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Research article

Does Socioeconomic and Environmental Factors Exacerbate Undernourishment in Asia and Africa?

Neng Zulfa Azhar[1*], Dito Alif Pratama[2], Amanca Pamalina Lapasa[3]

[1] Department of Economics, Faculty of Economics and Business, Universitas Islam Internasional Indonesia, Depok, Indonesia
[2] Department of Sharia Economics, Faculty of Sharia and Law, Universitas Perguruan Tinggi Ilmu Al-Qur'an, Jakarta, Indonesia
[3] Department of Public Administration, Faculty of Social and Political Sciences, Universitas Airlangga, Surabaya, Indonesia
* Corresponding author email: zulfa.azhar@uiii.ac.id

ABSTRACT

This study investigates the impact of socioeconomic and environmental factors on undernourishment, across seven selected countries in Asia and Africa from 2001 to 2020. Employing a fixed-effects panel regression, we analyze the impact of GDP per capita, female employment in agriculture, electricity access, greenhouse gas emissions, and foreign direct investment on the incidence of undernourishment. Our findings indicate that higher GDP per capita, greater female participation in agricultural labor, and improved electricity access are associated with significant reductions in undernourishment. Conversely, elevated greenhouse gas emissions and increased foreign direct investment appear to exacerbate undernourishment. These results underscore the critical need for policymakers to prioritize investments in sustainable agricultural practices, emphasizing low-emission technologies that enhance both efficiency and product quality. Furthermore, expanding electrification and empowering women in agriculture are crucial strategies for strengthening household food security by increasing food availability and diversity. This study provides an integrated perspective on the complex challenge of undernourishment, highlighting the dynamic interplay between economic and environmental policies.

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1. INTRODUCTION

The foundation of the modern food security paradigm was laid in the mid-1970s, notably during the 1974 World Food Summit. Following this, the 1975 United Nations World Food Conference's Committee on World Food Security articulated food securiy through three core dimensions: availability, access, and utilization (Devesh & Abdullah (2020). According to the United Nations International Children's Emergency Fund (UNICEF), food security exists when every person consistently enjoys unrestricted access to adequate amounts of nutritious food that fulfill both their dietary needs and individual preferences, thereby supporting a vibrant and healthy life (Bonuedi et al., 2020). Food security has emerged as a central focus within international policy frameworks, driven by the urgent need to address malnutrition and hunger—issues that continue to pose serious challenges across numerous regions worldwide (Smith et al., 2023). By 2030, "Zero Hunger" one of the Sustainable Development objectives, seeks to put an end to hunger and guarantee that everyone, especially the poor and those in vulnerable situations, has access to enough healthy food (United Nations, 2020). In developing countries, sizable segments of the population are disproportionately affected by elevated rates of undernourishment. The Food and Agriculture Organization (FAO) employs the Prevalence of Undernourishment (PoU) as a primary metric to estimate the share of individuals who fail to consume sufficient calories to meet their basic energy requirements (Molotoks et al., 2021).

The World Health Organization (WHO) observed a gradual rise in hunger rates beginning around 2010, despite earlier hopes for a sustained decline. Notably, in 2020, the prevalence of undernourishment surged sharply from 8.4 percent in 2019 to approximately 9.9 percent, marking a significant escalation in global food insecurity (World Health Organization, 2021). Asia is home to over half of the world's 418 million undernourished people, whereas Africa accounts for more than one-third, totaling around 282 million individuals. Among FAO regions, Africa exhibits the highest estimated prevalence of undernourishment, a situation that has worsened markedly in recent years due to the compounded effects of the COVID-19 pandemic, climate change, economic instability, and other contributing factors (World Bank, 2021). According to World Bank data, countries showing significant trends in food insecurity—reflected by high levels of undernutrition across Asia and Africa—are illustrated in Figure 1. The data summarized above span a decade and cover seven countries across Asia and Africa characterized by persistently high undernourishment rates. Figure 1 highlights Afghanistan as having the highest prevalence in 2020, at 29.8%, followed by The Gambia (21.6%), Pakistan (16.9%), Iraq (15.9%), Nigeria (12.9%), Sudan (12.8%), and Bangladesh (11.9%). Notably, all seven countries saw their undernourishment rates rise between 2019 and 2020, a surge largely attributed to the disruptive effects of the COVID-19 pandemic.

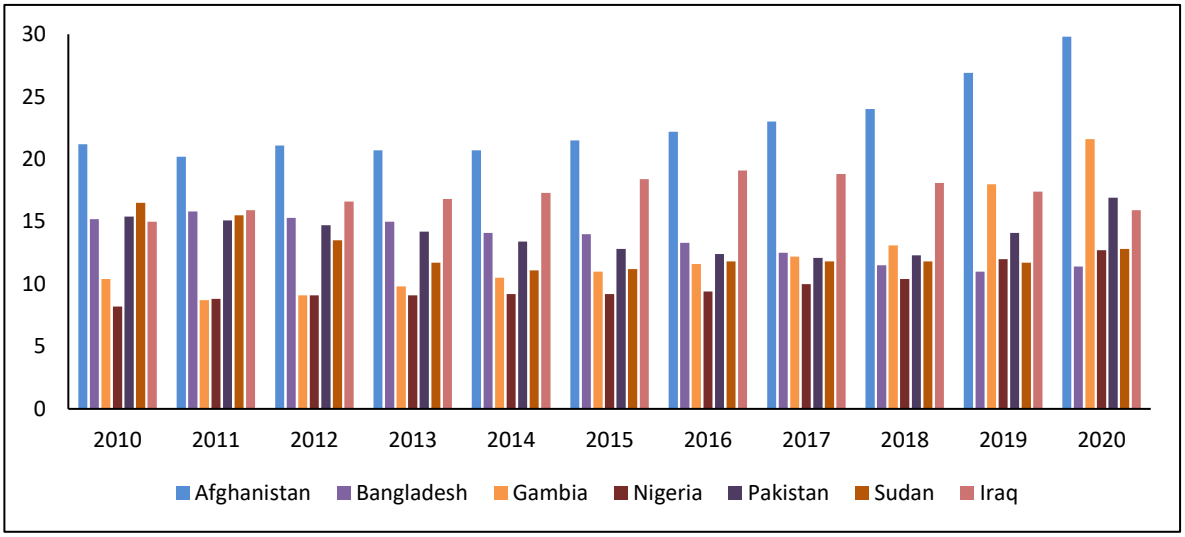

Figure 1. Prevalence of High Malnutrition in Asia and Africa (% of Population), 2010-2020
Source: World Bank (2021)

Several studies have investigated the causes of high rates of hunger and undernourishment in various countries, with the majority of studies focusing on population growth on the prevalence of undernourishment (Devesh & Abdullah, 2020; and Ahmad & Ali, 2016), socioeconomic factors such as per capita GDP, unemployment, and inflation rate (Devesh & Abdullah, 2020). Study by Awad (2023) examines the socioeconomic and institutional factors influencing food security in 107 developing countries across Africa, Asia, and Latin America during the period 2000–2019. The results suggest that per capita income plays a pivotal role in diminishing undernourishment rates, as increases in income substantially enhance the ability to obtain safe and nutritious food. This aligns with Clapp & Moseley (2020), who said that inadequate salaries impede individuals from affording food, therefore obstructing the attainment of Sustainable Development Goal 2 "Zero Hunger".

Other studies found that a factor that contributes to food insecurity is climate change (Shah et al., 2020). Adesete et al. (2022) found that a rise in greenhouse gas emissions increased the prevalence of undernourishment, impacting a decline in food security in sub-Saharan Africa. As well as Molotoks et al. (2021); and Hall et al. (2017) used the Intergovernmental Panel on Climate Change special report on emission scenarios projections to measure the influence of climate change on food security, the results asserted that climate change scenarios have a negligible impact on future crop yields. A study that conducted by Agidew & Singh (2018) analyzing the factors influencing food security among farming households in the rural Teleyayen sub-watershed, Ethiopia was also showed that Among the surveyed households, 79.1% were identified as food insecure, with primary drivers

including limited access to farmland, persistent poverty, frequent droughts, climate change impacts, and ongoing land degradation—all of which undermine food security.

Food security at the household level centers on three critical dimensions: (a) agricultural food production, (b) allocation of household income towards food purchases, and (c) guaranteeing sufficient intake of protein, energy, and essential micronutrients for every member of the household Herforth (2012). The study conducted by Asadullah & Kambhampati (2021) examines the increasing participation of women in agriculture amidst a global decline in female labor force participation in other sectors. The study highlights that empowering women is fundamental to strengthening food security at the household level. Building on this, it asserts that for the increasing involvement of women in agriculture to translate into genuine empowerment and improved food security, decisive policy actions are needed—not only within the agricultural domain but also across broader socio-economic sectors. As noted by Anik & Rahman (2021) in their study, Evidence suggests that empowering women in agriculture and reducing the gender disparities in empowerment lead to enhanced production efficiency.

Food security can additionally be examined through the lens of Foreign Direct Investment (FDI). In his study, Samdrup et al. (2023) explored the relationship between FDI and food security. Although a positive relationship between FDI and economic growth is widely recognized, the connection between FDI and food security remains ambiguous. Through a review of 24 previous studies, this study determined that FDI generally does not exert a significant influence on food security. Nevertheless, when FDI is measured as stock—the cumulative total of investments—the effect tends to be negative, whereas viewing FDI as flow—the investments received during a defined timeframe—yields a comparatively minor or negligible impact. Study by Bhat et al. (2024) highlights that FDI can have a beneficial effect on food security by lowering levels of food insecurity. This positive influence operates through several channels, including bolstering local production capacity, facilitating technology transfer, and enhancing market access and infrastructure. By promoting investment within the agricultural sector, FDI supports the uptake of more efficient farming techniques and fortifies food distribution networks, ultimately increasing both the availability and accessibility of food at the household level (Zhao & Chen, 2023).

Although earlier study has predominantly concentrated on economic indicators and climate change variables in examining food security, such approaches often fall short of capturing the multifaceted nature of food insecurity—particularly in regions burdened by severe undernourishment. Addressing this shortcoming, the present study integrates environmental and social factors alongside economic considerations, offering a more nuanced and comprehensive framework for understanding the complexities of food security. Incorporating female employment in agriculture enables this study to explore how gender dynamics within food production shape food security outcomes. By considering economic, environmental, and social drivers collectively, the study offers a richer understanding of the underlying factors that contribute to food insecurity, with a particular emphasis on the critical role women play in agricultural systems and their influence on overall food security.

This study's originality stems from its comprehensive, multidimensional approach that synthesizes gender, environmental, and economic variables to offer a deeper understanding of food insecurity. Utilizing panel data regression with a fixed effects model, the study is well-positioned to analyze the interplay among diverse factors across multiple countries and over an extended time frame. By controlling for unobserved heterogeneity, this methodological approach effectively addresses the intricate and interrelated determinants of food security. The primary goal is to investigate how these multifaceted factors collectively impact food security, with particular attention to the influence of gender roles within agricultural systems. In doing so, this study bridges a significant gap in the current literature and seeks to inform more targeted and impactful policy interventions aimed at fostering sustainable food security. The rest of this article is organized as follows, part two details the research methods; part three presents the findings alongside a thorough discussion; and part four explores the implications of the results and offers policy recommendations.

2. RESEARCH METHODS

This study employs a quantitative methodology to investigate the influence of socioeconomic and environmental variables, i.e. GDP per capita, female agricultural employment, greenhouse gas emissions, electricity access, and foreign direct investment—on food security, as measured by the prevalence of undernourishment, across seven selected countries between 2001 and 2020. The study's sample comprises the Afghanistan, Bangladesh, Gambia, Iraq, Nigeria, Pakistan, and Sudan. These countries were selected based on data from the World Bank and the United Nations, chosen specifically for their location in Asia and Africa and their notably high rates of undernourishment. Consequently, the selection criteria for this study focused on countries situated in Asia and/or Africa that have exhibited the highest undernourishment rates over the past twenty years, coupled with the availability of comprehensive published data. All relevant data for the variables and selected countries were sourced from the World Bank database.

Table 1. The Variables Description

Variables	Description	Sources
Prevalence of Undernourishment (PoU)	Prevalence of Undernourishment (% of population)	WDI, World Bank
GDP per capita (GDP)	GDP real per capita (current USD)	WDI, World Bank
Female employment in agriculture (female)	Employment in agriculture, female (% of female employment) (modelled ILO estimate)	WDI, World Bank
Greenhouse gas emissions (GHG)	Total greenhouse gas emissions (kt of CO2 equivalent)	WDI, World Bank
Access to electricity (electricity)	Access to electricity (% of population)	WDI, World Bank
Foreign Direct Investment (FDI)	Foreign direct investment, net inflows (% of GDP)	WDI, World Bank

This study employed a fixed effects panel regression model to investigate the relationships between multiple determinants and food security. The data utilized were primarily drawn from the World Development Indicators (WDI) database, supplemented by information from reputable sources including the World Bank, the FAO, the United Nations (UN), the UN Women, the WHO, and other authoritative institutions. The analysis incorporates variables such as the prevalence of undernourishment, GDP per capita, female employment in agriculture, greenhouse gas emissions, access to electricity, and foreign direct investment. These indicators collectively capture essential economic, environmental, and social dimensions critical to comprehending the complexities of food security. To account for unobserved heterogeneity both across countries and over time, the fixed effects model was utilized. This approach allows the analysis to control for country-specific characteristics, thereby yielding a more reliable assessment of the relationships among the variables. The fixed effects model can be represented by the following equation:

$$PoU_{it} = \alpha_0 + \beta_1 log(GDP)_{it} + \beta_2 female_{it} + \beta_3 GHG_{it} + \beta_4 electricity_{it} + \beta_5 FDI_{it} + \varepsilon_{it} \quad (1)$$

where, PoU represents prevalence of undernourishment for the dependent variable; α_0 is the intercept for each cross-sectional unit, capturing the unique characteristics of each individual unit; β_1 to β_5 are the regression coefficients of the independent variables; $log(GDP)$ refers to the logarithm of GDP real per capita; $female$ represents female employment in agriculture, expressed as a percentage of the total agricultural workforce; GHG denotes the total greenhouse gas emissions in kilotons of CO_2 equivalent; $electricity$ refers to the percentage of the population with access to electricity; FDI represents foreign direct investment, measured as net inflows as a percentage of GDP; ε is the error term, capturing the unobserved factors affecting the dependent variable; and The index i refers to the individual unit, while t refers to the time period of observation.

3. RESULTS AND DISCUSSION

3.1. Results

This study draws on cross-sectional data from seven countries combined with a 20-year time series spanning 2001 to 2020. Descriptive statistics presented in Table 2 reveal that the prevalence of undernourishment averages 16.55%, with a standard deviation of 6.98%, and spans a range from 6.6% to 47.8%, highlighting moderate variability in food insecurity across the selected nations. Meanwhile, GDP per capita exhibits an average value of USD.1,494.91, fluctuating between USD.183.53 and USD.6,612.90, accompanied by a standard deviation of USD.1,390.05, underscoring significant economic heterogeneity within the sample. Female employment in agriculture displays considerable variation, averaging 56.34% and ranging from 20.23% to 88.71%. Similarly, total greenhouse gas emissions show substantial fluctuation, with a mean of 159.06 kilotonnes of CO_2 equivalent, a standard deviation of 124.58, and values spanning from as low as 1.53 kt to as high as 509.13 kt. Access to electricity exhibits a wide range, spanning from 4.07% to an unusual upper bound of 160.00%, with an average coverage of 60.39% and a standard deviation of 23.97%, reflecting significant disparities in energy infrastructure accessibility. Foreign direct investment (FDI), expressed as a percentage of GDP, varies from -4.54% to 10.46%, with a mean of 1.76% and a standard deviation of 2.12%, indicating notable variation in investment inflows across the countries examined.

Table 2. The Result of Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
PoU	16.55	6.98	6.60	47.80
GDP	1,494.91	1,390.05	1,83.53	6,612.90
Female	56.34	19.22	20.23	88.71
GHG	159.06	124.58	1.53	509.13
Electricity	60.39	23.97	4.07	160.00
FDI	1.76	2.12	-4.54	10.46

Table 3 displays the outcomes of the panel unit root tests, revealing that all variables exhibit stationarity, though at varying orders of integration. Notably, variables including the PoU, GDP per capita, female employment in agriculture, the FDI, and the electricity are stationary in levels, indicating that differencing is not necessary to render these series stationary. Conversely, GHG emissions achieve stationarity only after second differencing, indicating that this variable follows an integrated process of order two or *I*(2). These findings affirm the appropriateness of the dataset for subsequent analysis, while underscoring the importance of considering varying integration orders when interpreting the model's results.

Table 3. The Result of Unit Root test

Variables	Stage	LLC-stat	Prob.
PoU	Level	-2.207	0.0139
log(GDP)	Level	-1.994	0.0231
Female	Level	-1.932	0.0266
ΔGHG	Second Difference	-1.841	0.0328
Electricity	Level	-3.379	0.0004
FDI	Level	-4.043	0.0000

Selecting the most suitable regression model for panel data analysis involves conducting three sequential tests, (1) the Chow test, (2) the Hausman test, and (3) the Lagrange Multiplier test. These procedures are designed to guide the choice among the pooled OLS (common) effects model, fixed effects model, and random effects model, ensuring the optimal specification for the data at hand.

Table 4. The Results of Model Selection test

Selection test	Statistics	*p*-value	Selected Model
Chow (*p*-value > F)	2.45	0.0126	Fixed Effect
Hausman (*p*-value > chi. sq)	10.90	0.0435	Fixed Effect
Lagrangian Multiplier (*p*-value > chi-bar.sq)	162.68	0.0000	Random Effect

Table 4 reports the identifies the optimal model based on diagnostic testing. The Chow test was applied to assess whether the fixed effects model offers a better fit than the common effects model, with a *p*-value of 0.0126, which is less than the 0.05 threshold, the results indicate that the fixed effects model is statistically preferred over the common effects model. The Hausman test was conducted to distinguish between the fixed effects and random effects models, with a *p*-value of 0.0435, which falls below the 0.05 significance level, the test favors the fixed effects model over the random effects alternative. Meanwhile, the Lagrange Multiplier test is used to determine whether the random effects model is more appropriate than the common effects model. The Lagrange Multiplier test yields a *p*-value of 0.00, well below the 0.05 threshold, indicating that the random effects model is preferable to the common effects model. However, considering the results from all three tests collectively across the sampled countries, the fixed effects model emerges as the most appropriate choice for this analysis.

Table 5. The Result of Model Estimation using Fixed Effect

Dependent variable = PoU			
Variables	**Coefficient**	**Driscoll-Kraay (std. error)**	**t-statistic**
Constant	62.001***	8.145	7.612
log(GDP)	-7.050***	2.034	-3.466
Female	-0.304***	0.068	-4.470
GHG	0.015**	0.006	2.502
Electricity	-0.179***	0.045	-3.977
FDI	0.750***	0.232	3.233
R^2	0.490		
Observations	139		
Countries	7		
Diagnostics test	**Statistics**	***p*-value**	
Normal	1.702	0.426	
Wooldridge	506.272	0.000	
Breusch-Pagan	35.160	0.000	
Pesaran CD	-1.712	0.086	

Note: significance is reported in asterisks at *** p-value < 0.01, ** p-value < 0.05, and * p-value < 0.10

Table 5 presents the results of the normality test, revealing a p-value of 0.4264, which exceeds the 5% significance threshold and thus indicates that the residuals follow a normal distribution. In contrast, the outcome of the autocorrelation test, where a p-value of 0.000 suggests the presence of serial correlation within the residuals. Similarly, the details the heteroskedasticity test results, yielding a *p*-value of 0.000, which confirms the presence of heteroscedasticity within the panel data model. Meanwhile, presents Pesaran's cross-sectional dependence (CD) test results, with a p-value of 0.086. Since this value exceeds the 5% significance level, there is insufficient evidence to reject the null hypothesis, indicating no significant cross-sectional dependence among the units. In summary, although the residuals show normality and there is no evidence of cross-sectional dependence, the model is affected by autocorrelation and heteroscedasticity. To correct for these issues and produce robust standard errors, the fixed effects model will be estimated using Driscoll-Kraay standard errors. This approach is preferred because it accommodates heteroscedasticity, autocorrelation, and possible cross-sectional dependence, thereby increasing the reliability of statistical inference (Hoechle, 2007).

Table 5 presents the findings from the fixed effects panel regression analysis, demonstrating that all the independent variables—GDP per capita, female employment in agriculture, GHG

emissions, access to electricity, and foreign direct investmen—collectively exert a statistically significant impact on the prevalence of undernourishment. This is evidenced by the F-statistic p-value of 0.000, which is well below the 0.05 significance threshold. An R^2 value of 0.490 suggests that the set of independent variables collectively accounts for approximately 49% of the variation in the dependent variable, the PoU, while the remaining 51% is attributable to factors not captured within this study. Examining the variables individually, the logarithm of per capita GDP reveals a statistically significant effect, with a p-value of 0.003 (less than the 0.01 threshold). Its coefficient, measured at -7.050, implies that a 1% increase in per capita income is associated with an estimated 0.07% decrease in undernourishment levels. The variable representing the proportion of women employed in agriculture carries a coefficient of -0.304 and is statistically significant with a p-value below 0.01 (0.000), suggesting that an increase in female agricultural employment correlates with a 0.3% reduction in the prevalence of undernourishment. Meanwhile, greenhouse gas (GHG) emissions demonstrate a positive relationship with undernourishment, evidenced by a coefficient of 0.015 and a p-value of 0.029 (less than 0.05). This indicates that for each additional kiloton of CO2 equivalent emitted, the rate of undernourishment rises by approximately 0.015%. Access to electricity shows a statistically significant negative association with undernourishment, as reflected by a p-value of 0.001 less than level significance at 0.01 and a coefficient of -0.179. This suggests that a one-percentage-point increase in the population's access to electricity corresponds to a 0.179% reduction in the prevalence of undernourishment. Conversely, the FDI exhibits a significant positive relationship with undernourishment, indicated by a p-value of 0.004 and a coefficient of 0.750, implying that a one-percent increase in FDI is associated with a 0.75% rise in the prevalence of undernourishment. rate.

3.2. Discussions

3.2.1. The Impact of GDP per capita on Prevalence of Undernourishment

The results of this analysis indicate that higher per capita GDP is significantly associated with a decrease in the prevalence of undernourishment. This result aligns with previous studies by Awad (2023); and Devesh & Abdullah (2020), which emphasize that economic growth plays a critical role in improving food security by enhancing household purchasing power, increasing access to nutritious food, and enabling better health and education services. With household incomes increasing in tandem with broader economic expansion, families gain greater capacity to secure sufficient nutrition and better living standards, which collectively help drive down undernourishment rates. However, this conclusion stands in contrast to other studies, such as that of Onatunji (2025), argues that GDP growth does not always equate to improved food security outcomes. Onatunji emphasizes that deteriorating income distribution can erode the positive effects of economic growth. Although GDP may increase, if the benefits disproportionately favor higher-income groups, marginalized populations could continue to face food insecurity or even see worsening nutritional conditions. This underscores the critical role that income inequality plays as a mediator between economic growth and food security outcomes.

These contrasting findings highlight a crucial insight although GDP per capita serves as a valuable measure of a country's economic progress, it does not fully reflect the complex ways in which economic growth influences food security within households. Consequently, policymakers should exercise caution in presuming that economic expansion by itself will adequately address undernourishment challenges. To ensure that the gains from economic growth reach all layers of society, a more comprehensive strategy is necessary—one that tackles inequality through targeted social protection initiatives, fairer food distribution mechanisms, and policies promoting rural development. Such an approach is vital for fostering inclusive progress and effectively combating undernourishment. In summary, the findings of this study affirm that rising GDP can contribute to lowering undernourishment levels; nonetheless, they also recognize that how income is distributed plays a pivotal role. Absent inclusive growth, the threat of sustained or exacerbated food insecurity persists, especially among marginalized and economically disadvantaged populations.

3.2.2. The Impact of Female Employment in Agriculture on Prevalence of Undernourishment

This research centers on countries with economies heavily reliant on the agricultural sector, where agriculture serves not only as the primary income source but also as a critical driver of national economic development. Within this framework, the rising involvement of women in agriculture is frequently regarded as a key catalyst for enhancing household food security. By gaining improved access to productive assets—such as capital, agricultural technologies, and training—women are better positioned to boost food production, thereby fostering improved nutritional status within their families. This finding is supported by Asadullah & Kambhampati (2021), who argue that the feminization of agriculture can enhance women's empowerment and improve food security. Similarly, UN Women (2022) reported that programs promoting women's empowerment have led to a 55% increase in nutritional security in developing nations. Moreover, according to estimates by the FAO, providing female farmers with equal access to productive resources could boost their yields by 20 to 30 percent. Practically speaking, this enhancement has the potential to increase food availability and diversity—especially of nutrient-rich items such as vegetables, fruits, and animal proteins—thereby improving dietary quality and lowering rates of undernourishment within households.

Nonetheless, this favorable association is not universally guaranteed. Although women's engagement in agriculture is undeniably important, their participation alone cannot drive transformative change without the backing of comprehensive structural reforms and supportive policy frameworks. Study by Rao et al. (2019) emphasize that when women are overburdened with agricultural work without adequate support systems—such as access to child care, healthcare, or water and sanitation infrastructure—the trade-off between time spent on income-generating activities and caregiving responsibilities can negatively affect child nutrition. In these circumstances, women's agricultural labor may, paradoxically, exacerbate undernourishment within their households. This paradox underscores the critical need for policy measures that go beyond merely expanding women's access to agricultural resources; they must also address and alleviate the unequal share of unpaid care responsibilities borne by women. Across many nations in Asia and Africa, women play a substantial role in agricultural production, yet their contributions frequently remain invisible and undervalued. Consequently, effective policies should encompass both economic and social aspects—formally recognizing women's labor, offering dedicated support for domestic tasks, and advancing gender equity in household decision-making processes.

In closing, although women's active involvement in agriculture holds promise for reducing undernourishment at the household level, this potential will remain unrealized without comprehensive policies that tackle underlying systemic obstacles. Absent such measures, expanding women's roles may inadvertently contribute to nutritional shortfalls, driven by the excessive demands placed upon them. Therefore, meaningful empowerment of women in agriculture must be coupled with concerted efforts to guarantee fair resource access, bolster social support structures, and implement gender-responsive development strategies—together fostering lasting progress in food security across developing nations.

3.2.3. The Impact of Greenhouse Gas Emission on Prevalence of Undernourishment

Greenhouse gas (GHG) emissions, especially carbon dioxide (CO_2), play a central role in driving global climate change, which subsequently alters environmental factors vital for food production. Shifts in rainfall patterns, escalating temperatures, and more frequent extreme weather phenomena—such as droughts and floods—pose significant threats to agricultural yields, particularly in nations where agriculture forms a substantial component of the economy. These environmental disturbances undermine both food availability and access, thereby contributing to higher rates of undernourishment. The study reveals a positive correlation between elevated greenhouse gas emissions and increased undernourishment, a linkage that aligns with evidence from multiple prior empirical investigations. For instance, Adesete et al. (2022); and Gobezie & Boka (2023) emphasized that rising GHG emissions significantly increase the prevalence of undernourishment, thereby reducing food security. Similarly, Mavodyo (2023) explains that climate change, driven by GHG emissions, negatively affects food production by altering rainfall and

temperature patterns, particularly in regions already experiencing food insecurity.

This concern is especially pertinent for the countries examined in this research—Afghanistan, Bangladesh, Gambia, Nigeria, Pakistan, Sudan, and Iraq—where agriculture continues to be a cornerstone of the economy and food insecurity poses an urgent challenge. For example, Quraishi (2021) highlights how Afghanistan's rural communities are especially vulnerable to climate-related shocks due to their heavy dependence on agriculture and limited adaptive capacity. These vulnerabilities amplify the risk of undernourishment, as ongoing greenhouse gas emissions perpetuate climatic instability. The results of this study highlight the urgent necessity for cohesive policies that bridge climate action and food security. It is imperative that governments and development agencies focus on adaptive measures aimed at strengthening the resilience of agricultural systems. Investments in early warning mechanisms, improved irrigation infrastructure, sustainable agricultural techniques, and climate-resilient crop varieties are essential to mitigating the detrimental impacts of climate variability. Moreover, tackling greenhouse gas emissions presents a dual benefit: it not only curbs climate change but also helps lower undernourishment rates by safeguarding and boosting food production capacity. While, the majority of existing literature concurs with the conclusions of this study, there is comparatively little discussion surrounding scenarios in which emissions-intensive development might temporarily enhance food access—primarily through boosted agricultural productivity fueled by energy-intensive farming methods or industrialized food systems. Nonetheless, these short-term benefits tend to be unsustainable and are eventually eclipsed by the far-reaching adverse consequences posed by long-term climate change. Therefore, although certain pathways might imply a complex or non-linear interaction between greenhouse gas emissions and nutritional outcomes, the preponderance of evidence—especially within vulnerable, agriculture-dependent regions—firmly indicates that rising GHG emissions intensify food insecurity.

3.2.4. The Impact of Access to Electricity on Prevalence of Undernourishment

The negative correlation observed between access to electricity and undernourishment highlights the pivotal role that improved electrification plays in bolstering food security. By enabling the use of irrigation systems, water pumps, and agricultural machinery, electricity access can significantly enhance productivity, resulting in greater crop yields. Furthermore, electrification facilitates improved food storage and refrigeration, which diminishes post-harvest losses and spoilage. Such improvements contribute to a more reliable and sustained food supply year-round, particularly in areas vulnerable to seasonal scarcity. This study In line with findings by Candelise et al. (2021); and Saing (2018), electrification supports the adoption of modern agricultural technologies, such as automated irrigation, cold-chain logistics, and mechanized processing, which not only improve yields but also preserve food quality. This, in turn, directly bolsters food availability and facilitates access to a wider variety of nutrient-dense foods. Beyond its immediate effects, electricity access also indirectly promotes food security by fostering broader socio-economic development: it enables the growth of small enterprises, expands employment prospects, enhances healthcare delivery—including cold chain systems for vaccines and maternal health services—and improves educational attainment. Together, these improvements contribute to higher household incomes and overall well-being, ultimately lowering vulnerability to malnutrition.

Nonetheless, despite these beneficial effects, it is crucial to recognize that increased electricity access does not uniformly translate into enhanced food security; in some instances, it may paradoxically coincide with rising undernourishment levels. This contradiction often arises when electrification efforts disproportionately target urban or industrial areas, leaving rural and agricultural communities—those most vulnerable to food insecurity—relatively underserved. In these situations, while national electrification statistics may show improvement, the advantages fail to extend to the communities most in nee (Mantravadi & Srai, 2022). Moreover, electricity might be predominantly consumed by industrial or commercial sectors, yielding little direct benefit for agricultural productivity or nutritional well-being. Additionally, increased electrification can spur urbanization, which often drives dietary transitions toward processed, energy-dense yet nutrient-deficient foods, potentially exacerbating hidden hunger and micronutrient deficiencies. In fragile or

conflict-affected settings, it is possible for electricity access to improve even as food security deteriorates, driven by structural issues such as weak governance, environmental decline, and economic instability. Thus, while electrification tends to be beneficial for food security, its actual impact hinges on the context and implementation strategies. To ensure that electricity effectively supports food security, integrated policies must prioritize equitable access—especially in rural communities—and encourage its productive application in agriculture, food preservation, and critical services that contribute to broader well-being.

3.2.5. The Impact of Foreign Direct Investment on Prevalence of Undernourishment

An increase in the FDI does not necessarily correspond with advancements in the agricultural sector or the enhancement of local food systems. Within the scope of this study, FDI encompasses the total foreign capital inflows into a country, irrespective of the specific sector involved. Frequently, FDI is directed toward non-agricultural industries such as manufacturing, mining, and services, which are commonly viewed as more lucrative investment opportunities. Such a sectoral bias can result in the marginalization of agriculture, particularly in vulnerable economies where the sector is pivotal for both food production and rural livelihoods. Neglecting agriculture may force countries to rely increasingly on food imports, thereby exposing them to fluctuations in global food prices and disruptions in trade—factors that intensify food insecurity.

This finding is in line with the research of Mihalache-O'keef & Li (2011), who argue that the impact of FDI on food security is highly sector-specific.Their research demonstrates that foreign direct investment directed toward agriculture generally promotes food security by boosting production capabilities, facilitating technology transfer, and expanding market access. In contrast, FDI predominantly channeled into secondary and tertiary sectors—such as industry and services—can exacerbate food insecurity by diverting resources and policy attention away from the agricultural domain. However, this stands in contrast to the findings of Bhat et al. (2024); and Zhao & Chen (2023), who contend that FDI, in general, has a positive effect on food security. Their study, centered on nations like the United States, China, and Russia, illustrates how foreign direct investment can bolster production capacity by introducing advanced technologies and capital inflows, thereby strengthening national food systems. While, these studies suggest that FDI can play a constructive role in food security, they also underscore a critical caveat: the distribution of FDI is highly uneven. Zhao & Chen (2023) point out that countries with the highest levels of food insecurity receive only around 20% of global agricultural investment, and most of these investments are small in scale. This disparity indicates that countries most dependent on agricultural development frequently attract insufficient foreign investment, constraining their capacity to improve domestic food production and infrastructure. Consequently, FDI may unintentionally exacerbate global food security inequalities—favoring nations with relatively stable food systems while overlooking the structural deficiencies faced by more vulnerable regions.

The implications of this trend are profound. Should foreign direct investment persist in favoring high-return industries and already-advanced regions, nations with fragile food systems risk falling further behind, confronting heightened undernourishment and stunted agricultural development. It is imperative, therefore, that policymakers actively steer foreign investment toward the agricultural sector—especially in food-insecure countries—by implementing targeted incentives, supportive regulatory frameworks, and region-specific development plans. Such measures will not only bolster local food security but also foster more inclusive and resilient food systems over the long term.

4. CONCLUSIONS

This study examines the impact of various socioeconomic and environmental variables—including GDP per capita, female employment in agriculture, greenhouse gas emissions, electricity access, and foreign direct investment—on food security in selected vulnerable nations across Asia and Africa. Findings indicate that elevated income levels, improved electrification, and enhanced female involvement in agriculture are associated with reductions in undernourishment, whereas rising greenhouse gas emissions and misdirected foreign investment tend to exacerbate food

insecurity. These insights emphasize the necessity for deliberate policies that foster inclusive agricultural growth. Governments are encouraged to prioritize rural electrification expansion, empower women farmers, and advocate for sustainable agricultural methods. Concurrently, foreign direct investment should be channeled into the agricultural sector rather than concentrated solely in high-return industries, particularly within nations grappling with significant food insecurity. Addressing climate change mitigation is equally critical, given the ongoing threat that environmental degradation poses to agricultural productivity. Future studies should expand their scope to include a greater number of countries and incorporate more recent data, thereby offering broader and more timely perspectives on food security challenges. This research aspires to contribute to evidence-based policymaking and to encourage enhanced regional and international collaboration aimed at securing sustainable food systems.

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