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Food Security, Economic Growth and Agricultural Output Nexus in Developing Countries

Ramzan Shabir
Ramzanshabbir558@gmail.com
M.Phil scholar, Department of Economics, COMSATS University Islamabad, Vehari Campus

Dr. Asad Abbas
asad.muhammad@uos.edu.pk
Assistant Professor, MFK Noon Business School, University of Sargodha

Dr. Asad Abbas
asad@cuivehari.edu.pk
Assistant Professor, Department of Economics, COMSATS University Islamabad, Vehari Campus

Naila Anjum
nailaanjum959@gmail.com
M.Phil Scholar, University of Sargodha

Corresponding Author: Dr. Asad Abbas asad.muhammad@uos.edu.pk

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ABSTRACT

The study examined the correlation between food security, economic growth, and agricultural production in developing nations. This study employed the secondary data from the World Development Indicators (WDI) and the FAOSTAT database for the period of 1990 to 2024. The dependent variable used in this study is the Food Security Index (FSI), and the explanatory variables are Agricultural Value Added (AVA), GDP per capita growth (GDPPC), Food Imports (FI), Money supply (M2) and Urban Population Growth (UPG). The Panel ARDL model has been incorporated to analyze the short-term and long-term relationships between the variables. The results demonstrate a positive and significant relationship between agricultural production, economic development and food security in developing countries. Higher agricultural productivity lead to more food available and better rural incomes and economic growth lead to higher household purchasing power and more food available. The results also indicate that the import of food at high levels and high urban population growth has a negative impact on food security. Inflationary pressure and economic instability are also some of the ways by which monetary expansion affected food security. The error correction model proved the presence of a stable long-run relationship between variables. The study had established that sustainable agricultural development and inclusive economic growth is a crucial precondition to enhance food security in developing countries. Thus, it is important for the policymakers to nurture investment in agriculture, adoption of modern farming technologies and food management policies, which in turn would secure the long-term food security and sustainable development.

Keywords: *Food Security Index, Agricultural Output, Economic Growth, Panel ARDL, Developing Countries*

INTRODUCTION

In developing nations, where poverty, hunger and malnutrition are pervasive, food security is now one of the world's most pressing development issues. According to the Food and Agriculture Organization (FAO), food security is defined as the ability of all people to access enough, safe and nutritious food to lead an active and healthy life, at all times and everywhere, in a situation of physical, social and economic security. Although world agricultural development and economic performance have improved, millions of people remain vulnerable to food insecurity because of escalating food prices,

economic instability, climate change, and fast population growth (FAO, 2023). The challenges have raised concerns about the sustainability of food systems and the capacity of developing economies to ensure food availability and access.

Agriculture is therefore an important actor to make food security happen, as food production, employment and income generation largely depend on agriculture in many developing countries. Agriculture is a key sector in rural livelihoods and economic development. The higher productivity in agriculture improves food availability, food price stability, and poverty alleviation (Dethier & Effenberger, 2011). In developing economies, however, agricultural productivity is still limited due to various reasons such as low level of technological development, degradation of land resources, scarcity of water resources and climate variability (Hassan & Adnan, 2025). This has caused the challenge of supplying the increasing demand for food, due to population growth and urbanization in many countries today.

Economic growth is also a key factor in food security as it enhances the income, employment opportunities and purchasing power of the household. An increase in income allows households to have access to adequate and nutritious food. Economic growth can be used, by governments, to invest in infrastructure, agricultural modernization, education, and social welfare programs (Headey & Hirvonen, 2023). However, the benefits of economic growth towards food security are not necessarily equally shared. In many developing countries, vulnerable groups have seen their capacity to take advantage of the economic growth diminish due to inequality, inflation and unemployment (Ceesay & Ndiaye, 2022). Economic growth may not therefore necessarily lead to food security unless growth is inclusive and reaches the poorest groups in society.

The connection between food security, economic growth and agricultural production is closely tied and an important research field in development economics. Agricultural growth and economic growth are mutually reliant in creating employment, generating income in rural areas and linking with other industrial sectors; and on the other hand, economic growth fosters agricultural growth by providing investment, infrastructure and technological innovation (Bozsik et al., 2022). This establishes a feedback loop between food security, agricultural productivity, economic growth, and agricultural development. Hence, the linkages of food security, economic growth and agricultural production are important in formulating successful policies that will contribute towards food security and hunger eradication in developing nations.

The Food and Agriculture Organisation (FAO) defined food security as the condition when all individuals, consistently, are able to obtain the social and economic access to enough safe and nutritious food to fulfil their dietary needs and for a healthy and active lifestyle (FAO, 2021; Ceesay & Ndiaye, 2022). It is considered a basic human right in most cases, but it is something that cannot be enjoyed by the rural majority in these countries because they depend on farming as a source of their daily life, as well as their livelihoods. It is against this backdrop that improving agricultural production, whether by intensification of production, increased productivity and the use of resources, is one of the pillar strategies since 1998 to reduce poverty, improve food security, and stimulate the economy of developing countries (Hasan & Adnan, 2025).

Three factors of food security are: (i) food provision, which incorporates components of production, allocation and exchange; (ii) food access, links to product cost, and use of food relies on income and wealth, provisioning systems and (iii) which deals with dietary quality, social norms and food security (Ingram, Robinson, & Busch, 2005). Rosegrant & Evenson (1995) introduce the idea of a 2-tiered food security system, which demonstrates that well-developed and rapidly developing economies tend to have access to reasonably priced and adequate food resources, and slow-growing and poor nations tend to experience food insecurity and malnutrition. This suggests that the less developed and developing

nations need to engage in increased agricultural production and productivity to realise food self-sufficiency, are initial and major pillar of food security.

As the economy expands, it may help to increase food access to the most at-risk populations by reducing poverty and making necessary goods more affordable, though such benefits are usually not extended to the most vulnerable populations (Batool & Sheikh, 2024; Ceesay & Ndiaye, 2022). There is also evidence that economic growth is a significant benefit to food security in developing countries by enhancing the distribution of incomes and access to necessities (FAO, 2023). Furthermore, sustained economic growth would provide more and better-paid jobs, and this would directly assist households to purchase sufficient and healthy foods, which would further enhance the outcomes of food security results (Headey & Hirvonen, 2023).

The relationship between food security, economic growth, and agricultural output is closely interwoven and constitutes a major aspect of development economics. The food security depends on the stable agricultural output, which is in its turn affected by the macroeconomic factors, including income, investment and government policies (World Bank, 2008; FAO, 2017). On the other hand, agriculture is supported by economic growth due to better investment in infrastructure, technology, and inputs, which further increase productivity and output (FOA, 2023). This creates a cyclic relationship where agricultural output fuels economic expansion, economic growth fosters agricultural progress, and both influence food security outcomes (Christiaensen, Demery, & Kuhl, 2010).

Problem Statement

Food security remains a crucial challenge in developing countries, where many people continue to face hunger and malnutrition despite advancements in agriculture and economic growth (FAO, 2021). While increased agricultural output can boost food availability and income, these benefits often do not improve food security due to some problems like income inequality, weak institutions, and poor food distribution systems (Allaoua & Krelifa, 2026). Also, structural ambiguities, including restricted land expansion, sluggish growth of productivity, and disproportionate adoption of modern technologies in agriculture, impede sustainable development in such economies (Aghaloo & Sharifi, 2023). The latest studies emphasize the necessity of combining the sustainable farming approach with the economic strategy to achieve long-term food security (Saragih and Ovalti, 2026; Ludher and Teng, 2026). Nevertheless, scanty empirical data exist on the overall impact of these factors on food security in developing countries. This highlights the importance of a wide cross-country examination that examines the dynamic relationships of agricultural output, economic growth, and food security, in the light of socio-economic and structural factors. This gap needs to be addressed to produce evidence-based policies to improve food security and to support the Sustainable Development Goals in developing countries.

Research Objective

The proposed aims of this research are:

1. To construct a Food Security Index (FSI) based on its four core dimensions: food availability, food access, food utilization and food stability.

2. To explore the nexus between agricultural output, economic growth and food security.

Significance of Study

This growing awareness of enduring food insecurity in developing countries in the context of growing economic development and food production points to an important research gap. According to many studies, economic growth can improve food access and poverty alleviation (Pourreza, Geravandi, &

Pakdaman, 2018). However, there are mixed results as growth does not necessarily lead to better food security, the most common reason being inequality and weak institutions (Fernandes & Samputra, 2022; Bozsik, et al., 2022). Also, increased agricultural production has been correlated with an increase in food availability (Yahaya, & Adamu, 2024); however, more food production does not guarantee food availability, particularly in regions where food distribution systems are weak (Nosov et al., 2020). The vast majority of research focuses on economic growth, agriculture, and food security in isolation and does not explore relationships between the three. While some research examines these connections, the intricate relationship between these factors has not been fully investigated (Ali et al., 2023). Moreover, the use of country-based case studies restricts the generalisability of results (Allaoua & Krelifa, 2026; Iftikhar & Mahmood, 2017). Thus, an empirical cross-country study on this issue is required to gain deeper understanding of this nexus to support policy making.

LITERATURE REVIEW

The present section summarizes the previous works on food security, economic growth and agricultural production in developing countries.

Song, Song, and Wang (2026) examined how rural digital transformation and smart agriculture were able to boost food security resilience despite growing environmental and economic uncertainties. Findings revealed that rural digital transformation greatly boost food security resilience through increased productivity, resource utilization, and market access. The technologies, such as big data, IoT, and digital platforms, can assist farmers in making more useful choices, reducing risks, and increasing efficiency. This paper recommended that policymakers invest in the digital infrastructure, enhance technical skills, and encourage innovation in order to maximise the benefits of smart agriculture.

Hasan and Adnan (2025) pointed out that food insecurity was a major issue in developing economies, especially in energy-dependent agricultural regions such as Sub-Saharan Africa and Southeast Asia. Researchers found that in trying to enhance food security, the tendency is to use energy-intensive production methods that result in increased CO2 emissions, which proves a trade-off between food security and environmental sustainability. Mugizi (2025) conducted a study of how extension advice affects agricultural productivity and food security in Tanzania. The National Agricultural Sample Survey 2019-2020 data was used in the study. In order to overcome the potential endogeneity and selection bias issues, the study utilised the instrumental variable method, the extended regression model and the endogenous switching regression model. The research determined that there was a strong positive impact of agricultural productivity on the receipt of extension advice. The research has also identified that there was a significant correlation bet between access to extension advice and food security.

Souza and Ribeiro (2025) investigated the policy outcomes, causes, and effects of the growth of agricultural exports in Brazil. It examined the way export priority led to a diminishing number of domestically consumed staple foods, which in turn caused food inflation and insecurity in nutrition. It also examined how the environment was harmed by the expansion of agricultural lands such as the Amazon and the Corrido area through deforestation, soil erosion and excessive use of water. There were also social impacts, including the marginalization of small farmers, increasing rural unemployment, and the spread of economic inequalities. The paper has ended with an assessment of possible solutions, which include, but are not limited to, the implementation of tougher environmental regulations, sustainable farming incentives, and trade policies ensuring that Brazil had enough food production without making it lose its status as a large agricultural exporter.

Atchade and Nougbode (2024) studied the relationships between climate change, economic growth, production of food, and agricultural productivity. The study used annual statistics between the years 1961 and 2021. The research Granger causality model, which was carried out, used the Toda-Yamamoto method, revealed the one-way links between food output and economic growth, temperature change and additional values of agricultural products.

Fan et al. (2024) investigated the drivers of food security in South Asia, focusing on agricultural trade openness, agricultural production and employment. The study suggests balanced trade policies to get the maximum benefit and minimise risk. The study also highlights the contribution of agricultural livelihoods to good food access. More employment in agriculture leads to higher income in households, which in turn boosts their purchasing power..

Khan et. Al., (2024) analysed a systematic review and compiled seven barriers to agricultural finance in underdeveloped and developing countries. The authors pointed out that farmers' financial constraints are affecting their investments in inputs, sustainable agricultural practices, and modern technologies, which directly impacts agricultural improvements and food supply. The findings revealed that there are major challenges to agricultural finance, mainly poor access to formal credit institutions, particularly for the smallholder farmers who were uncollateralized and without credit history, high interest rates and transaction costs that deter borrowers and poor financial infrastructure and regulatory structure.

Rasyid and Ningsih (2024) assessed the capability and the effect of the use of self-sustaining agricultural innovation in enhancing agricultural output and food security in the region. The findings of the study revealed that self-sustaining agricultural innovation would help to boost productivity and food security. The research indicated that Farmers who used sustainable agricultural technology tended to have more yields and were resistant to pests and disease.

Miladinov (2023) was an important missing piece in the literature discussing food system dynamics in developing countries, as it explores the relationship between population growth and economic development with regard to food security in low-, lower-middle, and upper middle income countries. The negative association between GDP per capita growth and undernourishment was found only in lower-middle-income countries, indicating that, at least under certain conditions, economic development can reduce food insecurity.

Ali et. Al., (2023) carried out an empirical analysis on the linkages between environmental pollution, economic development and farming output in Sub-Saharan African nations. The results indicated that economic growth had a significant impact on increasing environmental pollution, further substantiating the hypothesis that economic growth and industrialisation in the region have a direct impact on environmental degradation.

Idisi (2021) discussed the relationship between food security and economic growth and price stability in Nigeria with an emphasis on conceptual and theoretical relationship. The study identified structural issues such as dependency on imports, environmental shocks, and socio-political unrest, which have been associated with countries' vulnerability to import price volatility and the impact it has on the development of local agriculture.

Pawlak and Kołodziejczak (2020) reviewed the importance of agriculture in food security in developing countries, emphasising the need for sustainable agricultural practices for food security. Results showed that the countries with high agricultural dependence in GDP and with low infrastructure level and poor environmental conditions have more serious food security problems.

Asim and Akbar (2019) presented an analysis of the linkages of the agricultural sector with other sectors and their effects on food security in Pakistan. The study highlighted that agriculture continues to play a very crucial role in Pakistan's economy. Apart from having its own contribution in food production, it also contributes to the development of the other sectors of the economy, including industry and service sectors.

Osabohien, Osabuohien, and Urhie (2018) analysed how food security in Nigeria is affected by the institutional framework and technology, using the ARDL approach. They noted that food security is as critical as agricultural production, as much as it is about institutions and technological advancement.

Iftikhar and Mahmood (2017) examined the link between human capital development and food security in Punjab's districts, highlighting education and literacy as key factors influencing food security outcomes at a regional level. The results showed significant negative correlations between food insecurity and both overall and farmers' literacy rates, suggesting that higher literacy, especially among farmers, is associated with lower food insecurity. Koning (2017) provided an extensive long-term review of food security, agricultural policies, and economic growth, utilising historical, political-economic, and human-ecological viewpoints to analyse how food systems had changed over time. For developing countries, policy insights reinforced the idea that sustainable food security necessitates integrated policies that go beyond short-term growth metrics and support the structural development of agriculture.

Ghanem (2015) analysed the connection between inclusive growth and food security in Morocco, focusing on the dual challenges of child malnutrition and obesity. The study noted that the Moroccan government adopted a rural development strategy including modern farms, focused on supporting family farmers and smallholders to promote both inclusive growth and food security. Ozturk (2015) examined the sustainability of food-energy-water (FEW) nexus in the BRICS countries (Brazil, Russia, India, China, South Africa), highlighting the interconnections of these important resources, their impacts on economic development and the environment. The results indicate that environmental pressures actually rise as early growth stages are reached, but then improve at higher income levels, which has implications for the management of the FEW nexus.

Mukherjee and Kuroda (2003) employed a Tornqvist-Theil index on TFP growth between the years 1973 and 1993. The experiment did not find any evidence of converging at one level of TFP (a-convergence). Then, on grouping the different states based on their productivity performance, we discover that the high-performing states demonstrate a progressive pull towards the trend in comparison to the low-performing ones, which tend to be more volatile. The research findings are strong for different specifications of panel data unit root tests developed in the present.

Food Security and Economic Growth

Khalifa (2025) analyzed food security's link with economic growth, climate change, and agricultural output in Tunisia. The tests of Granger causality indicated a unidirectional relationship between economic growth and agricultural productivity, food security, and temperature change and between temperature variations and crop production. The highlighted study revealed that there was an urgent need to adopt adaptive strategies in addressing the negative impacts of climate variability. In the study, suggested measures to be applied include climate-smart agricultural practices, which might involve effective irrigation systems, resilient crop and soil management.

Batool and Sheikh (2024) addressed the research question of whether food security and exports of agricultural products, as well as income inequality, had effects on economic development in 89 underdeveloped countries between 1990 and 2020. They used Method of Moments Quantile Regression (MMQR) to examine all four factors of food security, and these are availability, access, stability and utilization. Their findings ended up in a favourable effect of the sufficient food supply on the development of the economy because it fostered health and productivity.

Othmani, Weriemmi, and Bakari (2024) examined the study of the correlation between food export and economic growth in Italy. The cointegration analysis and the ARDL Model employed by the researcher were on the annual data between 1990 and 2021. Empirical results found that food exports positively influence long-term economic growth. Nevertheless, even with this beneficial correlation, in the analysis of clear facts, a decreasing pattern in the portion of food exports was discovered in the period of analysis.

Sheikh, Ali, and Aslam (2022) investigated the food wastage and food security, environmental quality, and economic growth in developing countries. The analysis revealed that food wastage has a significant

negative impact on economic growth, as it has a negative effect on food availability and resource inefficiency. Fernandes and Samputra (2022) conducted a systematic literature review to analyse the relationship between food security and economic growth and to synthesize the findings from the literature to find out the food security-economic growth relationship, trends, gaps, and relationship. The overall findings of this study highlight the close relationship and interdependence of food security and economic growth. It is necessary to tackle both issues in order to achieve sustainable development with the support of appropriate policy measures.

Bozsik et. Al., (2022) analysed how economic factors influenced food security, especially regarding food availability and access in developing countries. Their research helped to build on existing literature by revealing that macroeconomic factors like economic stability, income distribution, and trade have a significant effect on food systems.

Lee and Son (2016) examined how income inequality affects the growth of the country in a large sample of regions between the years 1965 and 2014. The research employed a better inequality dataset with fewer measurement error, which promote cross-country comparability. The researcher discovers a benchmark impact of inequality on a country's growth, and that this effect is higher in developing countries than in developed countries.

Liu and Yang (2015) examined how structural transformation can explain the gap in combined output between two economic regions. The analysis proposed that the comparative performance in India depends upon bridging its output difference in both agriculture and manufacturing as compared to China.

Shuaib and Ndidi (2015) explored the link between asset formation and the advancement of the economics of Nigeria. The finding revealed that the growth proportion of domestic earnings will be explicitly proportional to the ratio of savings, asset formation, and the more the country can save and outward investment flow of the current GNP, the higher the growth of the said GDP.

Food Security and Agricultural Output

Laghari et. Al., (2025) explored the relationship between agricultural land and crop production with sustainable food production in China, highlighting the underlying role of environmental sustainability. This study used the advanced econometrics techniques including the Auto Regressive Distributed Lag (ARDL) models and moderation analysis to assess the short-term and long-term relationship. The study indicated a need for a balanced approach to attain food security, involving both development and agricultural productivity, along with environmental protection. Policymakers should promote sustainable land use, invest in eco-friendly technologies, and not allow economic development to affect environmental health.

Bello, Yahaya and Adamu (2024) explored the relationship between sustainable agricultural productivity and food security in Nigeria, highlighting the importance of improving agricultural production to guarantee food availability and stability in the long term. The study was able to conclude that food security in Nigeria requires a sustainable approach towards agricultural development, one that allows for increases in agricultural productivity without compromising the environment. The policy makers were encouraged to suggest sustainable agriculture, invest in research and technology, and develop institutional structures that support sustainable agriculture.

Kumar and Sharma (2022) investigated the effect of climate variation on agricultural output, both in form of output volume and monetary value, as well as food security in India. Their study relied on secondary data spanning from 1980 to 2009. They found that fluctuations in climate affect the productivity of both food and non-food grain crops.. The regression analysis in their study revealed that, for most food and non-food grain crops, climate variability tends to reduce both yield per unit area and the value of agricultural output. This decline points to increased risks for food security, particularly

among small and marginal farmers. Additionally, the researchers developed a state-wise food security index and found, through econometric modelling, that climate change hurts this index as well.

Nosov et. Al.,(2020) examined the role of government subsidies as a policy mechanism to support the food security of the region. The study found that secondary quantitative regional data analysis provided strong evidence that subsidies were a policy instrument that was crucial to increasing agricultural production and food security, particularly in vulnerable regions.

Porreza, Geravandi and Pakdaman (2018) explored the connection between economic growth and food security, highlighting the importance of access to food for sustainable development. The study highlighted that food security was not only a social aspiration but also an important economic determinant which can impact productivity, human capital building and the general economic well-being.

Overall, the studies highlighted the potential benefits of using agricultural biotechnology to enhance food security, but also indicated that they could only achieve this with the right policies, R&D investment and capacity building, and that regulatory mechanisms and/or systems needed to be strengthened to ensure safe and fair use.

THEORETICAL FRAMEWORK

There is no single theory that fully explains this relationship, so the study draws on several theories to explain the food security both on the supply side and on the demand side. Specifically, it is based on three theories: Amartya Sen's theory of entitlement, Agricultural Productivity theory and the Neoclassical Growth theory (Solow model). These theories can be combined to provide an understanding of the relationship between food security and income, agricultural output and overall economic development. The focus of entitlement theory is on access to food, of agricultural productivity theory on food availability, and of growth theory on long-term economic improvement as a determinant of food security.

The Neoclassical Growth Theory (also called the Solow Growth Model) describes long-term economic growth through the growth of capital, labour, and technology. The theory argues that sustained growth will be achieved through increases in productivity, primarily through technological innovation and the efficient use of resources.

As far as food security is concerned, economic growth is essential to improve living standards and alleviate poverty. The study uses the Neoclassical Growth Theory and considers variables that affect both the economic performance and food security, such as GDP per capita growth, In conclusion, this Solow Growth Model provides a macroeconomic lens to tie economic growth to agricultural development and food security and highlights the importance of sustainable long-term strategies.

MATERIALS AND METHODS

This section provides detailed information on the data sources, variable construction, model design, and econometric methods employed to analyze the relationship between agricultural output and food security, economic growth, land, socio-economic and demographic factors in developing economies. It aims to empirically explore how these macroeconomic and structural elements collectively impact food security results over time and among different countries.

Data source

The balanced nature of the panel data for selected developing countries based on the availability of data for the period 1990 to 2025 used in this study has captured the short-term and long-term fluctuations in food security, agriculture and macroeconomic conditions. It was suitable that the developing countries

chosen were comparable because they shared some problems such as food insecurity, reliance on agriculture, high population rates and limited technological advancement. The sources for data are reliable sources, including:

The data has been retrieved from the Food and Agriculture Organization (FAOSTAT).Annual, balanced observations in different countries were included in the dataset and increased the accuracy of estimation and reduced bias. The panel data was suitable for this because it allowed us to account for variation across countries and over time, boost observations and allow for the use of panel analysis tools to control for the unobserved heterogeneity and to examine dynamic relationships. Among all the methods, the panel data is more reliable in providing information on the complex relationships in developing economies.

Descriptions of the Variables

All variables, their unit of measurement, and their sources of datasets are presented in Table 1.

Table 1: Description of variables:

Dimension	Description	Variable Abbreviation	Unit	Data Source
Dependent Variables				
Food Availability	Average protein supply	APS	g/cap/day, 3-yearly averaged	FAOSTAT
Food Accessibility	Prevalence of undernourishment	PUN	%, Yearly estimates	
Food Stability	Per Capita Food Production Diversity	PFPD	Current thousand international $ per capita	
Food Utilization	A person using at least improved drinking water provisions	IDW	% of population	
Food Security Index	Using its four core dimensions: food availability, food accessibility, food stability, and food utilisation	FSI	Index	Constructed by the author
Food Security Index	Food Production Index	FPI	Index	WDI
Independent Variables				
Economic Growth	GDP Per Capita Growth	GDPPC	% Annual	WDI
	Agricultural Value Added	AVA	Annual % Growth	WDI
Food Imports	Relies on imported food supply	FI	% of GDP	WDI
Money Supply	Financial liquidity and availability of money in the economy	M2	% of GDP	WDI
Urban Pollution Growth	Urbanization growth	UPG	% Annual	WDI

Econometric Model Specification

The Panel Autoregressive Distributed Lag (ARDL) model has been used in this study to investigate the long-term and short-term relationship between food security and selected macroeconomic variables. The Panel ARDL model is suitable for this analysis as integrated variables of different orders (I (0) and I (1)) do not have to be stationary at the same level.

Furthermore, the Panel ARDL model can create dynamic relationships by incorporating lagged values of dependent and independent variables. This will help the model to examine the effect of previous values on current results. It also offers a thorough framework for estimating both short- and long- term equilibrium relationships in panel data.

Econometric models specification:

$$FSI_{it} = \alpha_0 + \beta_1 AVA_{it} + \beta_2 GDPPC_{it} + \beta_3 FIG_{it} + \beta_4 M2_{it} + \beta_5 UPG_{it} + \varepsilon_{it}$$

Where:

I = 1, 2,…,N, it represents cross-sectional units

T = 1,2,….,t denotes time.

Panel ARDL Dynamics

The Panel ARDL dynamics are based on the Unrestricted Error Correction Model (UECM), which deals with the relationship between food security and its main determinants like agricultural production, economic growth, population growth, inflation, education and other socio-economic and demographic factors. In this scheme, short-term dynamics are indicated by differenced variables (Δ), which describe the change from one time to the next. These terms describe the immediate effects of the changes in agricultural output, agricultural income, population, and inflation as well as changes in education on food security.

The long-term relationship, on the other hand, is represented by the error correction term (ECT). The ECT coefficient is a measure of the rate at which the deviations from the long term equilibrium are corrected. The negative and significant coefficient reinforces the long-term association between variables. Moreover, the UECM in the Panel ARDL framework enables estimating both short-term and long-term impacts and effects at the same time, thereby providing a detailed analysis of the determinants of food security.

The panel ARDL long-run and short-run equation of the model is as follows:

$$\begin{aligned}\Delta FSI_{it} = {} & \alpha_1 + \alpha_2 AVA_{i,t-1} + \alpha_3 GDPPC_{i,t-1} + \alpha_4 FI_{i,t-1} + \alpha_5 M2_{i,t-1} + \alpha_6 UPG_{i,t-1} \\ & + \sum_{j=1}^{\rho_1} \beta_{ij} \Delta FSI_{i,t-j} + \sum_{j=0}^{\rho_2} \beta_{ij} \Delta AVA_{i,t-j} + \sum_{j=0}^{\rho_3} \beta_{ij} \Delta GDPPC_{i,t-j} + \sum_{j=0}^{\rho_4} \beta_{ij} \Delta FI_{i,t-j} \\ & + \sum_{j=0}^{\rho_5} \beta_{ij} \Delta M2_{i,t-j} + \sum_{j=1}^{\rho_6} \beta_{ij} \Delta UPG_{i,t-j} + \varepsilon_{it}\end{aligned}$$

Where:

$\Delta FSI_{(it)}$ = represents the change in the dependent variable Food Security Index for cross-sectional unit i and time period t

$t-1$, $t-j$ = represents the lagged values

Σ = this sign represents the summation of over lags

α_1 = denotes the intercept

α_2, α_3, … α_7 = denotes the long-run coefficients of the independent variables

β_j = denotes the short-run dynamics coefficients allied with lagged differences.

$j = 0$ to p = represents the total number of lags in the model

$\varepsilon_{(it)}$ = denotes the error term for cross-sectional unit I and time period t

AVA, GDPPC, FI, M2, and UPG are the independent variables.

RESULTS AND DISCUSSION

This section discusses the empirical analysis results of food security and its determinants in developing countries from 1990 to 2024. Descriptive statistics, correlation matrix, Panel unit root analysis, Panel ARDL long run estimation and Error Correction Model (ECM) are the analysis tools employed. The study looks at how the Agricultural Value Added (AVA), GDP per capita (GDPPC), Food Imports (FI), Money Supply (M2) and Urban Population Growth (UPG) affect the Food Security Index (FSI).

Descriptive Statistics and Correlation Analysis

In Table 5.1, we are presenting the descriptive statistics of the key variables used in the study from 1990 to 2024 in developing countries. The table presents the mean, median, maximum, minimum, standard deviation, skewness, kurtosis and Jarque-Bera statistics for all variables, calculated from 2755 observations.

Table 1: Descriptive Statistics of Key Variables (1990-2024)

	FSI	AVA	GDPPC	FI	M2	UPG
Mean	121.9068	19.1438	2.0266	17.0851	41.2027	2.9888
Median	122.8552	16.7905	2.2932	14.7681	33.2744	3.0154
Maximum	176.3947	66.7868	42.7893	732.3977	211.8916	17.4991
Minimum	55.7390	1.7981	-47.5032	0.4738	-47.6279	-6.5118
Std. Dev.	16.7577	12.3331	5.2519	27.1232	29.0830	1.7446
Skewness	-0.1477	0.8832	-0.9809	22.3070	1.7387	0.4151
Kurtosis	3.4973	3.4232	16.2772	557.4417	7.2514	8.4179
Jarque-Bera	38.40	378.69	207.81	355.00	362.85	48.70
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observations	2755	2755	2755	2755	2755	2755

Source: Author's calculations

Table 2: Correlation Matrix of Key Variables (1990-2024)

Correlation	FSI	AVA	GDPPC	FI	M2	UPG
FSI	1					

AVA	-0.5022	1				
GDPPC	0.0264	-0.0348	1			
FI	-0.0913	0.0980	-0.0281	1		
M2	0.2939	-0.3590	0.0461	-0.0879	1	
UPG	-0.3898	0.2758	-0.0189	0.0163	-0.1547	1

Source: Author's calculations

The weak negative correlation between the FSI and Food Imports (FI) (-0.0913), indicates that there is a slight correlation between the dependence of food imports and food security levels.

GDPPC, on the other hand, has a very low positive correlation with FSI (0.0264), meaning that there is almost no direct linear link between economic growth and food security in the data.

The results indicate that there is a weak positive correlation between money supply (M2) and FSI (0.2939), implying that monetary expansion may provide a slightly positive contribution to food security through the channel of economic activity and income increase.

Unit Root Analysis

The unit root analysis focuses on whether the variables are stationary or non-stationary in the time period 1990-2024. The results of the tests LLC, IPS, ADF-Fisher and PP-Fisher under Individual Intercept, Intercept and Trend and None conditions are presented in Table 5.3. If significant values are obtained, then it can be concluded that the null hypothesis is rejected and it confirms that it is stationary.

Table 3: ADF Test

Unit Root Analysis													
Variable	**Individual Intercept**				**Intercept and Trend**				**None**				**Results**
	LLC	**IPS**	**ADF-Fisher**	**PP-Fisher**	**LLC**	**IPS**	**ADF-Fisher**	**PP-Fisher**	**LLC**	**IPS**	**ADF-Fisher**	**PP-Fisher**	
FSI	-179*	0.85	179.90*	168.55	-5.43*	-6.97*	319.84*	266.26*	11.04	0.85	73.43	79.33	I(0)
AVA	-7.54*	-3.09*	253.28*	309.42*	-1.36	1.17	201.05	241.55*	-10.70*	-3.09*	413.12*	554.33*	I(0)
GDPPC	-4.81*	-13.94*	552.13*	909.78*	-0.85*	-8.28*	406.29*	1145.40*	-14.44*	-13.94*	552.13*	1171.02	I(0)
FI	-6.91*	-7.46*	353.20*	433.36*	-8.78*	-5.71*	551.55*	409.79*	-1.43	-7.46*	146.71	159.85	I(0)
M2	5.46	7.22	140.18	143.90	-0.04	-0.92*	223.24*	236.23*	9.49	7.22	41.29	48.63	I(1)
UPG	12.10*	-11.51*	493.30*	-6.29	-15.52*	-13.17*	1051.90*	512.43*	-6.90*	-11.15*	393.75	5279.2*	I(0)

Source: Author's calculations

The results indicate that all the variables in the regression are stationary at level form and are integrated of order 0 (I(0)). It is found that Money Supply (M2) is non-stationary at level under the following conditions: however, when it is differenced once in order to make it stationary, it is found to have order one I(1) characteristics. From the overall result it is concluded that the result showed mixed I(0) and I(1) variables and thus the panel ARDL estimation technique can be used for future analysis.

Long Run Analysis

Table 5.4 presents the long-run Panel ARDL analysis in which, the relationship between Agricultural Value Added (AVA) and Food Security Index (FSI) is statistically significant and positive with a co-efficient value of 0.4082 (p-value = 0.0000), hence, the increase in AVA has a positive effect on the FSI in the long run. In a statistical sense, that translates to improved productivity in agricultural production improving food availability, rural income, and food supply stability. This finding is significant for the Agricultural Productivity Theory that states that enhancing agricultural productivity is crucial to achieve sustainable food security and economic welfare. Greater agricultural production leads to enhanced food self-sufficiency and the reduced need for imported food. This finding is consistent with that of Bello et al. (2024) and Ghosh et al. (2022) that agricultural productivity has an important role in the food security in developing economies.

Food Imports (FI) is positively and statistically significantly related to food security with coefficient of 0.1557 (p-value = 0.0243). This means food imports have a positive impact on food security by filling the domestic food gap, helping to regulate food supply and providing food availability during production gaps. The outcome confirms Amartya Sen's Entitlement Theory that food security is a function of both the ability of individuals to produce food at home and their access to food via trade, markets and purchasing. Food imports increase food commodity supply to domestic markets and help to fill supply gaps and therefore enhance food entitlement. This finding is corroborated by Bozsik et al. (2022), which found that both an increase in trade openness and food imports enhance food access and food security in developing countries.

Table 4: Long Run Panel ARDL Estimates of Food Security, Agricultural Output and Economic Growth (1990-2024)

Dependent Variable: Food Security Index				
Unrestricted Constant and Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
AVA	0.4082	0.0483	8.4433	0.0000
GDPPC	-0.1163	0.0507	-2.2951	0.0218
FI	0.1557	0.0691	2.2542	0.0243
M2	0.2450	0.0185	13.2756	0.0000
UPG	-3.7855	0.3503	-10.8061	0.0000
C	0.0025	0.0036	0.6881	0.4915

Source: Author's calculations

The coefficient of Broad Money Supply (M2) is 0.2450 (p-value = 0.0000), which means that monetary expansion creates the liquidity, investment opportunities and financial accessibility, which in turn leads to better food security. From a statistical perspective, the result points to the beneficial role of money supply on financing agricultural activities and market operations and on productive investment, thus positively impacting food security. This discovery is consistent with the Neoclassical Growth Theory (Solow Model) which holds that the accumulation of capital and its financial development are important

in achieving long-run economic growth and welfare gains. More resources allow for investments in agricultural infrastructure, technology and production, which enhance access and availability to food. Hasan and Adnan (2025) reached the same conclusion: financial and economic development has positive impact on food security in emerging economy.

GDP per capita (GDPPC) has a negative and statistically significant effect on food security, with a coefficient of -0.1163 (p-value = 0.0218). The result suggests that food security of all socio-economic groups is not necessarily linked with economic growth. On a statistical level, the negative coefficient implies there is a risk to food access for lower income groups, due to the benefits of economic growth, and therefore this could be an indication that the benefits of economic growth are not evenly shared. This result is contrary to the well-established belief of the Solow Growth Theory, that economic growth leads to welfare and living standards gains, however, it is in line with the Entitlement Theory of Amartya Sen. Sen said "growth, if it takes place at the wrong time, or with a lack of equity, can lead to people not being able to have better access to food and essential resources. This is in line with Allaoua and Krelifa (2026) who found that food security cannot be achieved in the absence of inclusive economic and social policies despite an economic growth.

The Urban Population Growth (UPG) variable has a negative and significant coefficient of -3.7855 (p-value = 0.0000) indicating that high urbanization rates put a high pressure on food security and resource allocation. On a statistical basis, this implies that for every increase in urban population growth, there may be a corresponding decrease in land for agriculture, an increase in food demand, and an imbalance in food supply resulting in a deterioration of food security. This has been established and helps support the Agricultural Productivity Theory, which states that urban expansion can lead to agricultural productivity decline and risk sustainable food production if it occurs in large quantities. In addition, the pace of urbanisation could lead to greater food imports and to the strain of food distribution networks. This is in line with the findings of Miladinov (2023) and Jambor and Elias (2024), which indicated that the negative impact of population growth and urbanization on food security in developing countries.

Error Correction Analysis

The short-run ECM estimates of food security and its determinants are provided in Table 5.5 for the developing countries for the period 1990-2024. The most important result is the coefficient that is -0.1226 with the probability value of 0.0000 which is negative and highly significant.

Table 5: Error Correction Estimates of Food Security, Agricultural Output, and Economic Growth (1990-2024)

ECM Regression				
Unrestricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
COINTEQ01	-0.1226	0.0182	-6.7376	0.0000
D(AVA)	-0.1189	0.1158	-1.0276	0.3042
D(GDPPC1)	0.0001	0.0201	0.0050	0.9960
D(FI)	-0.0091	0.0478	-0.1912	0.8484
D(M2)	-0.0545	0.0327	-1.6670	0.0957
D(UPG)	0.8781	0.4945	1.7760	0.0759
C	14.3775	2.0191	7.1207	0.0000

Source: Author's calculations

The negative sign of COINTEQ01 indicates the presence of long-run relationship among the variables and the high probability value meets the conditions of cointegration. The coefficient value of -0.1226

means that about 12% of the short run disequilibrium is adjusted towards the long run equilibrium every year.

The short-run results also indicate a negative relationship between the change of Money Supply (M2) and the change of food security in the short-run, and a positive and weak relationship between the change of Urban Population Growth (UPG) and the change of food security in the short-run. In the short run, however, AVA, GDPPC and FI are not statistically significant.

The aim of this study was to conduct an econometric analysis of food security determinants in the developing world from 1990 to 2024 through the panel method. In the long period, the results indicated that Agricultural Value Added (AVA), Food Imports (FI) and Money Supply (M2) are found to be positively and significantly affecting food security, while GDP per capita (GDPPC) and Urban Population Growth (UPG) are found to be negatively affecting food security.

The sign and significance of the error correction term proved that the variables were in a long run equilibrium, as was confirmed in the ECM results. In conclusion, the study findings indicate that agricultural production, food imports and monetary expansion are beneficial for food security while fast urbanization poses a threat to food security in developing countries.

CONCLUSION AND RECOMMENDATIONS

This study has investigated the factors determining food security in developing countries in the 1990–2024 period, employing a comprehensive panel econometric model. It was done using descriptive statistics, correlation analysis, Panel unit root tests, Panel ARDL long-run estimation and Error Correction Model (ECM) analysis to determine the long-run equilibrium relationship and the short-run dynamics among the selected variables.

The empirical results indicate that the food security is greatly affected by a mix of agricultural, economic and demographic characteristics. The Agricultural Value Added (AVA) was determined as a positive factor of food security, showing that food security can be enhanced by higher agricultural productivity, especially in developing countries. The positive correlation among food imports and food security indicates that the greater food import reliance would enhance food security for import dependent countries in the event of supply limitations and would help to fill food demand. This was also observed to be a positive relationship between Money Supply (M2) and food security, which indicate that improved liquidity conditions and economic activity lead to better purchasing power and access to food.

In the long run, however, GDP per capita (GDPPC) was found to have a negative relationship with food security, meaning that economic growth does not necessarily lead to better food security. This could be a sign of income inequality or lack of effective economic allocation. Rapid urbanization, as measured by Urban Population Growth (UPG), also had a negative impact on food security, indicating that if not managed appropriately, the rapid growth of urban centers puts pressure on food demand, food infrastructure, and supply systems, leading to deterioration in food security results.

The results of the panel unit root tests indicated a mixed order of integration of the variables and thus supported the use of the Panel ARDL approach. The long run estimates verified that the relationships between the variables were stable and the ECM result revealed that the error correction term was significant and negative, meaning that short run disequilibrium reverts to long run equilibrium over time. This validates the stability of the model and the presence of long term relationship between food security and its determinants.

In conclusion, it can be argued that food security in developing countries is the result of a combination of agricultural performance, reliance on trade, money supply, economic structure and population

growth. Of these, agricultural productivity and food imports are a key factor towards food security, and the high growth of urban populations poses a significant challenge to long-term food security.

Policy Implications

The following recommendations are suggested, based on the empirical findings:

- Food availability and food stability can be improved significantly through better use of modern farming methods, improved irrigation technologies and efficient use of inputs in farming.
- Food import systems can be strengthened to help meet a steady demand and mitigate food production shortages.
- Monetary stability is a key element of food access by ensuring purchasing power and food price stability.

Limitation

The present study has a few drawbacks.

- The study uses secondary data that may be subject to measurement errors and/or inconsistencies in reporting.
- Other important variables like climate change, food price volatility and political instability were not analysed.
- The study is done at the panel level and therefore can mask country specific differences and country specific heterogeneity.
- The sample period (1990-2024) may not fully reflect very recent economic and global shocks to food security.
- The results are subject to the model used (Panel ARDL) and might vary slightly if using other models.

REFERENCES

Aghaloo, K., & Sharifi, A. (2023). A GIS-based agroecological model for sustainable agricultural production in arid and semi-arid areas: The case of Kerman province, Iran. *Current Research in Environmental Sustainability, 6*, 100230.

Ali, E. B., Gyamfi, B. A., Bekun, F. V., Ozturk, I., & Nketiah, P. (2023). An empirical assessment of the tripartite nexus between environmental pollution, economic growth, and agricultural production in Sub-Saharan African countries. *Environmental Science and Pollution Research, 30*(27), 71007–71024.

Allaoua, S., & Krelifa, S. (2026). The interrelationship between food security and economic growth: A case study of Algeria (2020–2025). *Revue de Recherches et Etudes Scientifiques, 20*(1), 935–950.

Asim, H., & Akbar, M. (2019). Sectoral growth linkages of agricultural sector: Implications for food security in Pakistan. *Agricultural Economics/Zemědělská Ekonomika, 65*(6).

Atchadé, M. N., & Nougbodé, H. (2024). Statistical investigation on the relationship between climate change, food availability, agricultural productivity, and economic expansion. *Heliyon, 10*(12).

Batool, S., & Sheikh, M. R. (2024). Analyzing the role of food security, agricultural exports and income inequality in shaping economic growth trajectories in developing countries. *Journal of Contemporary Macroeconomic Issues, 5*, 91–106.

Bello, M. M., Yahaya, J. U., & Adamu, I. (2024). An analysis of sustainable agricultural productivity and food security in Nigeria. *Journal of Political Discourse, 2*(1), 2.

Bozsik, N., Cubillos T, J. P., Stalbek, B., Vasa, L., & Magda, R. (2022). Food security management in developing countries: Influence of economic factors on their food availability and access. *PLOS ONE, 17*(7), e0271696.

Ceesay, E. K., & Ndiaye, M. B. O. (2022). Climate change, food security and economic growth nexus in the Gambia: Evidence from an econometrics analysis. *Research in Globalization, 5*, 100089.

Christiaensen, L., Demery, L., & Kuhl, J. (2011). The evolving role of agriculture in poverty reduction: An empirical perspective. *Journal of Development Economics, 96*(2), 239–254.

Dethier, J.-J., & Effenberger, A. (2011). *Agriculture and development: A brief review of the literature* (Policy Research Working Paper No. 5553). World Bank. https://hdl.handle.net/10986/3323

El Weriemmi, M., & Bakari, S. (2024). *The impact of agricultural exports on economic growth: New evidence from low-income countries*. https://mpra.ub.uni-muenchen.de/id/eprint/121631

Emami, M., Almassi, M., Bakhoda, H., & Kalantari, I. (2018). Agricultural mechanization, a key to food security in developing countries: Strategy formulating for Iran. *Agriculture & Food Security, 7*(1), 24.

Fan, L., Aspy, N. N., Smrity, D. Y., Dewan, M. F., Kibria, M. G., Haseeb, M., Kamal, & Rahman, M. S. (2024). Moving towards food security in the South Asian region: Assessing the role of agricultural trade openness, production and employment. *Heliyon, 10*(13).

Fernandes, M., & Samputra, P. L. (2022). Exploring linkages between food security and economic growth: A systematic mapping literature review. *Slovak Journal of Food Sciences, 16*.

Food and Agriculture Organization. (2023). *The state of food security and nutrition in the world*. https://doi.org/10.4060/cc3017en

Food and Agriculture Organization of the United Nations. (2021). *The state of food security and nutrition in the world 2021*. FAO. https://www.fao.org/3/cb4474en/cb4474en.pdf

Ghanem, H. (2015). *Agriculture and rural development for inclusive growth and food security in Morocco* (Global Economy & Development Working Paper 82). Brookings Institution. https://www.brookings.edu/wp-content/uploads/2016/07/Agriculture_WEB_Revised.pdf

Ghosh, R. K., Otto, I. M., & Rommel, J. (2022). Food security, agricultural productivity, and the environment: Economic, sustainability, and policy perspectives. *Frontiers in Environmental Science, 10*, 916272.

Hasan, M. M., & Adnan, A. T. M. (2025). Nexus between environmental sustainability, energy intensity and food security: Evidence from emerging economies. *Journal of Business and Socio-Economic Development, 5*(2), 139–154.

Headey, D., & Hirvonen, K. (2023). Higher food prices can reduce poverty and stimulate growth in food production. *Nature Food, 4*(8), 699–706.

Idisi, P. O. (2021). Food security, economic growth and price stability nexus and conceptual issues. *Economic and Financial Review, 59*(4), 9–31.

Iftikhar, S., & Mahmood, H. Z. (2017). Human capital development and food security nexus: An empirical appraisal from districts of Punjab province. *Journal of Food and Drug Research, 1*(1), 3–7.

Independent Evaluation Group. (2011). *Growth and productivity in agriculture and agribusiness: Evaluative lessons from World Bank group experience*. World Bank. https://openknowledge.worldbank.org/handle/10986/2279

Jambor, A., & Elias, B. A. (2024). Determinants of food security: A comprehensive analysis across East, South, and Southeast Asia. *Journal of Sustainability Research, 6*(2).

Khalifa, J. (2025). The impacts of climate change, agricultural productivity, and food security on economic growth in Tunisia: Evidence from an econometrics analysis. *Research on World Agricultural Economy*, 577–599.

Khan, F. U., Nouman, M., Negrut, L., Abban, J., Cismas, L. M., & Siddiqi, M. F. (2024). Constraints to agricultural finance in underdeveloped and developing countries: A systematic literature review. *International Journal of Agricultural Sustainability, 22*(1), 2329388.

Koning, N. (2017). *Food security, agricultural policies and economic growth: Long-term dynamics in the past, present and future*. Routledge.

Kumar, A., & Sharma, P. (2022). Impact of climate variation on agricultural productivity and food security in rural India. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4144089

Laghari, F., Ahmed, F., Ansari, B., & Silveira Ferreira, P. J. (2025). Agricultural land, sustainable food and crop productivity: An empirical analysis on environmental sustainability as a moderator from the economy of China. *Sustainability, 17*(5), 1980.

Lee, D. J., & Son, J. C. (2016). Economic growth and income inequality: Evidence from dynamic panel investigation. *Global Economic Review, 45*(4), 331–358.

Liu, H., & Yang, T. (2015). Explaining the productivity growth gap between China and India: The role of structural transformation. *The Developing Economies, 53*(2), 100–121.

Ludher, E. K., & Teng, P. (2026). Agricultural development and food security in Singapore. In *Sustainable agriculture and food security in Southeast Asia: Towards climate resilience and digitalization* (pp. 17–30). Springer..

Miladinov, G. (2023). Impacts of population growth and economic development on food security in low-income and middle-income countries. *Frontiers in Human Dynamics, 5*, 1121662..

Mozumdar, L. (2012). Agricultural productivity and food security in the developing world. *Bangladesh Journal of Agricultural Economics, 35*, 53–69.

Mugizi, F. M. (2025). Extension advice, agricultural productivity, and food security in Tanzania. *Food and Energy Security, 14*(1), 47–70.

Mukherjee, A. N., & Kuroda, Y. (2003). Productivity growth in Indian agriculture: Is there evidence of convergence across states? *Agricultural Economics, 29*(1), 43–53.

Nosov, V. V., Zhichkin, K. A., Zhichkina, L. N., Novoselova, S. A., Fomenko, N. L., & Bespamjatnova, L. P. (2020). Subsidizing agricultural production of the region to achieve food security. In *IOP Conference Series: Earth and Environmental Science* (Vol. 548, No. 2, p. 022077). IOP Publishing.

Osabohien, R., Osabuohien, E., & Urhie, E. (2018). Food security, institutional framework and technology: Examining the nexus in Nigeria using ARDL approach. *Current Nutrition & Food Science, 14*(2), 154–163.

Othmani, A., El Weriemmi, M., & Bakari, S. (2024). Effect of food exports on economic growth: Fresh insights from Italy. *Journal of Developing Economies, 9*(2), 185–216.

Ozturk, I. (2015). Sustainability in the food-energy-water nexus: Evidence from BRICS (Brazil, the Russian Federation, India, China, and South Africa) countries. *Energy, 93*, 999–1010.

Pawlak, K., & Kołodziejczak, M. (2020). The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production. *Sustainability, 12*(13), 5488.

Pourreza, A., Geravandi, S., & Pakdaman, M. (2018). Food security and economic growth. *Journal of Nutrition and Food Security, 3*(3), 113–115.

Rasiah, R. (2026). Strengthening agricultural sustainability and food security in Southeast Asia. In *Sustainable agriculture and food security in Southeast Asia: Towards climate resilience and digitalization* (pp. 1–16). Springer.

Rasyid, H., & Ningsih, G. M. (2024). Application of sustainable agricultural technology to increase productivity and food security. *Journal of World Science, 3*(4), 500–506.

Rosegrant, M. W., & Evenson, R. E. (1995). *Total factor productivity and sources of long-term growth in Indian agriculture*. International Food Policy Research Institute.

Ruane, J., & Sonnino, A. (2011). Agricultural biotechnologies in developing countries and their possible contribution to food security. *Journal of Biotechnology, 156*(4), 356–363.

Saragih, U. H., & Ovalti, T. (2026). The role of sustainable agriculture in supporting economic development and food security: A literature review 2019–2024. *Journal of Economics, Management, Development, and Education, 1*(1), 1–8.

Seifu, A., & Eshetu, F. (2026). Unemployment, migration and food insecurity in developing countries: A systematic review. *Ethiopian Journal of Business and Social Science, 9*(1), 97–118.

Sheikh, M. R., Ali, N. A., & Aslam, A. (2022). Food wastage footprint, food security, environment and economic growth nexus in developing countries. In *Agricultural Waste—New Insights*. IntechOpen.

Shuaib, I. M., & Ndidi, D. E. (2013). Capital formation: Impact on the economic development of Nigeria 1960–2013. *European Journal of Business, Economics and Accountancy, 3*(3), 23–40.

Song, Y., Song, Y., & Wang, Q. (2026). Smart agriculture development: How can rural digital transformation enhance the resilience of food security? *Foods, 15*(3), 426.

Swietlik, K. (2018). Economic growth versus the issue of food security in selected regions and countries worldwide. *Problems of Agricultural Economics, 3*, 127–149.

Wolf, E. C. (1987). *Raising agricultural productivity*. W. W. Norton. https://ageconsearch.umn.edu/record/196764/files/Mozumdar.pdf

World Bank. (2008). *World development report 2008: Agriculture for development*. World Bank.

Zepeda, L. (2001). *Agricultural investment, production capacity and productivity in developing countries*. Food and Agriculture Organization of the United Nations.