



Gender-Specific Labour Dynamics in Zambian Livestock Production: Empirical Evidence

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ABSTRACT: This study investigates gender-specific labour dynamics in Zambia's livestock sector, a critical yet underexplored dimension of agricultural production and rural livelihoods. Drawing on World Development Indicators (1990–2024), the analysis applies an Autoregressive Distributed Lag (ARDL) framework to assess the impact of men's and women's labour contributions on livestock productivity. Results reveal that female employment in agriculture exerts a significant positive effect on livestock production in the long run, underscoring women's indispensable role in sustaining daily animal care and management. However, women's unpaid contributions as family workers, though essential for short-term operations, do not translate into long-term productivity gains, largely due to structural exclusion from decision-making and limited access to land, credit, and extension services. Male employment in agriculture and both male and female family labour show stronger short-run effects, reflecting men's influence in market-oriented tasks and household labour's role in immediate livestock upkeep. Control variables such as agricultural land and cereal yield further reinforce productivity linkages through feed availability and grazing space. Policy implications highlight the urgent need for gender-sensitive livestock policies that enhance women's access to productive resources, formally recognize unpaid labour, and promote equitable participation.

Keywords: Agriculture, gender, labour dynamics, livestock production, Zambia

1. INTRODUCTION

Livestock production is a cornerstone of Zambia's agricultural economy and rural livelihood systems. It contributes significantly to food security, household income, and wealth accumulation, while also performing important non-market functions such as risk mitigation and cultural identity preservation. Over 70 percent of smallholder farmers in Zambia keep some form of livestock, often under low-input, labour-intensive systems that integrate animals into broader livelihood strategies. Livestock are not only valued for their direct outputs such as milk, meat, and manure but also serve as financial assets, providing a buffer against agricultural shocks and acting as collateral in times of need (Volk & Walubita, 2024). Cattle, goats, and pigs further occupy a symbolic role in social relations, being used in marriage transactions, rituals, and community exchanges. These diverse roles position livestock production at the heart of both economic survival and cultural life, making it a critical sector for development interventions (Dutilly et al., 2020; Mumba et al., 2024).

However, the organization of livestock production is not gender-neutral. Gender shapes who contributes labour, who controls resources, and who reaps the benefits of production. In many Zambian households, men and women participate differently in livestock activities, with their roles determined by cultural norms, intra-household bargaining power, and institutional structures (Mulungu & Mudege, 2020; Namonje-Kapembwa et al., 2022). Men typically control ownership of cattle and other high-value animals, as well as decision-making over sales and income use. Women, in contrast, are heavily involved in daily tasks such as watering, feeding, grazing, milking, and caring for small livestock, particularly goats (Nyanga et al., 2020). These activities are indispensable for maintaining animal health and productivity, yet they are rarely recognized as economically significant or adequately compensated. The undervaluation of women's labour reflects a wider patriarchal framework in which men's contributions are more visible, while women's efforts remain largely invisible despite their importance to household food security and welfare (Clay & Yurco, 2024).

Structural barriers compound these inequalities. Women's access to land remains limited, often mediated through male relatives or restricted by customary tenure systems. Credit and financial services are similarly skewed in favor of men, constraining women's ability to invest in livestock expansion or commercialization (Brixiova et al., 2020; Nanziri, 2020). Agricultural extension services, which could provide knowledge and technical support, are often designed without consideration of women's needs, time constraints, or literacy levels (Adebayo & Worth, 2024). As a result, women are excluded from training opportunities that could enhance productivity. Such disparities perpetuate a cycle of marginalization: women contribute significantly to livestock management but are denied access to the resources and decision-making structures that would allow them to benefit fully from their labour (Burke et al., 2018; Nyanga et al., 2020).

While the gendered nature of agriculture in sub-Saharan Africa has been widely acknowledged (Sibanda, 2025), livestock-specific studies in Zambia remain relatively scarce. Much of the existing literature focuses on crop production (Siatwiinda et al., 2021; Wittmann & Malesu, 2024), with less systematic attention given to livestock systems despite their importance (Odubote, 2022; Siankwilimba et al., 2024). Where studies on livestock do exist, they are often descriptive, highlighting gender roles in general terms but not rigorously linking these dynamics to productivity outcomes (Alobo Loison



& Hillbom, 2020; Farnworth et al., 2015). This gap limits the ability of policymakers to design evidence-based interventions that respond to the realities of men's and women's labour contributions. Without robust empirical evidence, policies risk reinforcing existing inequalities by focusing on technical solutions while neglecting the social relations that underpin production.

The absence of empirical analysis is particularly problematic given the persistence of rural poverty and the centrality of livestock to poverty alleviation strategies. For many rural households, livestock are both an asset and a source of daily sustenance. However, if women—who perform much of the routine labour—remain systematically excluded from decision-making and resource control, the transformative potential of livestock production for poverty reduction and women's empowerment is undermined (Acosta et al., 2024; Nyanga et al., 2020). Bridging this gap requires moving beyond general discussions of gender inequality toward a more precise understanding of how gender-specific labour patterns influence livestock production outcomes.

Addressing this issue also carries important policy implications. Zambia, like many countries in the region, has embraced gender mainstreaming in agriculture, reflected in policies that promote women's participation in cooperatives, training programs, and land ownership (Mwalupaso et al., 2025; Wang et al., 2025). Donor-driven initiatives have introduced women's empowerment projects, joint land titling, and gender-responsive extension models. Yet, the impact of such initiatives remains mixed. Deeply embedded socio-cultural norms often limit women's actual agency even when formal rights are granted (Nakray & Kafukanya, 2019; Sommerville et al., 2022). For example, land registration in women's names does not necessarily translate into effective control over its use, while training programs may fail to account for women's limited mobility and heavy care responsibilities (Carney & Carney, 2018; Umar et al., 2023). The persistence of these challenges underscores the need for policies grounded in robust, context-specific evidence.

This study responds to these gaps by examining gender-specific labour dynamics in Zambia's livestock sector through an empirical lens. It seeks to illuminate how the organization of labour along gender lines influences livestock production outcomes and to uncover the socio-economic and cultural factors that sustain inequalities. In doing so, the study focuses directly on how gendered divisions of work and decision-making affect livestock productivity and household welfare, highlighting both the constraints and potential pathways for more inclusive livestock development.

The contribution of this research is twofold. First, it provides empirical evidence on the relationship between gendered labour allocation and livestock production outcomes in Zambia, thereby filling a critical gap in the literature. While many studies acknowledge gender disparities in agriculture, few have systematically quantified their implications for livestock productivity (Abdisa et al., 2024; Miriti et al., 2023; Ojo & Baiyegunhi, 2023). Second, it generates policy-relevant insights by demonstrating how gender-responsive strategies can strengthen both productivity and equity within the sector. By emphasizing the influence of gendered divisions of labour, decision-making, and resource access on livestock outcomes, the study highlights that sustainable livestock development in Zambia depends on addressing persistent gender inequalities.

Ultimately, the findings aim to inform debates on agricultural transformation and gender equity by demonstrating that livestock production is not only an economic activity but also a social process shaped by power relations and social norms. Recognizing and addressing gender-specific labour dynamics is therefore essential for designing interventions that are both effective and equitable. In doing so, this research contributes to the broader goal of fostering inclusive rural development in Zambia, where livestock production can serve as a vehicle for poverty alleviation, women's empowerment, and sustainable economic growth.

2. LITERATURE REVIEW

A substantial body of literature documents persistent gender disparities in agricultural production across sub-Saharan Africa. Women supply a large share of agricultural labour, particularly within smallholder systems, yet continue to experience lower productivity and economic returns compared to men (Burke et al., 2018; Ojo & Baiyegunhi, 2023). These disparities are widely attributed to structural inequalities in access to productive resources rather than differences in effort, skills, or preferences. Women face systematic constraints in land ownership, access to credit, extension services, and market participation, which limit the productivity of their labour inputs (Brixiová et al., 2020; Clay & Yurco, 2024).

From a gender economics perspective, men's and women's labour inputs are not perfectly substitutable due to socially embedded norms, task specialization, and intra-household bargaining arrangements. Women are typically concentrated in routine, labour-intensive activities that sustain daily production, while men dominate strategic and market-oriented functions associated with higher returns (Farnworth et al., 2015; Miriti et al., 2023). As a result, women's labour—particularly when unpaid or informal—is frequently undervalued in both policy frameworks and empirical models, despite its central role in household food security and livelihood resilience.

Household production theory provides further insight into these dynamics by emphasizing that output depends not only on labour quantity but also on access to complementary inputs such as land, technology, and institutional support. When labour is supplied under conditions of limited resource access, its marginal productivity is reduced. This framework is especially relevant



in gendered agricultural contexts, where women often provide substantial labour but lack control over key productive assets, constraining their ability to influence long-run productivity outcomes.

Within this broader literature, livestock production has received comparatively limited gender-disaggregated empirical attention, despite its importance for rural livelihoods and poverty reduction. Existing studies suggest that livestock systems are deeply gendered in terms of labour allocation, ownership, and decision-making authority (Dutilly et al., 2020; Odubote, 2022). In Zambia and similar contexts, men typically control high-value livestock such as cattle and dominate decisions related to sales and income use, while women are heavily involved in daily animal management, including feeding, watering, cleaning, milking, and care of small livestock such as goats and poultry (Namonje-Kapembwa et al., 2022; Nyanga et al., 2020).

Although women's contributions are critical for maintaining animal health and survival, much of this labour is unpaid and classified as contributing family work, limiting its recognition as a productive input with sustained returns (Naz et al., 2022). Evidence from Zambia indicates that growth in smallholder livestock systems relies heavily on household labour, yet gender-specific productivity effects are rarely quantified (Alobo Loison & Hillbom, 2020). Where gender is considered, analyses are often descriptive, focusing on roles and constraints rather than empirically linking labour inputs to livestock productivity.

Institutional constraints play a central role in mediating the productivity of gendered labour in livestock systems. Women's limited access to land under customary tenure arrangements restricts herd expansion, investment in improved breeds, and secure access to grazing resources (Burke et al., 2018; Umar et al., 2023). Financial exclusion further constrains women's ability to adopt productivity-enhancing technologies, even when they supply a substantial share of labour (Mwalupaso et al., 2025; Nanziri, 2020). Agricultural extension services also tend to be gender-biased, often failing to reach women due to program designs that overlook women's time constraints, mobility limitations, and lower literacy levels (Adebayo & Worth, 2024). Consequently, women's labour may sustain production in the short run but fails to translate into long-term productivity gains in the absence of supportive institutions.

Beyond labour inputs, livestock productivity is influenced by broader structural factors. Agricultural land availability affects grazing capacity and fodder production, while crop–livestock linkages—particularly cereal yields—enhance feed availability through crop residues and by-products (Siatwiinda et al., 2021; Volk & Walubita, 2024). Poverty further constrains households' ability to invest in animal health services, improved feed, and husbandry practices, reinforcing reliance on household labour and perpetuating gendered inequalities (Acosta et al., 2024).

Despite widespread acknowledgment of gender disparities in agriculture, empirical evidence linking gender-specific labour dynamics to livestock production outcomes in Zambia remains limited. Prior research has largely overlooked distinctions between paid employment and unpaid contributing family labour, thereby obscuring critical pathways through which labour affects productivity. This study employs a time-series Autoregressive Distributed Lag (ARDL) framework to examine both short- and long-run effects of male and female labour inputs—including unpaid contributions—on livestock productivity. By highlighting the interaction between gendered labour, institutional constraints, and structural factors, the analysis advances the literature on gender and agricultural productivity, providing empirically grounded insights to inform gender-responsive livestock and agricultural policy design.

2.1 Theoretical Framework

This study is informed by household production theory, gender economics, and institutional constraints theory to explain the relationship between gender-specific labour dynamics and livestock production in Zambia. Household production theory conceptualizes livestock output as a function of labour inputs, land, and complementary resources, where productivity depends on both labour allocation and access to productive assets. Gender economics emphasizes that men's and women's labour contributions are differentiated by social norms, task specialization, and intra-household bargaining power, implying that labour inputs are not perfectly substitutable. Women's labour is predominantly concentrated in routine livestock management, while men are more involved in strategic and market-oriented activities.

Institutional constraints theory highlights how unequal access to land, credit, and extension services limits the ability of women's labour—particularly unpaid family work—to translate into sustained productivity gains. Conceptually, livestock production is influenced by gender-disaggregated labour inputs and conditioned by agricultural land availability, cereal yields, and poverty levels, with distinct short-run and long-run effects shaped by structural and institutional factors (see Figure 1).

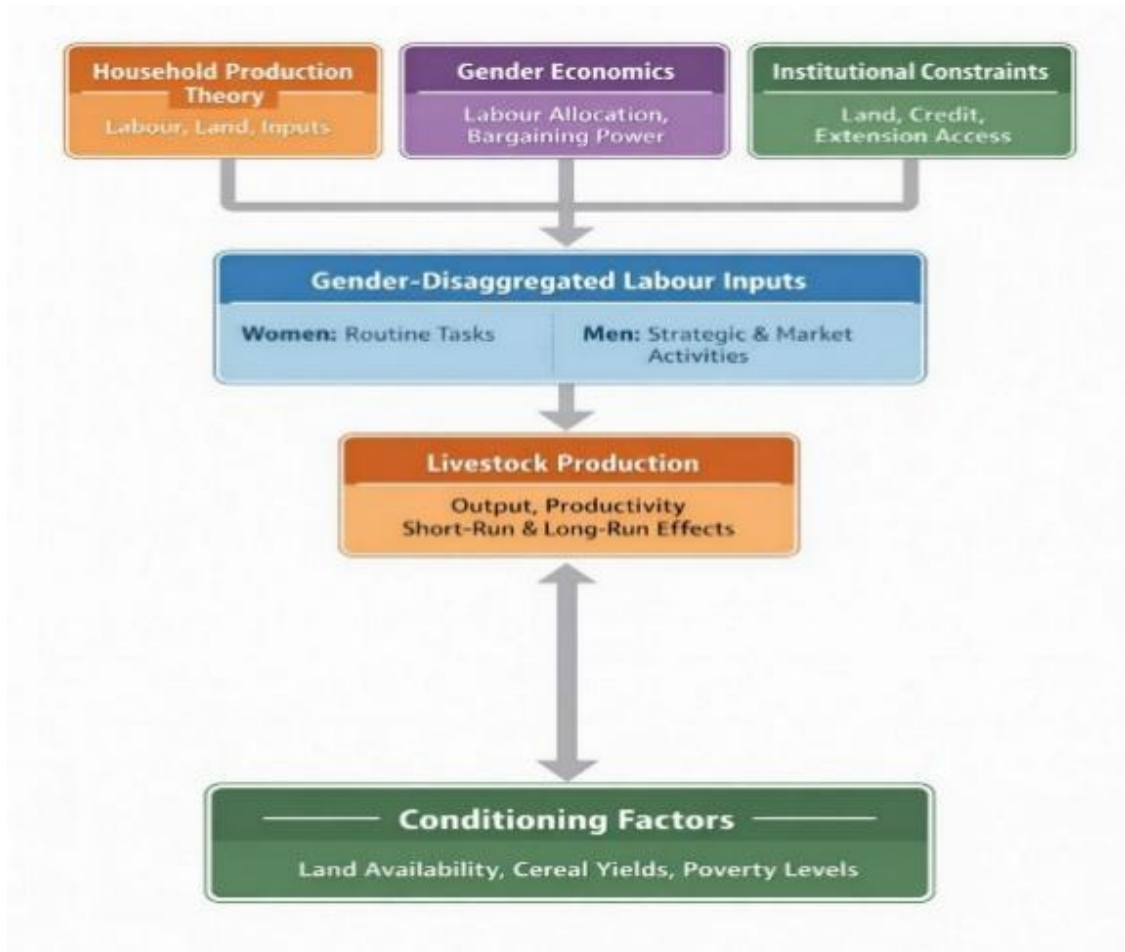


Figure 1-Conceptual framework: Gender-Specific Labour in Livestock Production
Source: Created by the authors

3. MATERIALS AND METHODS

3.1 Data and variable definition

The study uses time series data from 1990 to 2024 obtained from the World Development Indicators (WDI). This period was selected based on data availability, policy relevance, and econometric considerations, providing consistent and reliable indicators for Zambia. It captures major structural and policy changes, including economic liberalization in the 1990s and the introduction of gender mainstreaming initiatives in agriculture from the 2000s. The 35-year window allows for robust time-series analysis, including cointegration, and error correction modelling, while assessing long-term trends and recent policy impacts on gender-specific labour dynamics and livestock production.

Variables are classified into dependent, independent, and control variables. The dependent variable is the Livestock Production Index (LPI), measuring changes in livestock output over time. Independent variables capture gender-specific labour dynamics, including female and male employment and contributing family workers. Control variables account for socio-economic factors such as agricultural land, cereal yield, and the poverty headcount ratio. Table 1 provides definitions and sources.



Table 1: Description of study variables

Variable	Definition	Description	Source
<i>Dependent variable</i>			
Livestock Production Index (LPI)	Index of livestock output	Measures changes in livestock production over time.	WDI
<i>Independent variables</i>			
Employment in Agriculture, Female (EAF)	% of female employment	Share of employed women working in agriculture. Captures women’s labour participation in the sector.	WDI
Employment in Agriculture, Male (EAM)	% of male employment	Share of employed men working in agriculture. Provides a gendered comparison of labour allocation.	WDI
Contributing Family Workers, Female (CFWF)	% of female employment	Women employed as unpaid or contributing family labourers in agriculture.	WDI
Contributing Family Workers, Male (CFWM)	% of male employment	Men employed as unpaid or contributing family labourers.	WDI
<i>Control variables</i>			
Agricultural Land (AL)	% of land area	Proportion of total land area used for agriculture.	WDI
Cereal Yield (CY)	Kg per hectare	Average cereal output per hectare of harvested land.	WDI
Poverty Headcount Ratio (PHR)	% of population	Share of population living below \$3.00/day poverty line.	WDI

3.2 Unit root test

To ensure the reliability of the time series analysis, the study employs the Augmented Dickey-Fuller (ADF) test to examine the stationarity of all variables. Stationarity is critical to avoid spurious regression results, as non-stationary data can lead to misleading inferences. The ADF test augments the basic Dickey-Fuller equation by including lagged differences of the variable to control for autocorrelation, expressed as:

$$\Delta Y_t = \alpha + \beta_t + \gamma Y_{t-1} + \sum_{i=1}^p \delta_i \Delta Y_{t-i} + \varepsilon_t$$

- (1) where ΔY_t is the first difference of the variable, t is a time trend, p is the number of lags, and ε_t is the error term. Variables that are non-stationary at levels are differenced until stationarity is achieved, guiding appropriate model specification.

3.3 Empirical Model and Model Specification

This study employs the Autoregressive Distributed Lag (ARDL) bounds testing approach to investigate the impact of gender-specific labour dynamics on livestock production in Zambia. The ARDL method is suitable for this analysis as it accommodates variables with different integration orders (I(0) and I(1)), captures both short-run and long-run relationships, and is robust to small sample sizes (Chandio et al., 2019).

The dependent variable is the Livestock Production Index (LPI), while the independent variables include female and male employment in agriculture and female and male contributing family workers. Control variables—agricultural land, cereal yield, and poverty headcount ratio—are also incorporated.

Following the unit root test via the Augmented Dickey-Fuller (ADF) method, the optimal lag length for the ARDL model was determined using the Akaike Information Criterion (AIC). The ARDL model is specified as:

$$\Delta LPI_t = \alpha + \sum_{i=1}^p \beta_i \Delta LPI_{t-i} + \sum_{j=0}^q \gamma_j \Delta X_{t-j} + \phi_1 LPI_{t-1} + \phi_2 X_{t-1} + \varepsilon_t$$



- (2) where LPI_t is the dependent variable, X_t represents the vector of independent and control variables, Δ is the first difference operator, p and q are optimal lags, ϕ_1 and ϕ_2 are long-run coefficients, and ε_t is the error term.

The ARDL bounds test was applied to determine the existence of a long-run relationship between LPI and the explanatory variables. Once cointegration was confirmed, the long-run coefficients were estimated as:

$$LPI_t = \alpha + \beta_1 X_{1t} + \beta_2 X_{2t} + \dots + \varepsilon_t$$

- (3) To capture short-run dynamics and adjustment toward long-run equilibrium, an Error Correction Model (ECM) was formulated:

$$\Delta LPI_t = \delta_0 + \sum_{i=1}^p \delta_i \Delta LPI_{t-i} + \sum_{j=0}^q \theta_j \Delta X_{t-j} + \lambda EC_{t-1} + \eta_t$$

- (4) Here, EC_{t-1} is the lagged error correction term derived from the long-run relationship, and γ measures the speed of adjustment toward equilibrium. A negative and statistically significant γ confirms convergence to the long-run path.

4. RESULTS AND DISCUSSIONS

Table 2 presents the descriptive statistics for variables used in analyzing gender-specific labor dynamics in Zambian livestock production. The data, based on 35 observations, highlight both agricultural and labour-related indicators. Agricultural Land (AL) averages 30.78 percent, while the Livestock Production Index (LPI) records a mean of 72.49, reflecting moderate livestock activity. Cereal Yield (CY) shows considerable variation, with a mean of 2044.52 kg per hectare. The Poverty Headcount Ratio (PHR) stands at 59 percent, underscoring persistent poverty. Gender-disaggregated employment data reveal that women dominate agricultural employment (EAF, 65.25%) compared to men (EAM, 59.63%). Contributing family workers are more prevalent among women (12.84%) than men (4.27%).

Table 2: Descriptive statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Agricultural Land (AL)	35	30.78	1.34	27.99	32.07
Livestock Production Index (LPI)	35	72.49	28.65	33.77	113.28
Cereal Yield (CY)	35	2044.52	545.20	763.10	3026.40
Poverty Headcount Ratio (PHR)	35	59.00	4.97	56.10	62.79
Employment in Agriculture, Female (EAF)	35	65.25	5.17	56.02	72.86
Employment in Agriculture, Male (EAM)	35	59.63	5.35	51.74	65.30
Contributing Family Workers, Female (CFWF)	35	12.84	5.02	3.77	17.82
Contributing Family Workers, Male (CFWM)	35	4.27	1.17	1.48	5.38

The graph in Figure 2 illustrates changes in Zambia’s livestock production over the period 1990–2022. Between 1990 and 1995, LPI remained relatively stable (33.8–41.8), reflecting low productivity due to limited access to inputs, traditional livestock management practices, and socio-economic constraints. From 1996 onwards, LPI increased steadily, with marked gains from 2008 to 2014, peaking at 111.3 in 2014. These increases coincide with policy reforms, expansion of veterinary and extension services, and improved access to feed and husbandry techniques. Short-term declines or fluctuations, such as in 2015–2016, may be attributed to climatic shocks, disease outbreaks, and market disruptions, while the subsequent recovery reflects adaptive management, government interventions, and investment in livestock systems. Overall, the trend demonstrates gradual long-term improvement in livestock productivity, punctuated by short-term variations driven by environmental, institutional, and economic factors.

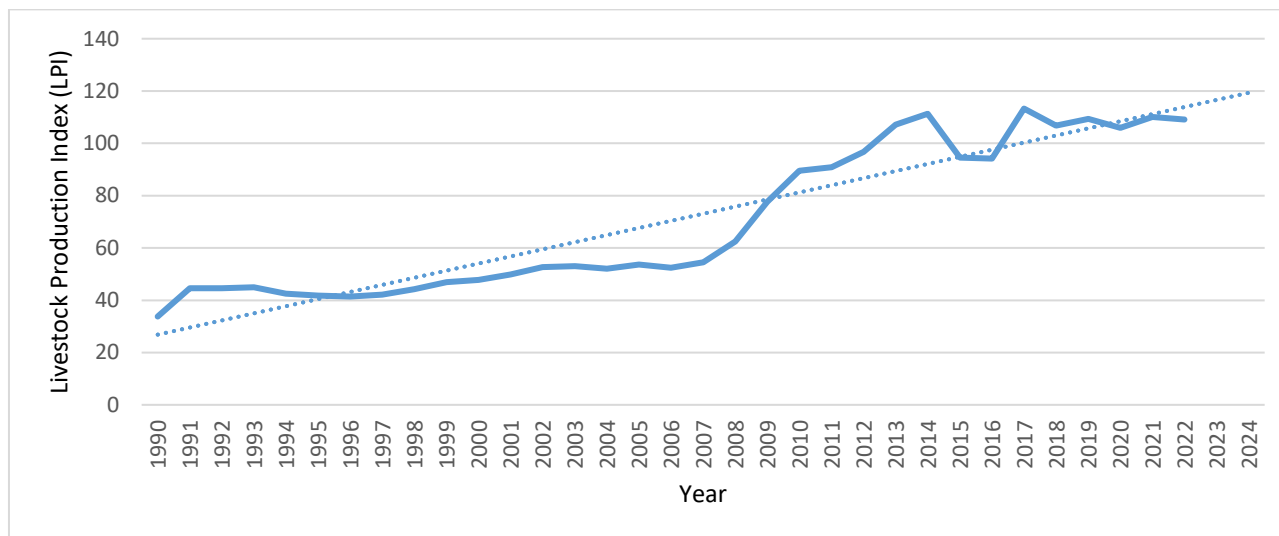


FIGURE 2: Livestock production index for Zambia between 1990 and 2024. Source: Author’s computation based on World Development Indicators (WDI) data (<https://data.worldbank.org/indicator>).

4.1 Unit Root Test results

Prior to estimating the ARDL model, it was essential to verify the stationarity of all variables to ensure reliable results. The augmented Dickey-Fuller (ADF) test was employed to determine whether each variable is stationary at level (I(0)) or becomes stationary after first differencing (I(1)), with none integrated of order two, I(2). Table 2 summarizes the results. The findings indicate that some variables, such as Agricultural Land and Cereal Yield, were stationary at their original levels, while others, including Livestock Production Index, Employment in Agriculture (Female), Employment in Agriculture (Male), Contributing Family Workers (Female), Contributing Family Workers (Male), and Poverty Headcount Ratio, became stationary only after first differencing, confirming their suitability for the ARDL bounds testing approach. See Table 3.

Table 3: Unit root test results

Variables	p<0.001	Order of Integration	Conclusion
Livestock Production Index (LPI)	p<0.001	1	I(1)
Employment in Agriculture, Female (EAF)	p<0.001	1	I(1)
Employment in Agriculture, Male (EAM)	p<0.001	1	I(1)
Contributing Family Workers, Female (CFWF)	p<0.001	1	I(1)
Contributing Family Workers, Male (CFWM)	p<0.001	1	I(1)
Agricultural Land (AL)	p<0.001	0	I(0)
Cereal Yield (CY)	p<0.001	0	I(0)
Poverty Headcount Ratio (PHR)	p<0.001	1	I(1)

4.2 Long- and Short-Run Estimation of Parameters

The estimated long run and short-run coefficients from the ARDL model, presented in Table 4, provide empirical evidence of the effects of gender-disaggregated labour dynamics and structural controls on livestock production in Zambia.

4.2.1 Long-run estimations

In the long run, female employment in agriculture (EAF) exerts a positive and statistically significant effect on livestock production. A 1% increase in EAF is associated with a sustained rise in the Livestock Production Index (LPI) by 3.3%, underscoring women’s structural role in animal feeding, care, and post-harvest processing. This finding aligns with the literature that identifies women as the backbone of household-level livestock management (Naz et al., 2022). Importantly, the



result emphasizes that policy interventions targeting female empowerment in resource access, extension services, and credit facilities are likely to yield durable gains in livestock productivity.

Turning to unpaid contributions, the variable contributing family workers, female (CFWF) is statistically non-significant in the long run. This finding suggests that, although women’s unpaid and often unrecognized labour is essential for sustaining household livestock activities, it does not translate into measurable improvements in livestock productivity. The lack of significance likely reflects women’s exclusion from decision-making processes and limited access to productive resources, which constrains their ability to exert a structural impact on production outcomes over time. Similarly, contributing family workers, male (CFWM) have no statistically significant long-term impact, confirming that their contributions, while non-negligible in daily labour, lack the consistency and strategic importance required to drive long-term productivity growth.

Among the control variables, agricultural land (AL) emerges as strongly significant in the long run. A 1% increase in agricultural land is associated with a proportional rise in LPI by 2.5%, indicating that land availability is a foundational driver of livestock productivity. This is consistent with the structural role of land in grazing and feed production. Additionally, cereal yield (CY) is found to positively influence livestock output in the long run, reflecting the critical role of crop-livestock linkages. Improved cereal yields provide surplus fodder, crop residues, and feed security, which directly support animal nutrition and productivity over time.

4.2.2 Short-run estimations

In the short-run, the dynamics differ. Male employment in agriculture (EAM) exerts a statistically significant positive effect on livestock production, consistent with men’s immediate role in decision-making, access to markets, and engagement in high-return but less routine livestock tasks. A 1% increase in EAM is associated with a measurable rise in LPI by 2%, suggesting that men’s engagement produces short-run productivity shocks.

Conversely, female employment in agriculture (EAF), though significant in the long run, has a weaker short-run impact. This reflects the routine and continuous nature of women’s labour, which sustains livestock productivity gradually rather than producing immediate surges.

The results indicate that contributing family workers, both female (CFWF) and male (CFWM), have significant short-run effects on livestock production (LPI). Specifically, CFWF is statistically significant, highlighting the important role of unpaid female labour in maintaining immediate livestock activities. Similarly, CFWM contributes meaningfully in the short term. However, neither variable demonstrates a significant long-run impact, suggesting that while family labour is crucial for day-to-day operations, its influence is limited over time without access to productive resources and structural support.

For control variables, cereal yield (CY), shows a short-run effect, as increases in crop productivity quickly enhance feed availability and livestock output in subsequent agricultural cycles.

Finally, the error correction mechanism (ECM) is negative (-0.7815) and statistically significant, confirming the presence of a stable long-run relationship between gender-specific labour dynamics, structural controls, and livestock production. The magnitude of the ECM coefficient suggests a relatively high speed of adjustment, meaning that deviations from long-run equilibrium in livestock production are corrected within a short period.

Table 4: Long-run versus short-run estimations of the ARDL models

Variable	Coefficient
<i>Long-run dynamics</i>	
Agricultural Land (AL)	2.5345*** (0.0587)
Cereal Yield (CY)	3.1182** (0.0765)
Employment in Agriculture, Female (EAF)	2.1986*** (0.0634)
Employment in Agriculture, Male (EAM)	3.3467 (0.0698)
Contributing Family Workers, Female (CFWF)	3.2051 (0.0492)
Contributing Family Workers, Male (CFWM)	2.7513 (0.1786)
<i>Short-run dynamics</i>	



Agricultural Land (AL)		2.5217 (0.0609)
Cereal Yield (CY)	3.2046**	(0.0713)
Employment in Agriculture, Female (EAF)		2.1765 (0.0672)
Employment in Agriculture, Male (EAM)		2.9321** (0.0628)
Contributing Family Workers, Female (CFWF)		3.0874*** (0.0486)
Contributing Family Workers, Male (CFWM)		2.7049** (0.0210)
ECM		-0.7815** (0.0637)
R-squared		0.7104
Number of observations		34

Note: Parentheses are used to denote standard errors. *** and ** denote significance at the levels of 1% and 5%, respectively.

4.3 Stability diagnosis

The stability of the estimated parameters was further examined using the Cumulative Sum (CUSUM) test. This method evaluates whether structural breaks exist within the model over the sample period. As shown in Figure 3, the plotted CUSUM statistic remains within the 5% significance boundaries (represented by the straight lines), indicating that the parameters of the model are stable across time. This outcome confirms the robustness and reliability of the econometric specification used in the study.

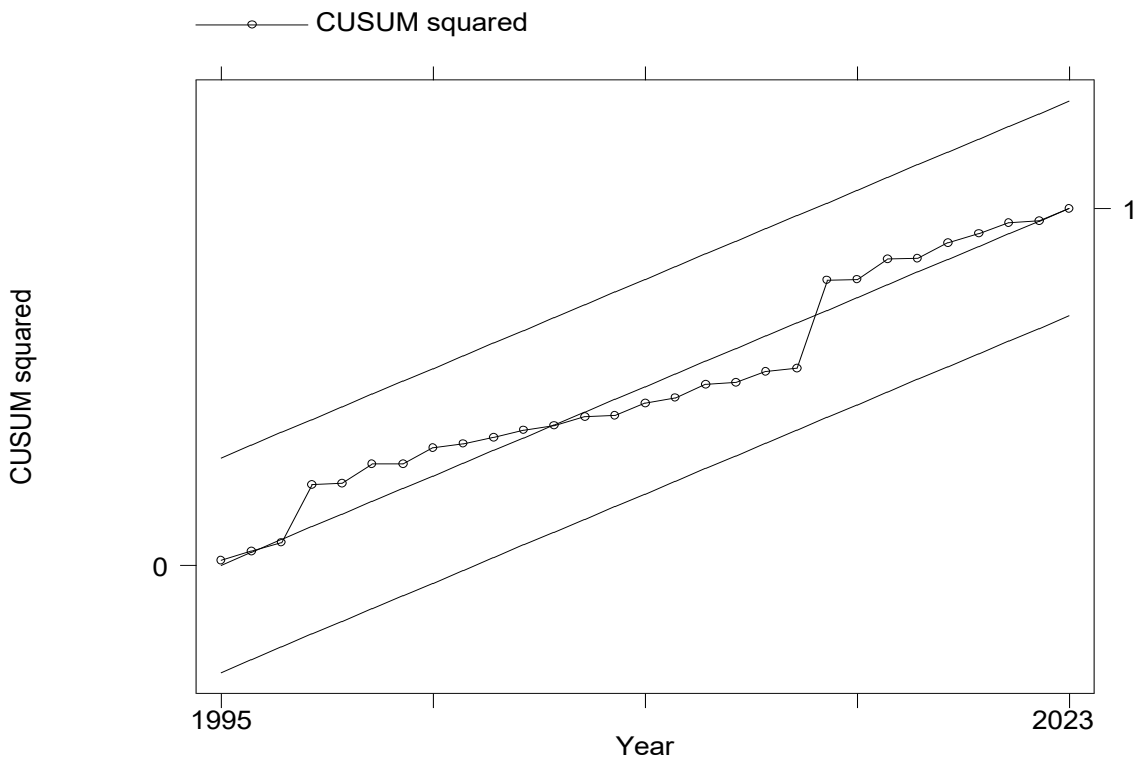


Figure 3: Cusum of Squares Plot



4.4 Model diagnostics and robustness checks

To validate the reliability of the estimated ARDL and ECM models, a series of diagnostic and robustness checks were performed. Diagnostic tests confirmed the absence of serial correlation (Breusch-Godfrey LM test), heteroskedasticity (Breusch-Pagan-Godfrey test), and model misspecification (Ramsey RESET test), ensuring that the estimates are unbiased and efficient. The Jarque-Bera statistic further indicated that the residuals were normally distributed, supporting the validity of inference. Robustness was checked through alternative lag-length criteria, which consistently confirmed the stability of the long- and short-run coefficients. Stability tests, including the CUSUM and CUSUMSQ plots, showed that the coefficients remained within critical bounds, reinforcing model stability over the sample period. Collectively, these diagnostic and robustness checks affirm that the empirical results are statistically sound and provide a reliable basis for interpreting the role of gender-specific labour dynamics in Zambia's livestock production.

4.5 Sensitivity analysis

A sensitivity analysis was conducted to assess the robustness of the estimated relationships. The poverty headcount ratio was re-estimated using alternative international poverty lines to examine whether gender-specific labour dynamics' effects on livestock production were sensitive to the poverty definition. Additionally, alternative land-use indicators, including arable land per capita and arable land as a percentage of land area, were employed in place of aggregate agricultural land. The consistency of estimated coefficients across these specifications confirms the stability and reliability of the results and supports the study's policy conclusions.

5. CONCLUSION

This study provides empirical evidence on the impact of gender-specific labour dynamics on livestock production in Zambia, highlighting the distinct roles of men and women within smallholder systems. Women's formal employment in agriculture significantly enhances long-run livestock productivity, emphasizing their central role in sustaining household livestock activities and the importance of empowering them through access to resources, training, and credit. In contrast, women's unpaid labour, while essential for daily operations, does not translate into long-term productivity gains due to limited decision-making power and restricted access to productive inputs.

Male employment in agriculture and both male and female contributing family workers significantly affect short-run livestock output, reflecting the importance of household labour in daily management and high-return tasks. Other key factors, such as crop yields and the availability of agricultural land, also support productivity by providing feed and grazing space. The statistically significant error correction term confirms a stable long-run relationship, indicating that livestock production adjusts efficiently to short-term fluctuations.

Overall, livestock production in Zambia is both an economic and socially mediated process shaped by gendered divisions of labour and access to resources. Addressing these dynamics is essential for policies that enhance productivity, promote equity, and empower women, enabling sustainable rural development and poverty reduction.

The findings of this study have clear policy implications, highlighting the need for gender-sensitive livestock policies in Zambia. Policies should enhance women's access to land, credit, inputs, and extension services, enabling their labour contributions to translate into increased productivity and improved household welfare.

Second, unpaid family labour, particularly women's contributions, should be formally recognized through compensation, training, or incentives to ensure all labour inputs are valued and supported. Third, extension services must be gender-responsive, accounting for women's mobility, literacy, and time constraints. Mobile services, flexible training schedules, and participatory approaches can improve knowledge transfer and livestock management practices.

Fourth, structural support for livestock systems should be strengthened through integrated crop-livestock programs, improved fodder availability, and equitable access to grazing lands. Fifth, policies must integrate gender considerations, addressing social norms that constrain women's agency through awareness campaigns, community dialogues, and male engagement to promote joint decision-making and equitable labour sharing.

Finally, policies should align short- and long-term strategies, leveraging men's immediate contributions while empowering women structurally to secure sustainable productivity and inclusive household welfare. Gender mainstreaming across agricultural programs is essential to ensure equitable benefits for both men and women.

5.1 Limitations and Future Research

This study uses secondary data from the World Development Indicators (WDI), which may underrepresent unpaid female labour and intra-household decision-making. Additionally, relying on annual time series data could overlook seasonal fluctuations in livestock production. The national-level analysis may mask regional heterogeneity in livestock systems and



gender roles. Future research should incorporate household surveys, qualitative interviews, and gender-disaggregated panel data to better capture intra-household dynamics, seasonal patterns, and socio-cultural heterogeneity.

5.2 Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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