**Dynamics of a Complex System: Investigating the Interplay between Food Security, Transition to Renewable Energy, Democracy, and Governance in Africa**

**Abstract**

In a time when climate patterns change, governance structures evolve, and economic landscapes shift, understanding food security, renewable energy adoption, and democratic governance in Africa is crucial for achieving sustainable development and resilience on the continent. This study investigates the intricate dynamics of food security, renewable energy transition, democratic governance, and economic policies across 51 African countries from 2000 -2022. Employing panel regression analysis with fixed effects, we analyse data spanning various regions of Africa and examine the interplay between key variables. Key findings reveal significant associations between certain variables and food security outcomes. While Transparency, Accountability, and Corruption (CPIA), Electoral Democracy (DEM), and ), Renewables - % Electricity (REN) display positive correlations with food supply across different African regions, Ease of Doing Business (EDB) and Foreign Direct Investment (FDI) exhibit varied impacts. Notably, renewable energy integration emerges as a crucial factor positively influencing food security, particularly in Southern Africa. Moreover, the study underscores the importance of democratic governance and transparent economic policies in fostering food security initiatives. Embracing transparent governance, fostering renewable energy integration, and prioritizing inclusive democratic practices are pivotal steps towards fostering enduring food security solutions across Africa

1. **Introduction**

The issue of food security is a significant concern for policymakers and researchers, especially as society’s transition to renewable energy sources such as wind and solar. The relationship between food security and the adoption of renewable energy in Africa is complex (Bellezoni et al., 2021). Proponents of renewable energy argue that it can improve agricultural productivity by enabling sustainable irrigation and mechanization, thus promoting food security (van Dijk et al., 2021). According to Nitescu & Murgu (2020), countries that have integrated renewable energy extensively tend to have better food security indicators. Although sustainable energy can help mitigate the effects of climate change on agriculture and lead to increased food production, there are disparities in research findings and opinions. Opponents of the transition to renewable energy highlight the initial high costs of renewable energy infrastructure, which may take away resources from crucial agricultural investments (Ahmed et al., 2021). Moreover, the intermittent supply of energy from renewable sources could disrupt important farming activities, potentially worsening food insecurity (van Dijk et al., 2021). Given regional differences and peculiarities in governance strategies and socio-economic factors, there is the need to study the transition to renewable energy based on the regional peculiarities.

Research studies indicate a complicated relationship between democracy and food security in Africa. Advocates argue that democratic governance promotes transparency, accountability, and citizen engagement, positively impacting food security as well the transition to renewable energy (Fontan Sers & Mughal, 2019; Khodaverdian, 2021). However, skeptics suggest that political instability in democracies can disrupt agricultural policies, worsening food insecurity and halting policies on renewable energy (Murshed et al., 2018). While democracies like Ghana show positive links between political stability and food production (Hemed, 2019), challenges persist in areas with governance issues like corruption and weak institutions that hinder the implement of the transition of renewable energy (Ogunniyi et al., 2020). The effectiveness of democracy in ensuring food security depends on strong governance mechanisms, economic stability, and social inclusivity (Adelle et al., 2021).

Empirical evidence highlights the importance of government involvement in achieving food security and transition to renewable energy (Fontan Sers & Mughal, 2019). Countries with effective agricultural policies and governance, such as China and Brazil, have witnessed significant improvements in food production and renewable energy generation (Giller, 2020). Robust government intervention is crucial for smooth transition to renewable energy, enabling effective policies, infrastructure development, and crisis management that ensures food security (Fontan Sers & Mughal, 2019). Conversely, critics argue that excessive government control may result in inefficiencies, corruption, and mismanagement, impeding the medium to large scale transition to renewable energy that will ensure food production and distribution (Hemed, 2019). Challenges arise when governance is plagued by corruption or lacks a comprehensive approach (Ogunniyi et al., 2020). Effective government intervention, guided by data-driven policies and international cooperation, is essential for addressing the diverse dimensions of food security on a global scale.

The correlation among food security, renewable energy, democratic governance structures, and government expenditure constitutes a pivotal area of investigation with significant implications for informing policymakers on cohesive approaches to foster sustainability, societal well-being, and democratic principles (Ogunniyi et al., 2020; Hemed, 2019; Giller, 2020; Bonuedi et al., 2020; Fontan Sers & Mughal, 2019). A harmonized strategy involving renewable energy, democracy, and government expenditure is indispensable for tackling food security issues in Africa (Giller, 2020). Nonetheless, skeptics express apprehensions regarding potential clashes in resource allocation between renewable energy ventures and immediate food security necessities, underscoring the subtle and critical equilibrium essential in policymaking (Bonuedi et al., 2020). Renewable energy holds the potential to augment agricultural output, while effective governance is imperative for judicious resource distribution (Giller, 2020). Achieving equilibrium necessitates evidence-driven policies, as evidenced by the case of Rwanda, where investments in renewable energy align with sustainable agricultural practices, yielding positive outcomes for food security (Giller, 2020).

Prior studies have delved into the nexus between food security and the adoption of renewable energy (Giller, 2020; Bonuedi et al., 2020; Ahmed et al., 2021), as well as the influence of democratic decision-making processes on sustainable agricultural methods (Hemed, 2019; Fosu, 2018). Nevertheless, there remains a paucity of research exploring the feedback mechanisms between food security and the adoption of renewable energy, along with the issues of governance and corruption that may bolster renewable energy endeavors and food production directly or indirectly. This study endeavors to bridge these knowledge gaps by conducting a comprehensive analysis of the relationship among food security, the transition to renewable energy sources, democratic governance structures, and government expenditure. Through theoretical and empirical inquiry, this study seeks to elucidate the connections between these variables and furnish insights that guide policymakers in devising integrated strategies to advance sustainability, societal well-being, and democratic values. Specifically the study will

* Evaluate the correlation between renewable energy integration and increased food security in Africa;
* investigate the connection between democratic governance and its impact on food security and;
* assess the effectiveness of government intervention in achieving food security, identifying key success factors and challenges.

1. **Literature Review**

The interconnection of food security, the shift to renewable energy, democracy, and government expenditure in Africa necessitates a thorough examination due to its complex nature. Advocates argue that a comprehensive approach, integrating renewable energy into agricultural practices under democratic governance, can enhance food security (Adams & Acheampong, 2019; Kinda, 2021). However, opponents highlight potential trade-offs and challenges in resource allocation, emphasizing the need for context-specific policies (Van Dijk et al., 2021).

There is a lack of specific understanding of the impact of democracy and renewable energy on carbon emissions in sub-Saharan African countries (Adams & Acheampong, 2019). This gap may be worsened by the absence of comprehensive studies considering the interaction between democracy, renewable energy, and carbon emissions in this region. The literature suggests controversial effects of green economy indicators on food security in the region, indicating a lack of consensus (Kinda, 2021). Additionally, there is insufficient attention given to the holistic needs of farmers for food production, the food-energy nexus, and the integrated solutions required to address the complex challenges faced by African agriculture and energy sectors (Shirley, 2021).

The transition to renewable energy can revolutionize agriculture in Africa, mitigating the impacts of climate change and enhancing food security (Kinda, 2021; Shirley, 2021). Improved access to sustainable energy promotes mechanization, irrigation, and post-harvest processing (Adams & Acheampong, 2019). Countries embracing renewable energy, such as Kenya and South Africa, witness increased agricultural productivity (Kinda, 2021). However, challenges emerge, including the initial high costs of renewable infrastructure and intermittent energy supply disrupting farming operations (Adams & Acheampong, 2019).

Democratic governance positively influences food security by fostering transparency, accountability, and citizen participation (Ogunniyi et al., 2020). Stable democratic institutions, as seen in countries like Ghana and Botswana, correlate with improved food security indicators (Ogunniyi et al., 2020). However, political instability within democracies can lead to policy fluctuations and disruptions in agricultural development, posing challenges to maintaining effective policy continuity (Hemed, 2019).

Strategic government spending, fight against corruption, and ease of doing business can address food security challenges amidst Africa's rapid population growth (Fontan Sers & Mughal, 2019; Ogunniyi et al., 2020). However, critics contend that excessive population growth strains resources, hindering food security (van Dijk et al., 2021). The transition to renewable energy is seen as pivotal, yet skeptics argue that initial costs may divert funds from immediate needs (Adams & Acheampong, 2019). Democracy is viewed as beneficial for governance, but detractors highlight potential instability affecting policies (Khodaverdian, 2021). Scientifically, statistics show a complex interplay, demanding nuanced strategies (Ahmed et al., 2021).

Economic growth stimulates resources for effective governance, aiding food security and renewable energy transition (Giller, 2020). However, critics contend that uneven wealth distribution can exacerbate food insecurity (Fontan Sers & Mughal, 2019). The transition to renewable energy is viewed favorably for environmental sustainability, but skeptics question its feasibility amidst economic constraints (Adams & Acheampong, 2019). Democracy is seen as fostering responsible governance, yet detractors highlight potential policy fluctuations (Hemed, 2019). Africa's challenge lies in harmonizing economic growth, resource allocation, food security, renewable energy adoption, and democratic governance (Kinda, 2021; Shirley, 2021).

Foreign Direct Investment (FDI) can spur economic growth, benefiting government spending, food security, and renewable energy transition (Kinda, 2021; Adams & Acheampong, 2019). However, critics caution against exploitation risks, potential misalignment with local needs, and economic inequality (Nitescu & Murgu, 2020). FDI is seen as promoting democracy, but skeptics highlight its influence on policy autonomy (Fosu, 2018). Scientifically, FDI statistics indicate both positive and negative impacts, emphasizing the need for strategic policies. Africa faces the challenge of navigating FDI to align with sustainable development goals, ensuring equitable benefits for food security, renewable energy adoption, and democratic governance

The ease of doing business is often advocated for its potential benefits in diversifying food sources and fostering economic growth, which can, in turn, improve food security and support the transition to renewable energy (Asongu & Odhiambo, 2018; Bonuedi et al., 2020). However, the vulnerability to global market fluctuations and unequal distribution of benefits, potentially exacerbating food insecurity (Asongu & Odhiambo, 2018). Trade openness, although aligning with democratic principles, faces criticism for potential exploitation and policy challenges (Asongu & Odhiambo, 2018). Trade statistics reveals both positive and negative impacts, necessitating nuanced strategies to optimize trade openness in Africa (Asongu & Odhiambo, 2018).

Africa, in particular, grapples with the challenge of optimizing trade openness to balance economic growth, resource allocation, food security, renewable energy transition, democratic governance, and transparency of bureaucratic processes for comprehensive development (Asongu & Odhiambo, 2018). To address food security in Africa, reducing delays in documentation and border compliance is identified as a critical factor (Bonuedi et al., 2020). The study by Bonuedi et al. (2020) indicates that poor trade facilitation is a significant driver of food insecurity in Africa, with reductions in delays promising to be effective trade facilitation reforms to enhance food security. Furthermore, the role of informal food traders in South Africa is highlighted as crucial for ensuring food security and economic growth, but their contributions are undervalued and undersupported by state responses (Wegerif, 2020). This emphasizes the need for a new valuation of the informal sector, recognizing and building on its contributions to society (Wegerif, 2020).

The impacts of climate change, particularly carbon emissions, pose a significant threat to food security in Africa (Becker Pickson & Boateng, 2021). Transitioning to renewable energy can mitigate these impacts and enhance resilience (Becker Pickson & Boateng, 2021). However, economic challenges hinder this shift, as highlighted by detractors (Becker Pickson & Boateng, 2021). Africa faces increased vulnerability due to climate change, affecting agriculture (Fusco, 2022). The impact on food security is evident in Northern and Eastern African regions, where climate change negatively influences food security levels (Fusco, 2022). A panel data analysis for the period 2000–2012 revealed adverse effects on food security, emphasizing the need for policy actions to mitigate global warming and reduce economic impacts (Fusco, 2022).

Furthermore, a population-based study in Central Africa predicts high levels of hunger due to climate change-induced extreme droughts and a rise in mean temperature (Hassan et al., 2023). This study emphasizes the economic and health-related adverse impacts of climate change on food insecurity, childhood malnutrition, mortality, and infectious diseases (Hassan et al., 2023). The role of democracy in facilitating climate-conscious policies is acknowledged, but political instability poses risks (Becker Pickson & Boateng, 2021). Effective government spending is crucial in addressing climate change impacts, but resource constraints persist (Becker Pickson & Boateng, 2021). The challenge lies in aligning renewable energy adoption, democratic governance, and government spending to combat climate change's adverse effects on food security and sustainable development in Africa.

**2.1 Conceptual Framework**

The intricate interplay among food security, renewable energy transition, democracy, and governance in Africa unveils a complex array of relationships among key factors is presented Figure 2.1. Governance indicators such as CPIA Transparency, Accountability, and Corruption in Public Sector Ratings delineate the governance landscape, exerting considerable influence on both food security and the adoption of renewable energy (Fosu, 2018; Ogunniyi et al., 2020). Higher CPIA ratings may signal robust governance frameworks, potentially facilitating improved food provision and a smoother shift to renewable energy sources. Conversely, lower ratings might impede progress in these domains due to issues like mismanagement or corruption.

The Ease of Doing Business Score shapes investment climates, thereby impacting the inflow of Foreign Direct Investment (FDI) and, subsequently, economic stability and food security (Asongu & Odhiambo, 2018). Furthermore, levels of FDI may align with the expansion of renewable energy infrastructure, contributing to energy security. Temperature fluctuations, driven by global environmental dynamics, directly impact agricultural output, thereby influencing food security.

Electoral democracy, a gauge of political stability and citizen engagement, can mould governance efficacy and policy choices pertaining to food security and renewable energy endeavours (Hemed, 2019). Moreover, the proportion of electricity generated from renewable sources mirrors a nation's dedication to sustainable energy practices, influenced by governance frameworks and public demand.

The interconnectedness of these variables underscores the multifaceted challenges and opportunities confronting African nations. Grasping these intricate dynamics is essential for formulating policies that foster sustainability, resilience, and fair development across the region.

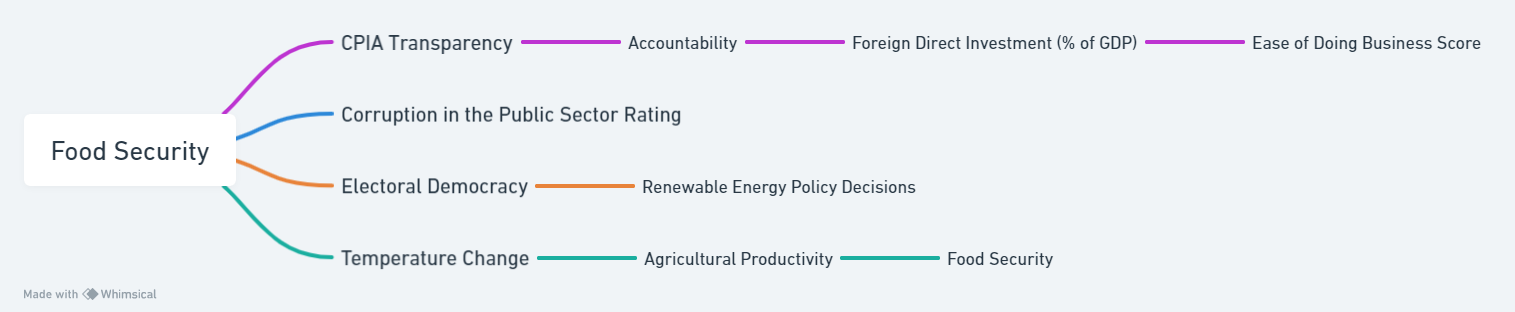


Figure 2.1: Conceptual Framework

Source: Developed by the author.

1. **Methodological framework (A panel data analysis)**

In our empirical examination, we utilize panel data methodologies incorporating fixed effects to capture latent diversity among countries and temporal intervals (Balázsi, Mátyás, & Wansbeek, 2018). The choice of fixed effects estimation stems from its capacity to give dependable assessments of the relationship between food security, the transition to renewable energy, democracy, and governance in Africa, while considering unobserved effects unique to time and country (Adams et al., 2018; Das, 2019). This approach aids in alleviating bias arising from variables omitted, thereby fortifying the resilience of our analysis (Hill et al., 2020).

To ensure the validity and reliability of our empirical results, we conduct the Hausman test to determine the appropriate panel model – fixed effects or random effects (Mérel & Gammans, 2018). The Hausman test assists in assessing whether the fixed effects model is more suitable for our analysis, contributing to accurate and valid estimation (Andersen, 2019).

The panel data analysis, specifically using fixed effects, is a crucial methodological choice in our study, offering a robust framework to explore the dynamics of research variables over time and across different countries.

**3.1 Theoretical Framework**

The intersection of food security, renewable energy transition, democracy, and governance in Africa represents a complex and interdependent system that requires a critical theoretical framework for comprehensive analysis. This framework draws on key theories and concepts from various disciplines to elucidate the dynamics and relationships shaping these critical aspects.

Political ecology offers a robust theoretical lens for examining the intricate connections between social, political, economic, and environmental factors (Blanton & Kirsch, 2019). This framework posits that environmental issues, such as food security and energy transitions, are not just technical problems but deeply embedded in power structures, political processes, and societal arrangements.

Drawing on the work of Anser et al. (2021), the impact of ICT adoption and governance on food security in West Africa can be understood through the political ecology lens. The study highlights the role of governance, specifically government effectiveness and anti-corruption measures, in enhancing food security. Political ecology emphasizes how governance structures influence resource distribution, access, and sustainability. In the context of renewable energy transition, the study by Zakari et al. (2022) underscores the need for policy focus on achieving energy security. Political ecology allows for an exploration of power dynamics in energy production and distribution, examining how decisions about energy sources are influenced by political and economic interests.

Dijkshoorn-Dekker et al.'s (2019) work on the Transition Support System approach for urban food security in Ghana can be analyzed through political ecology. The study emphasizes the integration of decision support tools and stakeholder analyses, revealing the political dimensions in decision-making for future urban food security.

Ogunniyi et al. (2020) explore the positive impact of remittances and improved governance on food security in Sub-Saharan Africa. Political ecology can contribute to understanding how democratic governance structures influence the flow of remittances and their subsequent impact on food and nutrition security.

Adams et al. (2018) examine the relationship between renewable and non-renewable energy consumption, regime type, and economic growth in Sub-Saharan African countries. Political ecology can aid in scrutinizing the political dimensions of energy policies and their implications for economic growth.

Political ecology provides a comprehensive framework for analyzing the complex interactions between food security, renewable energy transition, democracy, and governance in Africa. By focusing on power relations, political processes, and socio-environmental dynamics, this theoretical perspective enhances our understanding of the challenges and opportunities within this multifaceted system.

**3.2 Empirical model**

Based on the theoretical framework, the empirical model for the study can be formulated as follows:

FSK = f(CPIA, DEM, EDB, FDI, REN, TMP) …(1)

​ …(2)

​ …(3)

From equation (2), contains the variables to be used in the model:

…(4)

is the food supply (kcal per capita per day) for country i at time t (dependent variable).

is the CPIA transparency, accountability, and corruption in the public sector rating for country i at time t.

is the Ease of doing business score for country i at time t.

is the Foreign direct investment net inflows (% of GDP) for country i at time t.

is the Temperature change for country i at time t.

is the Electoral Democracy for country i at time t.

is the Renewables - % electricity for country i at time t.

​ is the error term.

The error term ​ can be decomposed as follows:

​ …(5)

​ … (6)

​ …(7)

Where:

is the unobservable specific cross-section effects

Unobservable specific time effects.

​ is the mutual cross-section time series effect.

Hence, if in equation (7), it signifies a unidirectional temporally specific effects paradigm. The amalgamation of equations (6) and (7) infers the presence of cross-sectional and temporally specific effects paradigm, denoting a bidirectional fixed effects regime:

…(8)

Equation (8) denotes the stochastic effects paradigm, wherein 'a' signifies the shared intercept, and the error term is . The bifurcation of the perturbation into two constituents elucidates the nomenclature of the model as the error components paradigm.

This framework facilitates the exploration of the associations between food security and the designated exogenous variables, encompassing both cross-sectional and temporally-specific ramifications. The parameters β0, β1,…, β6 delineate the impacts of the respective variables on food security. The perturbation term encapsulates latent factors influencing food security that evade incorporation within the model.

Where I =1, …, 50; t =2000, 2001 … , 2022

The Hausman model serves as a statistical examination utilized to ascertain the suitability between the random effects model and the fixed effects model for panel data scrutiny. It aids researchers in discerning whether panel data analysis warrants a model accommodating random effects (random intercepts) or one incorporating fixed effects (individual-specific intercepts). The Hausman test statistic is derived through the following computation:

*H*=(*β*^​*RE*​−*β*^​*FE*​)′[*Var*(*β*^​*RE*​)−*Var*(*β*^​*FE*​)]−1(*β*^​*RE*​−*β*^​*FE*​) …(9)

Where:

β^​RE​ is the coefficient estimate from the random effects estimator.

β^​FE​ is the coefficient estimate from the fixed effects estimator.

Var(β^​RE​) is the covariance matrix of the coefficients estimated from the random effects estimator.

Var(β^​FE​) is the covariance matrix of the coefficients estimated from the fixed effects estimator.

The test statistic denoted by H adheres to a chi-squared distribution with degrees of freedom corresponding to the quantity of coefficients under estimation within the model. Should the null hypothesis positing the consistency of the random effects model be repudiated, it intimates that the fixed effects model better suits the dataset. The Hausman test aids scholars in adjudicating between employing random effects (RE) or fixed effects (FE) frameworks in panel data analysis contingent upon the assumption regarding the error structure and the existence of unobserved individual-specific effects.

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**3.3 Data sources, variable description and empirical results**

The data utilized in this study were collected from various sources encompassing 51 African countries spanning the years 2000 to 2022. It is important to note that the panel constructed from these data is unbalanced, reflecting the diverse nature of the countries and the temporal scope of the study.

The countries included in the dataset are as follows: Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo (Democratic Republic), Congo (Republic), Cote d'Ivoire, Djibouti, Egypt (Arab Republic), Eswatini, Ethiopia, Gabon, Gambia (The), Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe, and Lesotho.

The variables examined in the study, the detailed description and the sources are presented in Table 3.1. The approach to data collection involves integrating secondary data from various reputable sources to ensure the comprehensiveness and reliability of the analysis.

**Table 3.1: Description of the variables**

|  |  |  |
| --- | --- | --- |
| **Variable** | **Description** | **Source** |
| Food supply (kcal per capita per day) | The average number of kilocalories available per person per day for consumption in a country. | UN Food and Agriculture Organization (FAO) |
| CPIA transparency, accountability, and corruption in the public sector rating | A rating system ranging from 1 to 6 that measures the transparency, accountability, and corruption levels in the public sector. | World Development Indicators of The World Bank |
| Ease of doing business score | A score ranging from 0 to 100 that evaluates the ease of doing business in a country, with higher scores indicating better performance. | World Development Indicators of The World Bank |
| Foreign direct investment net inflows (% of GDP) | The percentage of Gross Domestic Product (GDP) represented by the net inflow of foreign direct investment. | World Development Indicators of The World Bank |
| Temperature change | The change in average temperature over a specified period, typically measured in degrees Celsius. | Climate Indicator of International Monetary Fund |
| Electoral Democracy | A measure of the level of democracy in a country, often based on factors such as free and fair elections, political participation, and civil liberties. | Varieties of Democracy |
| Renewables - % electricity | The percentage of electricity generated from renewable energy sources such as solar, wind, hydro, biomass, and geothermal. | Energy Institute - Statistical Review of World Energy |

1. **Analysis and discussion of results**

This part presents a descriptive analysis of the variables utilized in the study, focusing on key statistics such as the minimum, average, maximum, standard deviations, and the number of observations for each variable. This analysis provides crucial insights into the dynamics of food security, renewable energy, democracy, governance, and related factors within the context of African nations.

Table 4.1 offers a comprehensive overview of the descriptive statistics for the variables under examination, namely Food Supply (FSK), CPIA Transparency, Accountability, and Corruption Rating (CPIA), Electoral Democracy (DEM), Ease of Doing Business Score (EDB), Foreign Direct Investment (FDI), Renewables as Percentage of Electricity (REN), and Temperature Change (TMP).

Starting with Food Supply (FSK), the mean value stands at 2188.139 kcal per capita per day, with a median of 2348.788 kcal. The minimum recorded value is 0.000 kcal, indicating instances of severe food insecurity, while the maximum value reaches 3588.146 kcal. The standard deviation of 836.358 reflects notable variability in food supply across the observed African countries.

In terms of CPIA, the mean score for transparency, accountability, and corruption in the public sector is 1.596, with a median of 2.000. The data indicates a wide range of scores, from a minimum of 0.000 to a maximum of 4.500, with a standard deviation of 1.440.

Electoral Democracy (DEM) showcases a mean value of 0.423, indicating the extent of democratic governance across the region. The data ranges from a minimum score of 0.072 to a maximum of 0.806, with a standard deviation of 0.187. The Ease of Doing Business Score (EDB) demonstrates considerable variability, with a mean of 10.818 and a standard deviation of 21.446. The range spans from 0.000 to 81.468, reflecting diverse business environments across African countries.

Foreign Direct Investment (FDI) exhibits a mean percentage of 4.432 of GDP, with considerable fluctuation as depicted by a standard deviation of 8.712. The data range extends from -17.292% to 103.337% of GDP, indicating substantial variations in FDI inflows among the observed nations. Renewables as Percentage of Electricity generated reveals a mean value of 40.195%, suggesting the level of renewable energy integration in the electricity sector. The data ranges from 0.000% to 100.000%, with a standard deviation of 37.907, highlighting the diversity in renewable energy adoption.

Temperature Change (TMP) displays a mean change of 1.441 degrees, with a wide-ranging standard deviation of 3.636. The observed temperature changes vary from -1.305 to 27.370 degrees, underscoring the diverse climatic conditions experienced across African countries.

The skewness and kurtosis values provide insights into the distributional characteristics of the variables. Skewness and kurtosis values that deviate significantly from zero indicate non-normality in the distribution of data, warranting careful consideration in statistical analyses.

Furthermore, the Jarque-Bera test assesses the normality of the data distribution. The probability values associated with each variable indicate that the null hypothesis of normality is rejected at a statistically significant level, suggesting non-normal distribution patterns.

**Table 4.1: Descriptive statistics**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **FSK** | **CPIA** | **DEM** | **EDB** | **FDI** | **REN** | **TMP** |
| Mean | 2188.139 | 1.596 | 0.423 | 10.818 | 4.432 | 40.195 | 1.441 |
| Median | 2348.788 | 2.000 | 0.397 | 0.000 | 2.255 | 28.266 | 0.968 |
| Maximum | 3588.146 | 4.500 | 0.806 | 81.468 | 103.337 | 100.000 | 27.370 |
| Minimum | 0.000 | 0.000 | 0.072 | 0.000 | -17.292 | 0.000 | -1.305 |
| Std. Dev. | 836.358 | 1.440 | 0.187 | 21.446 | 8.712 | 37.907 | 3.636 |
| Skewness | -1.626 | 0.011 | 0.314 | 1.647 | 5.089 | 0.362 | 6.746 |
| Kurtosis | 5.231 | 1.406 | 1.992 | 4.030 | 38.791 | 1.541 | 47.364 |
| Jarque-Bera | 759.185 | 124.052 | 68.829 | 581.752 | 67613.98 | 129.489 | 104998.9 |
| Probability | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sum | 2564499. | 1870.500 | 495.856 | 12678.770 | 5193.665 | 47108.50 | 1688.158 |
| Sum Sq. Dev. | 8.19E+08 | 2428.951 | 41.022 | 538567.8 | 88879.65 | 1682676. | 15478.78 |
| Observations | 1172 | 1172 | 1172 | 1172 | 1172 | 1172 | 1172 |

Source: Eviews Output and Authors' Computation, 2024.

The percentage distribution of renewable energy generation across African countries, as depicted in Figure 4.1, presents a mixed picture regarding the adoption and integration of renewable energy sources. Some nations demonstrate promising figures, such as Burundi, with a substantial 4.29%, and Lesotho, Malawi, Mozambique, Namibia, and Zambia, all exceeding 4% renewable energy generation. These figures highlight commendable efforts towards transitioning to sustainable energy sources, aligning with global environmental goals.

However, contrasting patterns emerge, with several countries registering minimal contributions to renewable energy, including Botswana, Comoros, Gambia, Libya, and South Africa, with percentages ranging from 0.00% to 0.12%. This disparity underscores the varied policy landscapes and implementation challenges across the continent.

For countries with low percentages, barriers to renewable energy adoption may include limited financial resources, inadequate infrastructure, and dependence on traditional energy sources. In contrast, countries with higher percentages often prioritize renewable energy in national policies, invest in infrastructure, and leverage natural resources for energy production.



Figure 4.1: Percentage Distribution of Renewable Energy Generation in Africa

Source: Tableau Output and Authors' Computation, 2024.

**4.2. Correlation analysis**

The correlation analysis presented in Table 4.2 sheds light on the relationships between various variables central to understanding the dynamics of food security, renewable energy, democracy, and governance in Africa. The correlation coefficients range from -1 to 1, indicating the strength and direction of the relationships between pairs of variables.

Starting with food supply (FSK), correlations with other variables are generally weak, with coefficients close to zero. This suggests that food supply may not be strongly influenced by the variables examined in this analysis, including CPIA, democratic governance (DEM), and ease of doing business (EDB), foreign direct investment (FDI), renewables (REN), and temperature change (TMP).

The correlation between food supply and CPIA transparency, accountability, and corruption ratings is nearly negligible (-0.005), indicating minimal association between food security and the level of transparency and accountability in the public sector. Similarly, correlations between food supply and other governance indicators such as democratic governance (DEM) and ease of doing business (EDB) are weak, suggesting that these factors may not significantly impact food security outcomes.

Foreign direct investment (FDI) and renewables (REN) show minimal correlation with food supply, with coefficients close to zero. This implies that the inflow of foreign investment and the adoption of renewable energy sources may not directly translate into improvements in food security across African nations.

Temperature change (TMP) exhibits a slight positive correlation (0.094) with food supply, suggesting a weak association between climatic variations and food security outcomes. However, the magnitude of this correlation is relatively small, indicating that temperature changes alone may not be the primary determinant of food supply fluctuations.

Overall, while correlations between variables provide insights into potential relationships, the weak associations observed in this analysis suggest that food security outcomes in Africa are influenced by a multitude of complex factors beyond those examined in this study. Further research incorporating additional variables and employing advanced statistical techniques may offer deeper insights into the nuanced dynamics of food security and its interplay with renewable energy, democracy, and governance in the African context.

**Table 4.2 Correlation analysis**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **FSK** | **CPIA** | **DEM** | **EDB** | **FDI** | **REN** | **TMP** |
| FSK | 1 |  |  |  |  |  |  |
| CPIA | -0.005 | 1 |  |  |  |  |  |
| DEM | 0.219 | 0.207 | 1 |  |  |  |  |
| EDB | 0.189 | 0.116 | 0.119 | 1 |  |  |  |
| FDI | -0.008 | 0.118 | 0.075 | -0.040 | 1 |  |  |
| REN | -0.014 | 0.1027 | -0.160 | -0.001 | -0.036 | 1 |  |
| TMP | 0.094 | 0.068 | 0.045 | 0.044 | -0.052 | -0.064 | 1 |

Source: Eviews Output and Authors' Computation, 2024.

**4.3. Pre-estimation analysis: unit root test**

The unit root tests, as presented in Table 4.3, are crucial for determining the stationarity of time series data, particularly in analyzing variables related to food security, democracy, governance, and renewable energy in Africa. The results indicate the presence or absence of unit roots, which signify non-stationarity, and help determine the appropriate order of differencing required to achieve stationarity.

For each variable, two statistics are provided: one for the level of the series and the other for the first difference. The statistics are expressed in terms of Levin, Lin & Chu t-values, with values indicating stationarity at the respective levels of the series or differences.

Food Supply (FSK): The level statistic is 24.2331, while the first difference statistic is 87.2978. These values suggest that the FSK series is stationary both at the level and the first difference, denoted as I(0) and I(1) respectively.

CPIA, DEM, EDB, FDI, REN, TMP: Similarly, for the variables CPIA, DEM, EDB, FDI, REN, and TMP, the unit root test results indicate stationarity both at the level and the first difference, with negative statistics for both. This implies that these variables exhibit stationary behaviour after taking the first difference, represented as I(0) and I(1).

The stationarity of variables is crucial for time series analysis as it ensures that statistical properties remain consistent over time, facilitating reliable modelling and forecasting. The results suggest that the variables under consideration in the study do not exhibit unit roots, indicating that they are stationary after taking the first difference. This provides a solid foundation for conducting further analysis, such as examining the relationships between variables, identifying causal links, and developing predictive models.

**Table 4.3 Unit root/stationary tests results**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Level** | **First Difference** | **Decision** |
| FSK | 24.2331 | 87.2978 | I(0), I(1) |
| CPIA | -5.5294 | -7.68449 | I(0), I(1) |
| DEM | -2.66354 | -10.6271 | I(0), I(1) |
| EDB | -1.35457 | -16.374 | I(0), I(1) |
| FDI | -2.71442 | -12.5128 | I(0), I(1) |
| REN | 4.21474 | 9.03178 | I(0), I(1) |
| TMP | -10.5137 | -22.519 | I(0), I(1) |

Source: Eviews Output and Authors' Computation, 2024.Note: I(0) and I(1) stationary at level and first difference. Value are Levin, Lin & Chu t

**4.4. Panel data model estimation**

This section reveals the results obtained from panel regression analysis. To determine the correlation, we examined the combined regression assuming consistent intercepts across nations and years. Additionally, we assumed different constants for each nation and then conducted both random and fixed effect regressions. We used the Hausman test statistic (Table 4.4) to choose between random and fixed effects. The null hypothesis suggests that random effects are the preferred model, but we rejected this in favour of fixed effects. This analysis primarily investigates whether the unique errors (ui) are correlated with the regressors. The null hypothesis suggests that the unique errors (ui) do not correlate with the regressors. The random effect approximations can be found in the appendix.

Table 4.5 Hausman Test

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Test Summary | | Chi-Sq. Statistic | Chi-Sq. d.f. | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| Cross-section random | | 52.634 | 6 | 0.000 |
|  |  |  |  |  |
|  |  |  |  |  |
| Cross-section random effects test comparisons: | | | | |
| Variable | Fixed | Random | Var(Diff.) | Prob. |
|  |  |  |  |  |
|  |  |  |  |  |
| CPIALEVEL | 41.467 | 21.918 | 25.554629 | 0.0001 |
| DEM | 852.915 | 1008.936 | 15475.713043 | 0.2098 |
| EDB | 4.796 | 5.042 | 0.073683 | 0.3646 |
| FDI | 5.726 | 5.478 | 0.100675 | 0.4341 |
| REN | 13.364 | 9.466 | 0.361677 | 0.0000 |
| TMP | 47.942 | 27.216 | 2266.290428 | 0.6633 |
|  |  |  |  |  |
|  |  |  |  |  |

Source: Eviews Output and Authors' Computation, 2024.

The panel regression results presented in Table 4.6 offer valuable insights into the relationships between various economic indicators and food security (FSK) across different regions of Africa. The fixed effects model allows for the examination of within-group variations and provides region-specific coefficients for each explanatory variable.

In Africa as a whole, higher CPIA scores are associated with increased food security, as indicated by the positive coefficient of 41.467. This suggests that improved transparency and accountability in governance positively impact food supply.

However, in North Africa, the coefficient of -131.988 suggests an inverse relationship between CPIA scores and food security. This could reflect specific challenges or dynamics within North African countries regarding governance and food security.

Across Africa, higher levels of electoral democracy correspond to increased food security, supported by the positive coefficient of 852.915. Democratic governance structures may facilitate better resource allocation and policy implementation, positively affecting food supply.

Notably, East Africa exhibits a particularly strong positive relationship between electoral democracy and food security, with a coefficient of 784.667.

Positive coefficients across most regions indicate that improvements in the ease of doing business generally coincide with enhanced food security. For instance, in West Africa, a positive coefficient of 5.298 suggests a favourable impact of business-friendly policies on food supply.

Notably, Central Africa demonstrates a weaker relationship between ease of doing business and food security, with a coefficient of 3.311.

In Africa overall, higher levels of foreign direct investment are associated with improved food security, as indicated by the positive coefficient of 4.796. Foreign investment inflows may contribute to economic development and infrastructure improvements, positively impacting food supply.

However, the negative coefficient in North Africa suggests a potential discrepancy in the relationship between FDI and food security within this region. Across all regions, higher percentages of electricity generated from renewable sources are positively associated with food security. Southern Africa, with a coefficient of 22.716, exhibits the strongest relationship between renewable energy integration and food supply.

While temperature change does not show consistent significant effects on food security across regions, East Africa exhibits a positive relationship, with a coefficient of 143.118. This suggests that climatic variations may play a more significant role in food security dynamics in this region.

1. **Summary and conclusion**

The study discovered that:

* Higher transparency and accountability, as indicated by CPIA scores, generally correspond to increased food security across Africa.
* Stronger electoral democracy is positively associated with improved food security, particularly notable in East Africa.
* Improvements in the ease of doing business tend to positively impact food security, although the relationship varies across regions.
* Increased FDI levels generally coincide with enhanced food security, except for some discrepancies observed in North Africa.
* Higher percentages of electricity generated from renewable sources are positively associated with food security, with Southern Africa showing the strongest relationship.
* While temperature change does not consistently impact food security across regions, East Africa stands out with a positive relationship between temperature variations and food supply.

Improving transparency and accountability in governance can enhance public trust and confidence in government institutions. It can lead to more effective allocation of resources towards agricultural development programs, better management of food distribution networks, and reduced corruption in the food supply chain.

However, solely relying on transparency and governance reforms may not be sufficient to address systemic issues contributing to food insecurity. Structural challenges such as inadequate infrastructure, limited access to markets, and unequal distribution of resources also need to be addressed.

Strengthening electoral democracy can promote citizen participation and representation, fostering inclusive decision-making processes that prioritize food security initiatives. Democratic institutions can facilitate the implementation of policies that address the needs of vulnerable populations and promote sustainable agriculture practices.

Overreliance on electoral democracy alone may overlook the importance of strong institutions and policy continuity. Political instability and frequent changes in leadership may disrupt long-term strategies aimed at improving food security, leading to inconsistency and inefficiency in policy implementation.

Improving the ease of doing business can attract investment, stimulate economic growth, and create employment opportunities, all of which are essential for enhancing food security. Streamlining bureaucratic processes and reducing regulatory burdens can encourage entrepreneurship and innovation in the agricultural sector.

Prioritizing ease of doing business reforms without adequate safeguards may exacerbate inequalities and marginalize small-scale farmers and rural communities. Policies that primarily benefit large corporations or foreign investors may neglect the needs of smallholders and fail to address structural barriers to agricultural productivity.

Increased FDI can bring in capital, technology, and expertise needed to modernize agricultural practices, improve infrastructure, and expand market access. Strategic partnerships with foreign investors can promote knowledge transfer and innovation, contributing to sustainable agricultural development.

However, the pursuit of FDI-driven growth strategies may prioritize profit motives over social and environmental considerations. There is a risk of land grabbing, environmental degradation, and displacement of local communities if FDI projects are not carefully regulated and aligned with national development priorities.

Investing in renewable energy infrastructure can reduce reliance on fossil fuels, mitigate climate change impacts, and enhance energy security, which is critical for supporting agricultural activities. Renewable energy technologies such as solar-powered irrigation systems can increase productivity and resilience in the face of climate variability.

While renewable energy integration is desirable, the transition may face implementation challenges such as high upfront costs, technological limitations, and insufficient investment incentives. Uneven access to renewable energy resources and inadequate grid infrastructure may exacerbate disparities between urban and rural areas.

Acknowledging the impact of temperature change on food security can inform adaptive strategies and resilience-building efforts. Investing in climate-smart agriculture practices, crop diversification, and early warning systems can help mitigate the adverse effects of temperature fluctuations on agricultural productivity.

However, relying solely on adaptive measures may not address the root causes of temperature change, which are primarily driven by global factors such as greenhouse gas emissions. Effective climate action requires international cooperation, policy coordination, and concerted efforts to reduce emissions and limit global warming.

**5.1. Recommendations**

Based on the findings from the regression analysis and their critical implications, several recommendations emerge for policymakers in addressing food security challenges across Africa:

* Enhance Governance and Transparency: Strengthen efforts to improve transparency, accountability, and governance structures within countries. Implement measures to combat corruption in the food supply chain, enhance public trust in government institutions, and ensure equitable distribution of resources for agricultural development.
* Promote Democratic Institutions: Foster inclusive democratic processes that prioritize the needs of vulnerable populations and promote sustainable agricultural policies. Engage stakeholders in participatory decision-making processes to ensure that food security initiatives reflect the diverse needs and perspectives of local communities.
* Streamline Business Regulations: Implement reforms to improve the ease of doing business, particularly in the agricultural sector. Simplify bureaucratic processes, reduce regulatory burdens, and provide support mechanisms for small-scale farmers and rural entrepreneurs to access markets, finance, and technology.
* Attract Responsible Foreign Investment: Encourage responsible foreign direct investment that aligns with national development priorities and contributes to sustainable agricultural development. Establish clear regulatory frameworks and safeguards to mitigate risks associated with land grabbing, environmental degradation, and social displacement.
* Promote Renewable Energy Integration: Invest in renewable energy infrastructure to reduce reliance on fossil fuels and enhance energy security for agricultural activities. Prioritize the adoption of climate-smart agriculture practices, such as solar-powered irrigation systems and agroforestry techniques, to improve resilience to climate change impacts.
* Invest in Climate Resilience: Develop adaptive strategies and resilience-building measures to mitigate the adverse effects of temperature fluctuations and climate variability on agricultural productivity. Prioritize investments in climate-resilient crops, water management systems, and early warning mechanisms to anticipate and respond to climate-related risks.

**Table 4.6: Panel regression result (fixed effects).**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Africa** | **West Africa** | **North Africa** | **Central Africa** | **East Africa** | **Southern Africa** |
| CPIA | 41.467 | -3.708 | -131.988 | 63.070 | 93.739 | 129.394 |
|  | [17.702] | [21.725] | [240.272] | [47.485] | [33.558] | [61.121] |
|  | (2.3425)\* | (-0.171) | (-0.549) | (1.328) | (2.793)\*\* | (2.117)\* |
| DEM | 852.915 | 63.689 | 2080.672 | 1056.159 | 784.667 | 2020.361 |
|  | [244.639] | [347.949] | [601.701] | [1039.912] | [547.923] | [778.090] |
|  | (3.486)\*\* | (0.183) | (3.458)\*\* | (1.016) | (1.432)\* | (2.597)\* |
| EDB | 5.726 | 5.298 | 3.311 | 7.472 | 4.922 | 0.547949 |
|  | [2.2969] | [1.408] | [3.114] | [3.033] | [1.514] | 1.706645 |
|  | (2.493)\* | (3.763)\*\*\* | (1.064) | (2.464)\* | (3.251)\*\* | (0.321) |
| FDI | 4.796 | 2.596 | -23.5706 | -2.674 | 25.790 | -15.1173 |
|  | [0.887] | [2.499] | [42.998] | [5.490] | [5.101] | [15.597] |
|  | (5.409)\*\*\* | (1.039) | (-0.548) | (-0.487) | (5.056)\*\*\* | (-0.969) |
| REN | 13.364 | 14.400 | 10.568 | 7.900 | 16.499 | 22.716 |
|  | [1.181] | [1.911] | [8.096] | [2.548] | [2.105] | [2.346] |
|  | (11.312)\*\*\* | (7.536)\*\*\* | (1.305)\* | (3.100)\*\* | (7.838)\*\*\* | (9.682)\*\*\* |
| TMP | 47.942 | 3.728 | 17.048 | 31.504 | 143.118 | 22.565 |
|  | [51.025] | [92.847] | [151.162] | [165.798] | [98.852] | 85.591 |
|  | (0.940) | (0.040) | (0.113) | (0.190) | (1.448)\* | (0.264) |
| C | 1077.631 | 1914.781 | 2105.958 | 1035.340 | 202.391 | -106.806 |
|  | [126.440] | [273.338] | [278.946] | [382.076] | [253.484] | 456.304 |
|  | (8.523)\*\*\* | (7.005)\*\*\* | (7.550)\*\*\* | (2.710)\* | (0.798) | -0.234 |
| R-squared | 0.520 | 0.608 | 0.445 | 0.421 | 0.582 | 0.293 |
| Adjusted R-squared | 0.496 | 0.570 | 0.395 | 0.377 | 0.557 | 0.250 |
| F-statistics | 21.601\*\*\* | 16.105\*\*\* | 9.023\*\*\* | 9.525\*\*\* | 22.935\*\*\* | 6.828\*\*\* |
| Akaike info criterion | 15.658 | 14.753 | 16.224 | 15.619 | 15.743 | 15.284 |
| Schwarz criterion | 15.904 | 15.016 | 16.48062 | 15.863 | 15.976 | 15.518 |
| Hannan-Quinn criter. | 15.751 | 14.860 | 16.328 | 15.718 | 15.835 | 15.377 |
| Durbin-Watson stat | 0.766 | 1.170 | 0.642 | 0.722 | 0.706 | 1.151 |

Source: Eviews Output and Authors' Computation, 2024. Note: Values in () and [] are standard errors and t-values respectively. t-values with \*,\*\*, \*\*\* are statistically significant at 10%, 5% and 1% respectively.

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