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Industrialization, Economic Growth, and Food Security in The Gambia: An ARDL Approach

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Abstract

This study investigates the long-run and short-run effects of industrialization, GDP per capita and agricultural land on food security in The Gambia. An Autoregressive Distributed Lag (ARDL) framework was utilized to estimate an annual time series data spanning from 1970 to 2023. The ARDL bounds test confirms a stable long-run cointegrating relationship among the variables. The long-run estimates find that industrialization exerts a significant negative effect on food production (coefficient = -1.121, $p < 0.01$), suggesting that industrial expansion is not always favorable to food security. GDP per capita exerts a significant positive long-run effect (coefficient = 0.453, $p < 0.01$), indicating that income growth is associated with improved food production outcomes. Agricultural land registers a negative long-run effect (coefficient = −0.879, $p < 0.10$), consistent with evidence from the literature that land extensification does not guarantee increased food production in land-constrained economies. The error correction term confirms adjustment toward long-run equilibrium at approximately 56 percent per period. Diagnostic and stability tests validate the model. The findings call for industrialization policies that complement rather than crowd out agricultural development, alongside land management strategies that prioritize productivity over area expansion in the for quest for sustainable food security.

Keywords: Industrialization, Economic Growth, Food Security, Gambia, ARDL.

JEL classification: O14, Q18, C22

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1. INTRODUCTION

Food security in many developing nations remains a serious development challenge and has a huge social and economic impact. Food availability and domestic production have not been able to be sustained in certain countries over the past few decades and these countries remain vulnerable to hunger and nutrition insecurity (Miladinov, 2023; Timmer, 2017). Agricultural performance and macro-economic factors such as economic growth, industrialization and land-use behaviour are cited as causes of such challenges (Bellemare & Novak, 2017; Diao et al., 2019).

While agriculture is an important sector of the Gambia economy, the country has a huge challenge to ensure food availability is stable. Though 70% of the population are dependent on the sector for their livelihood and employment, domestic food production accounts for only about half of the national food consumption requirements (FAO, 2024; World Food Programme, 2024). The reliance on imported food commodities, especially rice, makes the food system vulnerable to external shocks such as volatility in global commodity prices and exchange rates, further compromising food access and availability (World Bank, 2023; World Food Programme, 2024). Those structural vulnerabilities underscore the importance of understanding the macroeconomic drivers of food production in The Gambia (Ceesay & Ndiaye, 2022).

However, recent estimates suggest that food insecurity may worsen and food imports will rise accordingly (Ben & El Bilali, 2022; FAO, 2024). Limited irrigation infrastructure and low agricultural productivity, coupled with climatic shocks, further aggravates vulnerability. The structural restrictions, along with chronic poverty, have turned food insecurity and malnutrition into a universal reality especially for families in rural areas (Neglo et al., 2021; World Food Programme, 2025). Food security outcomes in The Gambia is therefore key to improve through better domestic agricultural production, resilience to climate and price shocks and food import dependence.

Economic growth is considered a key driver of food security, which works through increased income, reduced poverty, and increased food accessibility (Bogmans et al., 2025; Diao et al., 2019; Ntiamoah et al., 2023). An increase in per capita income boosts household consumption power and encourages public and private investment in agricultural infrastructure and technology (Ardianti & Hartono, 2022; Maisonnave & Mamboundou, 2022). However, in the absence of a productive agriculture sector, economic growth does not equate to better food security results (Diao et al., 2019; Neglo et al., 2021). Industrialization is equally fundamental in structural change and long-term economic growth. The classical and modern development theories argue that industry leads to productivity gains and quickens income growth (Herrendorf et al., 2014; Lewis, 1954). However, the connection between food security and industrialization is not straightforward and context specific, as industrial expansion can draw factors of production away from agriculture (Belton et al., 2021; Cramer et al., 2022).

Agricultural land remains a critical factor in food production, particularly in land-constrained economies. The quantity of land influences the scale of cultivation, cropping intensity, and long-term production capacity (Chamberlin et al., 2014). However, expansion of agricultural land does not consistently translate into increased food production when land is of low productivity or converted to non-food uses (Bellemare & Novak, 2017; Koryo-Dabrah et al., 2021; Wang, 2022). The conversion of agricultural land to urbanization and industrial purposes further constrains agricultural land availability (Kocur-Bera & Pszenny, 2020). Moreover, competing pressures from urbanization and industrialization raise concerns about sustainability and long-term food security in land-scarce economies (Deininger et al., 2022; Jayne et al., 2014).

The Gambia is an adequate setting to discuss these relationships. Hunger is directly related to domestic food production, and the country is an agriculture-based economy (Addo & Palazzo, 2023). Agriculture is an important livelihood, but production is low and is constrained by climate and structural factors (Chamberlin et al., 2014; Nyathi, 2025). To design effective food security policies, it is necessary to identify the relationship between macroeconomic factors (Ceesay & Ndiaye, 2022), agricultural land and industrialization (Göçoğlu & Göksu, 2024). Yulianti et al. (2021) conclude that food security should be an essential part of government plans to attain food sovereignty. Ardianti and Hartono (2022) similarly show that access to complementary infrastructure reduces food insecurity among agricultural households, underscoring the relevance of the broader structural environment to food outcomes.

However, empirical research on the broad economic influences on food security in The Gambia still remains unexplored. While studies by Ceesay and Ndiaye (2022) and Bojang and Emang (2024) explore food security in The Gambia, they didn't test effects of our study variables on food security. Moreover, existing literature mainly relies on cross-country or panel analysis of larger economies and mask country-specific dynamics and institutional contexts (Belton et al., 2021; Farah & Sugiyanto, 2024; McMillan & Zeufack, 2022; Ntiamoah et al., 2023). However, studies like Mohamed et al. (2022), Hassen et al. (2024) and Setiawan et al. (2023) use time-series methods that differentiate between the short-run adjustment and long-run equilibrium relationships in food production analysis. Whether industrialization has the same negative and land-driven effect on food production elsewhere (Lan et al., 2023; Li et al., 2024; Ungwa & Godwin, 2024), and whether GDP per capita growth improves food security in other regions (Ghufran et al., 2024; Ntiamoah et al., 2023) their effects on food security remain an open question for The Gambia.

The objective of this study is to address these gaps by jointly estimating the short-run and long-run effects of economic growth, industrialization and agricultural land on food security in The Gambia. The Autoregressive Distributed Lag (ARDL) bounds testing method is used because it is suitable for small samples and it allows the use of variables of different orders such as I(0) and I(1) (Banerjee et al., 1993). This approach captures both dynamic short-run adjustments and long-run equilibrium relationships, which are directly relevant to food security and structural transformation policy. It is useful for policy analysis in the field of food security and structural transformation because it describes dynamics in policy and long-run relations.

This research contributes to the literature on food security in small open African economies, where country-specific time-series evidence remains scarce. It offers the first such evidence for The Gambia, clarifying the macroeconomic determinants of food production in a context that cross-country and panel studies tend to mask. This provides insights into the trade-offs between industrialization and the use of agricultural land for food production. Our study also provides policy makers the know-how to balance economic transformation and sustainable food production. The study contributes methodologically by deriving its ARDL specification explicitly from structural transformation, growth, and production theory, offering a replicable framework for similar agriculture-based economies.

2. METHODS

2.1 Model Framework and Empirical Strategy

The paper uses the ARDL bounds testing cointegration method suggested by Banerjee et al. (1993) to explore the dynamics between industrialization, economic growth, agricultural land and food security in The Gambia. The ARDL method is found to be more appropriate for most of the classical cointegration methods in which the regression variables are mostly integrated of order I(0) and I(1). It works with small samples and at the same time estimates relationships of long-run equilibrium as well as short-run adjustment dynamics in a single reduced-form equation without the need for pre-tests for integration order as in Banerjee et al. (1993) and Kripfganz and Schneider (2020).

2.2 Data and Variable Measurement

We utilized annual time series data for the Gambia within a 54-year period spanning between 1970 and 2023. All variables were extracted from the World Bank's World Development Indicators (WDI) database that ensures international comparability and reliability of data. The variables are presented in detail with their operationalization in Table 1 below.

Table 1. Variable Measurement

Variable	Unit	Notation	Source
Food security proxy	Food production index (2014–2016 = 100)	*lnFPI*	WDI
Industrialization	Industry (incl. construction), value added (% of GDP)	*lnINDU*	WDI
Economic growth	GDP per capita (current US$)	*lnGDP*	WDI
Land availability	Agricultural land (sq. km)	*lnAGL*	WDI

Note: All variables are log-transformed to stabilize variance and enable elasticity interpretation.

In empirical food security studies for developing economies, the Food Production Index (FPI) is commonly used as an indicator of food security (Mohamed et al., 2022; Pawlak & Kołodziejczak, 2020). It shows the overall agricultural production compared with the 2014-2016 base period. The explanatory variables are gross domestic product per capita (in current US dollars) as a measure of economic growth. GDP per capita is a standard operational measure of economic growth in the food-security literature because it captures the income channel through which growth is theorized to affect food access and investment (Bogmans et al., 2025; Diao et al., 2019; Ntiamoah et al., 2023), and it is the measure used in the closest comparable country-specific ARDL studies (Cao et al., 2026; Mohamed et al., 2022). We adopt Industry value added (as a percentage of GDP) as an indicator of industrialization, while agricultural land (in square kilometres) as a measure of land available for food production. Logarithm transformations are applied to all variables to ensure constant variance and ease of interpretation of elasticity.

2.3 Model Specification

The empirical model is grounded in three complementary theoretical strands, each motivating one of the explanatory variables and the expected sign of its long-run coefficient. Structural transformation theory (Lewis, 1954) predicts that industrialization reallocates labour, capital and land from low-productivity agriculture toward higher-productivity industrial activity. This realignment often enhances growth but can lead to food production tensions if the loss of land and labour is not matched by production (Wang, 2022). This leads to the assumption that industrialization has a negative long-run relationship with food production in a small or resource-constrained economy like The Gambia unless it is accompanied by robust agro-industrial linkages (Belton et al., 2021).

Moreover, economic growth theory (Ravallion, 2016) predicts that rising income raises food consumption and finances investment in agricultural technology. GDP per capita in this regard should be positively associated with food production provided growth is not driven exclusively by non-agricultural sectors (Diao et al., 2019; Neglo et al., 2021). Third, in the classical production theory (Foss, 1997), land is considered as a primary production factor, suggesting that the land area of agriculture activity should be positively correlated with output in the economies where mechanization is limited. However, this relationship is dependent on land quality and use; where land expansion occurs on marginal or degraded land, or where competing urban and industrial pressures drive land expansion, the theoretically anticipated positive relationship could be negative in reality (Jayne et al., 2014; Kocur-Bera & Pszenny, 2020).

Consistent with the theoretical framework in Section 2.3, food production is assumed to depend on economic growth, industrialization, and agricultural land. The theoretical relationship can be expressed as:

$$FPI_t = f(GDP_t, INDU_t, AGL_t)$$

where FPI denotes food production, GDP represents economic growth, $INDU$ measures industrialization, and AGLcaptures agricultural land availability.

To obtain an estimable empirical model, the functional relationship is specified in log-linear form as:

$$ln\, FPI_t = \beta_0 + \beta_1 ln\, GDP_t + \beta_2 ln\, INDU_t + \beta_3 ln\, AGL_t + \varepsilon_t$$

where $\beta_0$is the intercept, $\beta_1 - \beta_3$are the long-run elasticities, and $\varepsilon_t$is the stochastic error term.

Given the possibility that the variables are integrated of mixed orders, the Autoregressive Distributed Lag (ARDL) framework developed by Pesaran et al. (2001) is employed. The unrestricted ARDL (q_3) specification is expressed as:

$$ln\,FPI_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i ln\,FPI_{t-i} + \sum_{j=0}^{q_1} \beta_j ln\,GDP_{t-j} + \sum_{k=0}^{q_2} \gamma_k ln\,INDU_{t-k} + \sum_{m=0}^{q_3} \delta_m ln\,AGL_{t-m} + \varepsilon_t$$

where p, q_1, q_2,and $q_3$denote the optimal lag lengths orders of lnFPI, lnGDP, lnINDU and lnAGL respectively selected using the Akaike Information Criterion (AIC).

2.4 Unit Root and Cointegration Tests

Stationarity is examined using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests (Pesaran et al., 2001). The existence of a long-run relationship is assessed via the (Pesaran et al., 2001) bounds test; finite-sample critical values follow (Kripfganz & Schneider, 2020). Following Pesaran et al. (2001), we re-parameterized the ARDL model into an unrestricted Error Correction Model (ECM) to separate short-run dynamics from the speed of adjustment toward the long-run equilibrium defined above:

$$\Delta ln\,FPI_t = \sum_{i=1}^{n} \beta_i \Delta X_{t-i} + \lambda ECT_{t-1} + \mu_t$$

We have;

$$\Delta ln\,FPI_t = \alpha_0 + \sum\phi_i \Delta ln\,FPI_{t-i} + \sum\beta_j \Delta ln\,GDP_{t-j} + \sum\gamma_k \Delta ln\,INDU_{t-j} + \sum\delta_m \Delta ln\,AGL_{t-j} + \lambda ECT_{t-1} + \varepsilon_t$$

where ECT_{t-1} is the lagged error-correction term and λ measures the adjustment speed toward the long-run equilibrium. A negative and significant λ confirms long-run stability.

2.5 Diagnostic and Stability Tests

Model robustness is validated through the Breusch-Godfrey LM test for serial correlation, the Breusch-Pagan test for heteroskedasticity, and the Skewness-Kurtosis test for normality assessment. Parameter stability is assessed using CUSUM and CUSUM of Squares tests (Brown et al., 1975).

3. RESULTS AND DISCUSSIONS

3.1 Results

Table 2 shows descriptive statistics for all variables used in our study. The food production index (*lnFPI*) shows moderate variation during the period of study, indicating economic and structural vulnerability. Industrialization (*lnINDU*) has a relatively low mean value, reflecting the relatively low speed of structural change in the industrial sector in The

Gambia. The standard deviation for GDP per capita (*lnGDP*) is the highest, suggesting high income volatility over time. Agricultural land (*lnAGL*) displays minimal variation, confirming that land expansion has been largely constrained throughout the sample period.

Table 2. Descriptive Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
lnFPI	58	4.395	0.234	3.919	4.994
lnINDU	58	2.512	0.264	2.105	3.041
lnGDP	58	5.921	0.708	4.420	6.783
lnAGL	58	8.649	0.087	8.457	8.770

Note: All variables are in natural logarithms. lnFPI = food production index; lnINDU = industrialization; lnGDP = GDP per capita; lnAGL = agricultural land.

The pairwise correlation coefficients are summarized in Table 3. Food production index is negatively correlated with industrialization and agricultural land but positively correlated with GDP per capita. The positive correlation between the industrialization and GDP per capita indicates the close relationship between industrial development and income in The Gambia. No pairwise correlation exceeds the conventional threshold for multicollinearity which indicates that the regressors are not problematically collinear.

Table 3: Correlation Matrix

Variable	*lnfpi*	*lnindu*	*lngdp*	*lnagl*
lnFPI	1.000			
lnINDU	-0.166 (0.214)	1.000		
lnGDP	0.215 (0.105)	0.741 (0.000)	1.000	
lnAGL	-0.109 (0.414)	0.230 (0.083)	0.342 (0.009)	1.000

Note: figures in parentheses are p-values.

Figure 1 illustrates the time-series trends of the logged variables. The food production index (*lnFPI*) alternates between periods of stagnation and mild growth and this reflects the vulnerability of food production to economic and structural shocks. Industrialization (*lnINDU*) exhibits a gradual upward trend while GDP per capita (*lnGDP*) displays long-term growth with intermittent fluctuations. Agricultural land (*lnAGL*) remains largely flat throughout the sample which is consistent with constrained land expansion in The Gambia. These trends collectively confirm the need for econometric modelling to uncover both short-run and long-run dynamics.

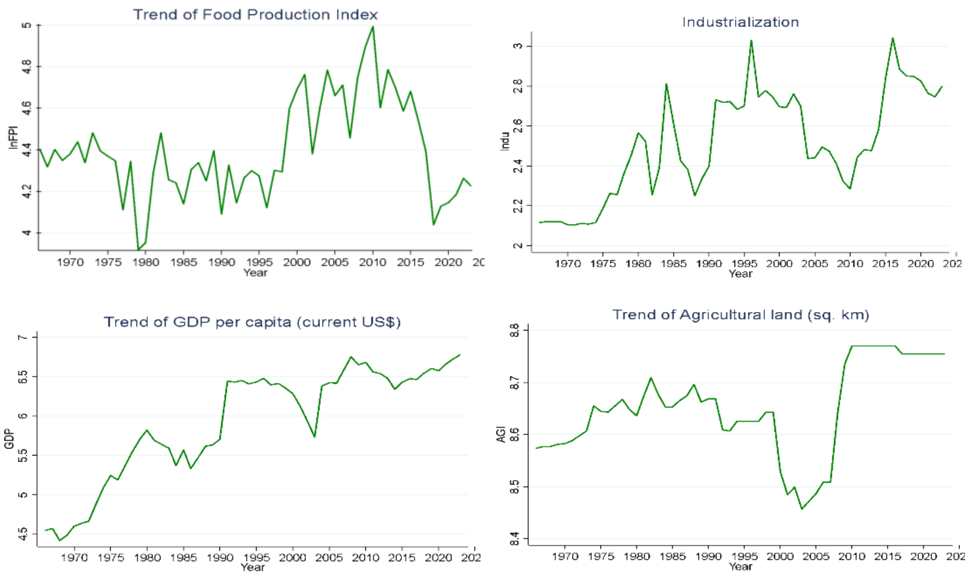

Figure 1. Time-Series Trend Plots of Logged Variables

Table 4 presents the ADF and PP unit root test results. All the variables at levels fail to reject the null hypothesis of a unit root requirement. The null hypothesis is rejected at the 1% significance level for all series following first differencing, confirming that all variables are integrated of order I(1) and satisfying the preconditions for ARDL estimation.

Table 4. Unit Root Tests

Variable	ADF Level	ADF First Diff.	PP Level	PP First Diff.	Order
lnFPI	-2.186 (0.211)	-6.410 (0.000)***	-2.862 (0.050)	-11.054 (0.000)***	I(1)
lnINDU	-2.164 (0.219)	-6.764 (0.000)***	-1.969 (0.300)	-7.454 (0.000)***	I(1)
lnGDP	-1.623 (0.471)	-5.190 (0.000)***	-1.577 (0.495)	-7.367 (0.000)***	I(1)
lnAGL	-1.929 (0.319)	-4.714 (0.000)***	-1.674 (0.445)	-5.218 (0.000)***	I(1)

*Note: figures in parentheses are p-values. * $p < 0.01$.*

Table 5 reports the Johansen cointegration test results required in this study. The Trace and Maximum Eigenvalue statistics fall below their respective 5% critical values at all ranks which indicate the absence of multiple cointegrating vectors under the Johansen framework. This outcome is common in small-sample studies and does not invalidate the ARDL bounds test specifically designed for such conditions.

Table 5. Johansen Cointegration Test

Rank	Trace Stat.	5% Critical Value	Max-Eigen Stat.	5% Critical Value
0	46.023	47.21	24.564	27.07
1	21.458	29.68	15.800	20.97
2	5.659	15.41	3.395	14.07
3	2.263	3.76	2.263	3.76

Note: Critical values at 5% significance level.

Table 6 presents the bounds test results. The computed F-statistic of 6.788 exceeds the upper-bound critical values at all conventional significance levels, confirming a stable long-run equilibrium relationship among food production, industrialization, economic growth, and agricultural land. The null hypothesis of no cointegration is therefore rejected.

Table 6. ARDL Bounds Test (Pesaran et al., 2001)

Test	Value	*k*
F-statistic	6.788	3
Critical Values	Lower I(0)	Upper I(1)
10%	2.809	3.968
5%	3.395	4.690
1%	4.749	6.329

Note: *k* = number of regressors (3). Critical values from Kripfganz and Schneider (2020).

Table 7 presents the ARDL (2,0,4,0) short and long-run estimates in panel A and B respectively. It shows that all of our explanatory variables except lag GDP have no significant effect on food security in The Gambia during the study period. There's however a statistically significant relationship between all three variables on food security in the long-run. The results indicate that industrialization and Agricultural Land negatively affect food security but Economic growth positively influences it.

Table 7 ARDL(2,0,4,0) Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	p-Value
	Panel A: Short-Run Results			
ΔlnFPI (Lag 1)	-0.216	0.123	-1.76	0.086

Variable	Coefficient	Std. Error	t-Statistic	p-Value
ΔlnGDP (D1.)	-0.183	0.130	-1.41	0.167
ΔlnGDP (Lag 1)	-0.273	0.125	-2.18	0.035**
ΔlnGDP (Lag 2)	-0.194	0.125	-1.55	0.128
ΔlnGDP (Lag 3)	-0.291	0.124	-2.35	0.024**
Panel B: Long-Run Results				
Industrialization	-1.121	0.241	-4.64	0.000***
Economic Growth	0.453	0.095	4.77	0.000***
Agricultural Land	-0.879	0.441	-1.99	0.053*
Constant	6.841	2.315	2.96	0.005***
ECT (λ)	-0.562			0.000***

*Note: *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$. ECT = error correction term; λ = adjustment speed.*

Table 8 presents the post-estimation diagnostic results. All tests confirm the statistical adequacy of the estimated model: no evidence of serial correlation, homoskedastic residuals, and normally distributed errors.

Table 8. Diagnostic Tests

Test	Statistic	p-Value	Decision
Breusch–Godfrey LM (serial correlation)	$\chi^2(1) = 0.834$	0.361	No serial correlation
Breusch–Pagan (heteroskedasticity)	$\chi^2(1) = 1.920$	0.166	Homoskedastic residuals
Skewness–Kurtosis (normality)	$\chi^2(2) = 0.430$	0.808	Normally distributed residuals

Note: H_0 not rejected in all cases at 5% significance level.

Table 9 decomposes the Cameron and Trivedi IM-test. All components such as heteroskedasticity, skewness, and kurtosis are statistically insignificant, confirming that the residuals satisfy classical regression assumptions and the model is correctly specified.

Table 9. Cameron & Trivedi's Decomposition of the IM-Test

Source	χ^2	df	p-Value
Heteroskedasticity	3.07	2	0.2156

Source	χ^2	df	p-Value
Skewness	1.59	1	0.2071
Kurtosis	1.15	1	0.2828
Total	5.81	4	0.2135

The CUSUM and CUSUMSQ test statistics remain within the 5% critical bounds throughout the sample period (Figure 2), confirming structural parameter stability and reinforcing the robustness of the estimated long-run relationships.

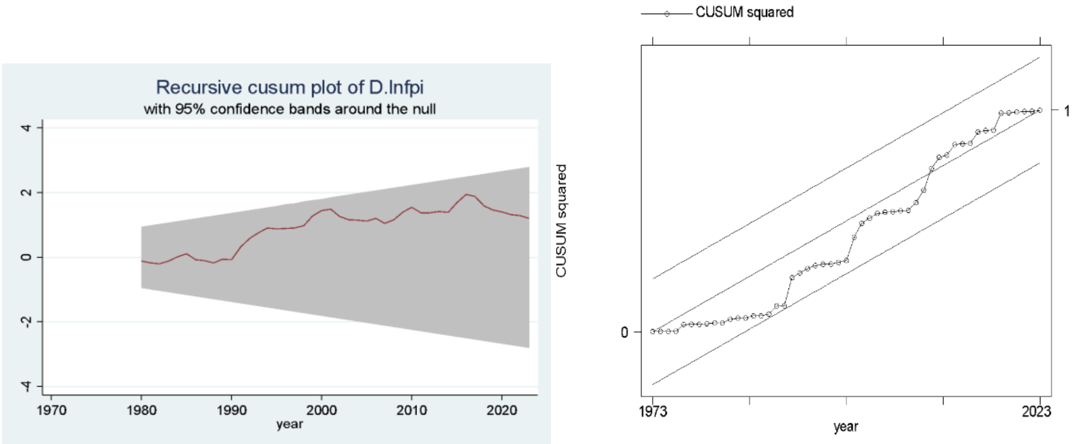

Figure 2: CUSUM and CUSUM of Squares Stability Test Plots

3.2 Discussions

Industrialization has a negative and statistically significant impact on the production of food in the long term. An increment in the industrial value added by 1 percent lowers the food production index by about 1.12. This indicates that an increase in industrialization in The Gambia can be at the expense of agriculture in terms of land, labor and governmental investment, thus compromising food production. Our result is contrary to the structural transformation hypothesis (Johnston & Mellor, 1961; Lewis, 1954) that predicts increased productivity in agriculture due to technological spillovers and infrastructure development in the industrial sector. The findings are consistent with those of (Zhang et al., 2020) and McMillan & Zeufack (2022), who show that industrial growth in developing countries is likely to be at the expense of agricultural development as industrial expansion drives a loss of fertile land.

Our findings also align with those of Ungwa and Godwin (2024) who document asymmetric effects of industrialization on food production in Nigeria, while Gobezie and Boka (2023) show that industrial-related environmental degradation adversely affects food security across sub-Saharan Africa. Segbefia et al. (2023) also suggest that industrial carbon emissions contribute to food insecurity in African countries, but that human capital investment can mitigate this effect. The magnitude of our estimated coefficient of -1.121 is significantly higher than similar estimates reported for Indonesia (Setiawan et al., 2023), reflecting the intensity of resource displacement in The Gambia's comparatively small and less diversified economy. This is pertinent to The Gambia where the industrial sector is still narrow and focused on tourism, groundnut processing and construction, suggesting even a small expansion of the industries will put additional strain on scarce land and labour resources for food production. The Gambia's industrial development policies should therefore be reconsidered to encourage agriculture sector, especially agro-based and agro-processing industries that create backward and forward linkages with food production.

The long-run effect of GDP per capita on food production has a significant positive coefficient of 0.453, indicating that an increase in income strengthens the capacity of the population to attain self-food sufficiency. This outcome is in line with the overall empirical literature. In East African economies, Ntiamoah et al. (2023) employed a panel cointegration approach and demonstrated a positive and significant relationship between economic growth and food security. Income growth reinforces sustainable long-run economic performance with implications for food system investment (Yusuf & Setiawan, 2022). Similarly, Ghufran et al. (2024) conclude that economic growth has a positive impact on food security across OECD and sub-Saharan African countries in the post-Paris Agreement period.

The country-specific time-series analysis results for Sudan also indicate a positive long-run relationship between economic growth and food security (Mohamed et al., 2022), and the positive relationship between GDP performance and all four pillars of food security is report for Ghana (Debrah, 2024; Twumasi-Ankrah et al., 2020). The elasticity derived here are however comparatively low compared to the values of these estimates, which may be indicative of the limited absorptive capacity of The Gambia in terms of translating increased incomes into long-term investments in agriculture. This limited absorptive capacity is consistent with The Gambia's structural conditions, including low rural infrastructure, constrained access to agricultural credit, and the dominance of subsistence farming, all of which dampen the transmission of income growth into productive agricultural investment.

Agricultural land has a negative but not very strong long-run effect ($p = 0.053$). This contrasts with previous studies reporting positive land-production relationships (Bambi & Pea-Assounga, 2024; Pawlak & Kołodziejczak, 2020), and reflects The Gambia's unique structural constraints where land development has taken place mainly on marginal or degraded land, leading to a negative productivity-adjusted relationship with food production. Sarwar et al. (2025) highlight that sustainable land and water management is essential for increasing the long-term effectiveness of agricultural land, while Koryo-Dabrah et al. (2021) and Wang (2022)show that food production is hampered even when land is available due to insufficient land management and soil degradation. Agricultural land in The Gambia is largely rain-fed, highly fragmented and increasingly subject to salinity intrusion and soil degradation. Such conditions explain why additional land area has not translated into proportional gains in food output.

This Gambian evidence extends to Setiawan et al. (2023) and Li et al. (2024) who show that agricultural land expansion under industrialization pressure does not necessarily increase food production. Rahim et al. (2023) further demonstrate this evidence using Indonesian border province data and show that agriculture, infrastructure, and investment programmes jointly determine poverty and human development outcomes, underscoring the need for integrated land and agricultural policy. In line with Jayne et al. (2014) and Zhou et al. (2021), extensification alone is not sufficient to enhance food security in sub-Saharan Africa. Land policies should therefore focus on making land productive through effective and sustainable use practices, not on simply increasing land size. Greater institutional coordination is also needed between industrial, agricultural and land-use policy frameworks (Rahim et al., 2023).

Short-run results show that most variables in our study do not have a significant short-run impact on food security in The Gambia. In the short run, lagged changes in GDP per capita are negatively correlated with food production, implying transitional adjustment costs in response to macroeconomic change. The error correction term (λ = -0.562) is negative and statistically significant at 1 per cent, indicating a rapid adjustment speed of about 56 percent towards the long-run equilibrium following short-run shocks. This implies that food production in The Gambia reacts to disequilibrium brought about by industrialization, income, or land use changes relatively fast. The consistency of the estimated coefficients as confirmed by the CUSUM and CUSUMSQ tests enhances the plausibility of the long-run associations identified in this research In terms of relative magnitude show that industrialization exerts the largest effect on food production (-1.121), followed by agricultural land (-0.879) and GDP per capita (coefficient = 0.453). This ordering has direct policy implications in an way that industrialization management constitutes the most urgent priority for food security in The Gambia followed by land productivity improvements and income-enhancing policies.

4. CONCLUSIONS

This study explores the short and long-run relationship between industrialization, economic growth, agricultural land and food security in The Gambia between 1970 and 2023. Using the Food Production Index as proxy food security under the ARDL bounds test framework to establish cointegration. Empirical evidence confirms a stable long-term cointegrating relationship between the variables under study. The findings show that industrialization has a negative and significant long-run impact on food production, which suggests that industrial development in the Gambian context is a hindrance to food production index. The long-run effect of GDP per capita is positive and significant and signal the significance of income growth for agricultural investment and food production incentives. The long-run relationship between agricultural land and food production is negative, meaning that increased land area is not associated with increased food security if land quality and practices are poor. The significant error correction term confirms rapid adjustment towards the long-run equilibrium following short-run macroeconomic shocks.

This study provides significant contributions to the literature on development economics as it offers country-specific time-series evidence for the macroeconomic determinants of food security in The Gambia, a topic that is often neglected in cross-country and panel studies. The results are relevant to the debates on structural transformation in sub-Saharan Africa and indicate that the composition of economic growth is as important as its volume for food security outcomes. Industrialization policies should be overhauled to foster agro-based and agro-processing industries that complement food production, while land policies should be based on productivity and sustainable use of land rather than on land expansion. Future studies should consider other determinants including climate variability, trade openness and agricultural productivity and break down industrial activity into manufacturing and construction sub-sectors to offer greater insights into transmission channels.

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