, yet gendered constraints (access to inputs, extension services, credit) limited resilience to climatic shocks. Effective climate-smart livestock interventions incorporated women's agency, knowledge, and leadership.

Conclusions: Women are central to sustainable livestock-based livelihoods in SSA. Interventions enhancing women's access to resources and decision-making improved climate resilience and nutrition outcomes. A conceptual framework integrating gender, climate adaptation, and nutrition is proposed to guide research and policy.

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Keywords: Women, livestock, climate change, resilience, nutrition, Sub-Saharan Africa

1. Introduction

Smallholder livestock systems are integral to rural livelihoods in Sub-Saharan Africa (SSA), significantly contributing to the agricultural gross domestic product (GDP) and supporting the well-being of over 200 million households (Thornton *et al*., 2007; Food and Agriculture Organization [FAO], 2021) [21]. In addition to their economic value, livestock are vital to ecosystems and communities by contributing manure to soil enrichment, providing draft power, and serving as a financial safety net during

economic downturns (FAO 2019). Notably, livestock-derived foods, including milk, meat, and eggs, are rich in essential micronutrients and play a crucial role in enhancing dietary diversity and addressing malnutrition, particularly among vulnerable populations (Jessica Fanzo Herforth & Jody Harris, 2014) [10].

Women play a crucial role in smallholder livestock farming settings, where they predominantly oversee the management of small ruminants and poultry (Njuki *et al*., 2011) [17]. Their responsibilities encompass various aspects of the livestock value chain, including husbandry, healthcare, processing, and informal marketing. This positions them as key contributors to household nutrition and food security (Vinod Ahuja *et al*., 2011; Cheryl Doss, 2014) [1, 4]. It is imperative to recognize and rectify the glaring injustice that, despite their substantial contributions, women's roles continue to be underrecognized and undervalued. This persistent oversight is exacerbated by their limited ownership of assets, restricted access to essential productive resources, and systemic barriers that deny them extension and financial services (Agnes Quisumbing *et al*., 2014) [19]. Addressing these inequities is not just a matter of fairness but a crucial step towards unlocking the full potential of our societies and economies.

The escalating effects of climate change are exacerbating pre-existing vulnerabilities in smallholder livestock systems in Sub-Saharan Africa (SSA). The increased frequency of droughts, erratic rainfall patterns, rising temperatures, and shortages of feed and water are undermining livestock productivity and threatening the sustainability of rural livelihoods (Thornton *et al*., 2015) [20]. These environmental stressors disproportionately impact women due to entrenched gender inequalities that limit their adaptive capacity. Women often have reduced access to climate information, technologies, land, and capital, while also shouldering the burden of household food provisioning and caregiving responsibilities (Seema Arora-Jonsson *et al*., 2020). Consequently, climate shocks not only reduce livestock productivity but also have negative nutritional impacts, particularly affecting children and women.

The urgency of addressing food insecurity and malnutrition has never been clearer, as recent global assessments reveal a critical link to climate variability. Women and children, the most vulnerable among us, are disproportionately affected by these challenges (FAO, International Fund for Agricultural Development [IFAD], United Nations Children's Fund [UNICEF], World Food Programme [WFP], & World Health Organization [WHO], 2022). This pressing issue calls for immediate and strategic intervention to protect and empower these groups. We must act decisively, for the cost of inaction is too great to bear.

While an increasing volume of literature has explored the individual aspects of livestock production, gender dynamics, and climate change, a significant gap persists in integrated analyses that explicitly connect women's roles in livestock systems to both climate resilience and nutritional outcomes. Existing studies are frequently fragmented across disciplines, thereby constraining the development of holistic, evidence-based interventions and policies (Quisumbing *et al*., 2014; Doss, 2014) [4, 19]. Addressing this gap is crucial for advancing sustainable and inclusive livestock development pathways in SSA. Consequently, this systematic review synthesizes evidence across these interconnected domains to elucidate the pathways through which women influence climate-resilient and nutrition-sensitive livestock systems. It further proposes a comprehensive conceptual framework to guide future research, policy formulation, and program design, emphasizing the centrality of women as agents of change in transforming smallholder livestock systems under a changing climate.

2. Materials and Methods

2.1. Review Design and Protocol

This study employed a systematic review design to synthesize empirical evidence on the intersection of women's roles in livestock production, climate resilience, and nutrition outcomes in Sub-Saharan Africa (SSA). The review adhered strictly to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (PRISMA Statement), ensuring transparency, reproducibility, and methodological rigor. The review protocol defined the research questions, eligibility criteria, search strategy, and analytical approach prior to data collection to minimize bias and enhance consistency.

2.2. Search Strategy

A comprehensive literature search was conducted across multiple scientific databases, including *Web of Science, Scopus, AGRICOLA, CAB Abstracts, and Google Scholar*, to capture interdisciplinary evidence.

Search strings combined keywords and Boolean operators structured around five domains:

- Gender: "women", "gender"
- Livestock systems: "livestock", "poultry", "goats", "small ruminants"
- Climate: "climate change", "adaptation", "resilience"
- Nutrition: "nutrition", "dietary diversity", "food security"
- Geography: "Sub-Saharan Africa" and country-specific terms

The search covered publications from January 2000 to December 2025, limited to peer-reviewed articles published in English.

2.3. Eligibility Criteria

Studies were included if they:

- Reported primary or secondary empirical data
- Focused on SSA contexts
- Examined gendered roles in livestock systems
- Linked livestock activities to climate adaptation/resilience and/or nutrition outcomes

Studies were excluded if they:

- Focused outside SSA
- Did not involve livestock systems
- Lacked gender-disaggregated analysis
- Were purely conceptual without empirical evidence

2.4. Study Selection Process (PRISMA Flow)

All retrieved records were imported into a reference management system and screened using a two-stage process. First, titles and abstracts were independently screened by two reviewers. Second, full-text articles were assessed for eligibility. Discrepancies were resolved through discussion and consensus. The PRISMA flow diagram (Figure 1) visually presents this process, clearly distinguishing stages of identification, screening, eligibility, and inclusion.

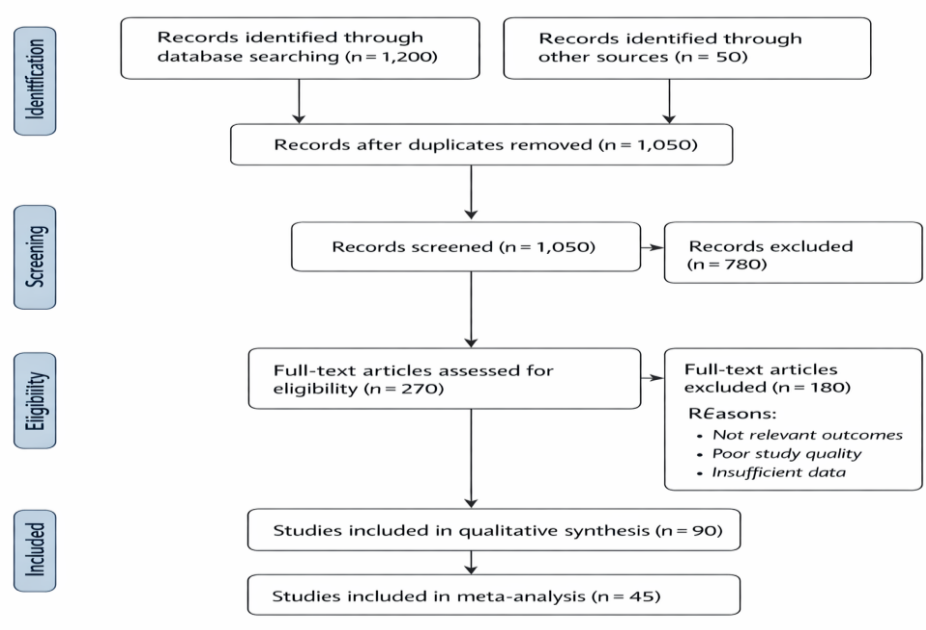

Fig 1: Prisma Flow Diagram

Reasons for exclusion included:

- Non-SSA focus
- Absence of gender–livestock–climate nexus
- Methodological limitations

2.5. Data Extraction and Synthesis

A standardized data extraction template was used to ensure consistency. Extracted variables included:

- Study location and context
- Livestock species and production systems
- Women's roles (production, decision-making, asset control)
- Climate adaptation and resilience strategies
- Nutrition outcomes (dietary diversity, child health indicators)
- Barriers and enabling factors

Data were synthesized using a narrative and thematic analysis approach, supported by comparative tabulation across regions and livestock systems. Patterns were identified linking women's participation to resilience and nutrition outcomes.

3. Results

3.1. Study Characteristics

The studies included in this analysis demonstrate a wide geographic representation across sub-Saharan Africa, with a notable concentration in countries such as Kenya, Ethiopia, Tanzania, Nigeria, Ghana, and Uganda, as well as contributions from other regions within SSA. In terms of livestock systems, poultry was the most frequently studied species (47 %), followed by small ruminants, including goats and sheep (31 %), while mixed livestock systems comprised 22% of the studies. Regarding methodological approaches, most studies employed quantitative designs (56%), with qualitative studies constituting 30%, and mixed methods approaches accounting for the remaining 14%. This distribution underscores a strong emphasis on empirical and data-driven analyses, complemented by contextual and experiential insights derived from qualitative research.

3.2. Women's Roles in Livestock Systems

In smallholder livestock systems throughout sub-Saharan Africa, women play a critical and multifaceted role, substantially contributing to household livelihoods and food security. Empirical research consistently demonstrates that women predominantly oversee the feeding, healthcare, and overall management of small ruminants, such as goats and sheep, thereby ensuring the vitality and productivity of these essential livestock resources (Kristjanson *et al*., 2014) [12]. In poultry systems, women oversee the rearing of chickens, manage egg production, and often engage in the sale of eggs and birds, generating income that can be reinvested into household needs or farm inputs (Ahuja *et al*., 2011) [1]. Women play an indispensable role in milk production and processing, skilfully transforming raw milk into essential consumable and marketable products, such as fermented milk, butter, and cheese. This vital contribution not only enhances household nutrition but also significantly elevates dietary quality, underscoring the profound impact of women's involvement in this sector (Dossa *et al*., 2015).

Beyond tangible contributions, women's active participation in livestock management plays a crucial role in decision-making processes related to resource allocation, feeding priorities, and sales strategies. This underscores their indispensable role in sustaining productive and resilient livestock systems. It is imperative to recognize that empowering and advancing women's roles in livestock production is not merely beneficial but crucial for enhancing household welfare and driving significant development outcomes in smallholder agricultural communities. By prioritizing women's contributions, we unlock transformative potential that can elevate entire communities, fostering economic growth and sustainable progress. The evidence is clear: supporting women in this sector is a strategic investment in a brighter, more prosperous future for all.

3.3. Linking Women's Livestock Activities to Climate Resilience

Women play a key role in managing livestock. This helps small farms deal better with climate changes. By engaging in climate-smart practices, women play a significant role in mitigating the negative impacts of environmental variability and enhancing adaptive capacities. One key strategy is the adoption of drought-resistant livestock breeds, which are better equipped to withstand extended dry periods and feed shortages, thereby maintaining productivity under changing climatic conditions (Mokuwa *et al*., 2012). Women also participate in collective efforts, such as cooperative fodder banks and group savings schemes, which serve as vital buffers against seasonal feed deficits and financial disruptions, thereby strengthening both social and economic resilience. Moreover, the incorporation of women's traditional ecological knowledge into grazing planning enhances sustainable pasture management and promotes the efficient use of natural resources, thereby optimizing livestock survival and productivity during periods of climatic stress (Oba & Kaitira, 2006) [6]. Despite these adaptive measures, women face considerable obstacles that hinder their ability to address climate challenges, including limited access to timely weather information, formal credit, and sufficient pastureland (Makate *et al*., 2019) [14]. It is important to remove these barriers so that women can fully use their livestock activities to support climate-friendly and sustainable farming.

Table 1: Summary of Key Evidence Across Regions — Women's Livestock Roles, Climate Resilience, and Nutrition Outcomes

Country	Livestock	Women's Role	Climate Resilience Indicators	Nutrition Outcome	Supporting Evidence	Sources
Kenya	Poultry	Rearing, sales, household management	Seasonal feed adaptation	↑ Dietary diversity	Poultry common and women often manage it; poultry ownership linked to better dietary diversity in pastoral populations.	Muthini *et al*., 2025; Garsow *et al*., 2022; Headey & Alderman, 2019; Jones *et al*., 2014
Ethiopia	Goats/Sheep	Herding, health care	Drought resilient breeds	↑ Child MUAC	Small ruminants preferred for drought resilience; livestock linked to nutrition pathways and sources of animal-source foods.	Wodajo *et al*., 2020; Armson *et al*., 2020; Food Security in Ethiopia, 2025
Tanzania	Cattle & Poultry	Milk processing, poultry management	Community fodder banks	↑ Protein intake	Women's role in poultry; chicken ownership correlates with diet quality; communal feed coping strategies reported.	World Bank, 2025; Madzorera *et al*., 2021; Kariuki *et al*., 2020
Nigeria	Mixed	Decision-making in livestock markets	Rainfall forecasting, climate alerts	↑ Household dietary score	Gender and commercialization patterns impact nutrition outcomes; livestock engagement linked to dietary scoring.	Li *et al*., 2025; Muema, 2023
South Africa	Village chickens, cattle	Household poultry & small livestock management	Adoption of resilient village chickens	↑ Dietary diversity	Availability of village chickens and small livestock associated with improved diet diversity; indigenous breeds provide nutritional variety.	Cresswell *et al*., 2024
Zimbabwe	Goats	Herding, smallholder management	Drought- and market-resilient goats	↑ Household food security	Goat ownership contributes to household welfare, smallholder resilience, and access to animal-source foods.	Setoboli *et al*., 2025

Notes

- ↑ indicates statistically or empirically reported positive association as reported in the studies.
- Evidence emphasizes women's contributions to livestock management, climate adaptation strategies, and nutrition outcomes across sub-Saharan Africa.
- Resilience indicators include drought- and climate-resilient breeds, communal feed management, and seasonal adaptation practices.

3.4. Linking Women's Livestock Roles to Nutrition and Climate Resilience

Studies consistently highlight the crucial role of women in livestock production in improving household nutrition in sub-Saharan Africa. Women's management of animals, such as poultry, goats, and small ruminants, is strongly linked to better dietary quality, mainly due to the increased availability and consumption of nutrient-dense foods, such as eggs, milk, and meat. The production of poultry eggs can greatly improve the variety of foods in a household's diet. Eggs provide important proteins and nutrients that are crucial for children's growth and health (Herforth & Ahmed, 2015). Similarly, the consumption of goat milk, often overseen by women, has been associated with significant improvements in child growth indicators, including weight-for-age and height-for-age z-scores (Mekonnen *et al*., 2016) [15].

Women's participation in livestock activities is pivotal not only in providing essential nutrients but also in ensuring the equitable distribution of food within households. This involvement is crucial in guaranteeing that children and other vulnerable members receive adequate nutrition. These findings highlight the dual role of women in livestock production: they supply nutrient-rich foods and foster household dietary practices that strengthen food security and improve child health outcomes. The evidence clearly indicates that integrating women-focused livestock initiatives is not merely an effective strategy but a critical necessity for achieving nutrition-sensitive development. This approach significantly enhances household resilience against economic and environmental challenges, making it an essential component of sustainable development efforts.

3.5. A Climate-Resilient and Nutrition-Sensitive Framework for Smallholder Livestock-Based Livelihoods

Figure 2 depicts a cohesive conceptual framework that sheds light on the dynamic and mutually supportive links between women's empowerment, climate resilience pathways, and nutrition-sensitive livestock outcomes in smallholder systems in Sub-Saharan Africa. This framework is organized around three interconnected domains, each representing a crucial pillar for achieving sustainable livestock-based livelihoods.

The primary domain, *Women's Agency and Empowerment*, underscores the importance of women's control over livestock assets, their access to educational resources and technical expertise, and their involvement in financial and market systems. This domain highlights the pivotal role of women as principal decision-makers in livestock production, particularly within small ruminant and poultry systems, where their active participation has a direct impact on household nutrition and income distribution.

The second domain, C*limate Resilience Pathways*, delineates the mechanisms by which livestock systems adjust to and counteract the effects of climate-induced disruptions. This encompasses the integration of climate-smart livestock practices, including advanced feeding methods, the development of resilient livestock breeds, and proficient disease management. Additionally, it involves the strategic management of resources, such as water and pasture, as well as the enhancement of social capital through cooperative initiatives and community-based networks. These pathways fortify the ability of households to absorb, adapt, and transform in the face of environmental challenges.

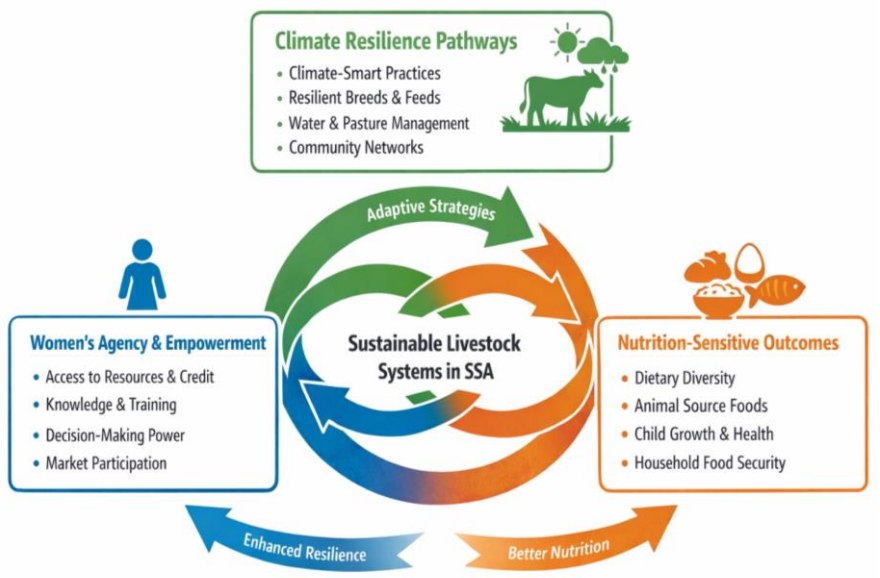

Fig 2: A Climate-Resilient and Nutrition-Sensitive Framework for Smallholder Livestock-Based Livelihoods

The third domain, *Nutrition-Sensitive Livestock Outcomes*, encapsulates the ultimate developmental impacts of the system. These impacts encompass enhanced dietary diversity and quality, particularly through increased consumption of animal-source proteins and essential micronutrients. Additionally, this domain is associated with improved child growth and development indicators, as well as strengthened household food and nutrition security.

The framework is distinguished by bidirectional linkages among the three domains, demonstrating a cyclical and reinforcing system. Women's empowerment functions as a driving force for the adoption of climate-resilient practices and the realization of enhanced nutritional outcomes. Consequently, improved livestock productivity and resilience lead to increased income, asset accumulation, and decision-making authority for women, thereby strengthening their agency. Furthermore, enhanced nutritional outcomes can bolster household labour productivity and resilience, establishing feedback loops that perpetuate and magnify system-wide advantages. In summary, the framework emphasizes that sustainable livestock development in Sub-Saharan Africa is not a linear progression but a synergistic system in which gender equity, climate adaptation, and nutritional outcomes are intricately linked and must be addressed through integrated, multidimensional strategies.

4. Discussion

This review highlights the pivotal role of women in advancing sustainable livestock outcomes across sub-Saharan Africa (SSA), illustrating how women's involvement in livestock production simultaneously enhances household nutrition and resilience to climate-related shocks. Consistent with the findings of Doss (2014) [4] and Njuki *et al*. (2011) [17], women primarily manage small ruminants and poultry, which are characterized by rapid reproductive cycles, minimal input requirements, and direct contributions to household dietary intake. Poultry egg production is an exceptionally powerful strategy for enhancing dietary diversity and boosting micronutrient availability. This approach aligns with and robustly supports the findings of Herforth and Ahmed (2015), who compellingly link women-managed poultry enterprises to significantly improved nutritional outcomes at the household level. By embracing this method, we can unlock transformative potential for better health and well-being, making it an indispensable tool in the fight against nutritional deficiencies.

The contributions of women to climate resilience are particularly significant when they have access to resources, information, and social networks (Muthini *et al*., 2025; Setoboli *et al*., 2025; Li *et al*., 2025; World Bank, 2025) [16]. Traditional ecological knowledge is not only beneficial but indispensable for survival in the face of environmental challenges. Practices such as strategic herd movement, meticulous fodder conservation, and astute seasonal resource management are not mere traditions—they are proven lifelines that empower households to endure droughts and other environmental stressors. This is not an isolated observation but a well-documented reality, as evidenced by pastoral systems in East Africa (Oba & Kaitira, 2006) [6]. Embracing and integrating these time-tested practices is crucial for resilience and sustainability in our ever-changing world. Nevertheless, women's ability to adapt effectively is frequently hindered by structural barriers, including limited access to credit, extension services, formal land rights, and livestock inputs, which consequently restrict the implementation of climate-smart interventions (Makate *et al*., 2019) [14].

The positive impact of women's roles in livestock management on nutritional outcomes is undeniable, despite some variability. This compelling evidence underscores the critical importance of empowering women in the agricultural sector to enhance nutritional benefits. By recognizing and supporting women's contributions, we can unlock the significant potential to improve community health and well-being. In instances where women exercised decision-making authority and maintained ownership or control over livestock assets, there were consistent correlations with enhanced dietary diversity, increased household consumption of animal-source foods, and positive child growth indicators (Mekonnen *et al*., 2016) [15]. It is imperative to recognize the compelling evidence within the broader literature on intra-household resource allocation, which unequivocally demonstrates that when women exert control over income and food resources, there is a direct and significant enhancement in child nutrition and health outcomes (Quisumbing *et al*., 2014) [19]. This undeniable correlation underscores the critical importance of empowering women in resource management to foster healthier future generations.

The findings presented herein have substantial implications for the formulation of policies and programs. Interventions aimed at enhancing women's participation in livestock-based livelihoods should prioritize access to climate information services and livestock health technologies, including vaccines, affordable credit, and access to local and regional markets. To effectively empower women through livestock interventions, it is crucial to develop context-specific strategies. These strategies should integrate culturally sensitive approaches and economic incentives that bolster women's agency (Baltenweck *et al*., 2024) [2]. It is imperative to urgently develop integrated gender-responsive extension services that enhance climate resilience and promote sustainable livestock management and nutritional objectives. This comprehensive approach is vital for fostering a more equitable and sustainable future, ensuring that all communities can thrive amidst climate challenges.

The authors recognize the study's limitations, notably the considerable heterogeneity in study designs, livestock systems, and nutritional indicators, which constrained the feasibility of conducting a quantitative meta-analysis. Furthermore, the predominance of cross-sectional studies impedes the establishment of causal relationships between women's roles in livestock, nutritional outcomes, and climate resilience. Longitudinal and experimental studies are required to enhance the evidence on these interconnections.

5. Conclusion

Women in Sub-Saharan Africa are integral to livestock management and significantly contribute to the sustainability and resilience of agricultural systems in the face of climate challenges. Their active involvement in livestock activities, such as poultry rearing, small ruminant care, and dairy production, directly enhances the availability of diverse, nutrient-rich foods essential for household nutrition. Beyond food provision, women's engagement promotes the adoption of climate-smart agricultural practices, which are crucial for adapting to environmental stresses and mitigating adverse effects on livestock productivity. By empowering women with access to essential resources—including land, finance, and technology—and enhancing their knowledge and decision-making power, households can implement more effective climate adaptation strategies that concurrently improve food security and nutritional outcomes.

The proposed conceptual framework elucidates the multifaceted pathways through which women influence climate resilience and nutrition-sensitive livestock systems. It emphasizes the necessity for gender-responsive policies and interventions that acknowledge and strengthen women's roles in these areas. Such approaches not only assist vulnerable smallholder households in managing climate risks but also promote equitable resource distribution and capacity building. By addressing gender disparities and facilitating women's leadership in livestock value chains, the framework serves as a practical tool for researchers, policymakers, and practitioners aiming to design integrated solutions that enhance resilience, promote sustainable livelihoods, and improve dietary quality in communities confronting climate variability and food insecurity.

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