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Economy

Dynamics of a complex system: investigating the interplay between food security, transition to renewable energy, democracy, and governance in Africa

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Abstract. In a time when climate patterns change, governance structures evolve, and economic landscapes shift. Understanding the link between food security, renewable energy adoption, and democratic governance in Africa is crucial for achieving sustainable development and resilience on the continent. **The purpose.** This study investigates the intricate dynamics of food security, renewable energy transition, democratic governance, and economic policies across 51 African countries from 2000–2022. **Methods.** The study utilized panel regression analysis with fixed effects to examine the interplay between governance indicators, democracy, renewable energy integration, and food security outcomes across African regions. **Results.** The fixed effect regression analysis revealed significant associations between key variables and food security outcomes across different African regions. Higher CPIA scores were positively correlated with increased food security in Africa as a whole, indicating the impact of improved governance transparency. Representative democracy was also linked to enhanced food security, with particularly strong relationships observed in East Africa. Positive coefficients for ease of doing business suggested favourable impacts on food supply, albeit with regional variations. Additionally, renewable energy integration emerged as a crucial factor positively influencing food security, especially in Southern Africa. Moreover, the study underscores the importance of democratic governance and transparent economic policies in fostering food security initiatives. **The scientific novelty.** Embracing transparent governance, fostering renewable energy integration, and prioritizing inclusive democratic practices are pivotal steps toward fostering enduring food security solutions across Africa.

Keywords: systems, food security, political system, regression analysis, management, business, energy sources

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Экономика

Динамика сложной системы: исследование взаимосвязи между продовольственной безопасностью, переходом к возобновляемым источникам энергии, демократией и государственным управлением в Африке

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Аннотация. В то время, когда климатические условия меняются, структуры управления развиваются, а экономические ландшафты меняются, понимание связи между продовольственной безопасностью, внедрением возобновляемых источников энергии и демократическим управлением в Африке имеет решающее значение для достижения устойчивого развития и устойчивости на континенте. **Цель.** В исследовании изучается сложная динамика продовольственной безопасности, перехода к возобновляемым источникам энергии, демократического управления и экономической политики в 51 африканской стране в период 2000–2022 гг. **Методы.** В исследовании использовался панельный регрессионный анализ с фиксированными эффектами для изучения взаимодействия между показателями управления, демократией, интеграцией возобновляемых источников энергии и результаты продовольственной безопасности в африканских регионах. **Результаты.** Регрессионный анализ с фиксированным эффектом выявил значительные связи между ключевыми переменными и результатами продовольственной безопасности в различных африканских регионах. Высшие CPIA оценки положительно коррелировали с повышением продовольственной безопасности в Африке в целом, что указывает на влияние повышения прозрачности управления. Представительная демократия также была связана с повышением продовольственной безопасности, поскольку особенно крепкие связи наблюдаются в Восточной Африке. Предложены положительные коэффициенты легкости ведения бизнеса и благоприятного воздействия на снабжение продовольствием, хотя и с региональными различиями. Кроме того, интеграция возобновляемых источников энергии стал решающим фактором, положительно влияющим на продовольственную безопасность, особенно в Южной Африке. Более того, исследование подчеркивает важность демократического управления и прозрачной экономической политики в продвижении инициатив в области продовольственной безопасности. **Научная новизна.** Обеспечение прозрачного управления, содействие интеграции возобновляемых источников энергии и установление приоритетов инклюзивной демократической практики являются важнейшими шагами на пути к поиску устойчивых решений в области продовольственной безопасности по всей Африке.

Ключевые слова: системы, продовольственная безопасность, политическая система, регрессионный анализ, менеджмент, бизнес, источники энергии

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Introduction

One of the major problems that the policymakers and researches face nowadays has to do with food security [1], especially when the society shifts to renewable types of energy like wind and solar. The bond between food security and the absorption of renewable energy in Africa is bright [2]. Proponents of renewable energy believe that it is the key to better agricultural productivity, providing sustainable irrigation and mechanization, hence providing food security [3]. As claimed by Nitescu & Murgu [4], substituting fossil energy by renewable energy sources contribute positively to food security. Sustainable energy can complement climate change initiatives in the agricultural sector and there is research consensus that leads to improvement in food production. However, there are disparities in research findings and opinions. In opposition to transition from renewable energy to fossil fuels, the following argument is put forward: This implies that money that would have been used to make necessary agricultural investments will no longer be available [5]. Furthermore, renewable sources like wind and solar energy can cause intervals in energy supply, which may lead to the disruption of many primary farming businesses, hence aggravating food insecurity [6]. Due to the regional specifics in the regional governance strategies and socio-economic factors, the switch to renewable energy must be analyzed as an experience based on regional particularities.

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 as the transition to renewable energy [7; 8]. However, sceptics suggest that political instability in democracies can disrupt agricultural policies, worsening food insecurity and halting policies on renewable energy [4]. While democracies like Ghana show positive links between political stability and food production [9], challenges persist in areas with governance issues like corruption and weak institutions that hinder the implementation of the transition to renewable energy [10; 3]. The effectiveness of democracy in ensuring food security depends on strong public management and governance mechanisms [11], economic stability, and social inclusivity [12].

Empirical evidence highlights the importance of government involvement in achieving food security and the transition to renewable energy [1; 7; 11]. Countries with effective agricultural policies and governance, such as China and Brazil, have witnessed significant improvements in food production and renewable energy generation [13]. Robust government intervention is crucial for a strong commitment to agriculture and even a smooth transition to renewable energy, enabling effective policies, infrastructure development, and crisis management that ensures food security [7]. Conversely, there are arguments 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 [9]. Challenges arise when governance is plagued by corruption or lack a comprehensive approach, and as such this impedes policies and programmes which may be formulated to better the life of the citizens [6; 11]. 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 [3; 9; 13, 14; 15]. A harmonized strategy involving renewable energy, democracy, and government expenditure is indispensable for tackling food security issues in Africa [13]. 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 [14]. Renewable energy holds the potential to augment agricultural output, while effective governance is imperative for judicious resource distribution [13]. 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 [3].

Prior studies have delved into public financial management of developing countries [11], institutional designing of food security by instruments of matrix modeling and value flows synchronization [1] as well as the nexus between food security and the adoption of renewable energy [5; 13; 14], and also the influence of democratic decision-making processes on sustainable agricultural methods [13; 9]. 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 affect renewable energy endeavours and food production directly or indirectly. This study endeavours 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.

Literature review

A thorough analysis of the links between food security, transition to renewable energy, democracy, and government spending, that is characteristic of an African society, has to be conducted since the topic is quite complicated. Supporters of food security note that the approach that is both comprehensive and incorporates renewable energy to agricultural practices under democratic government helps to advance improved food security [16; 17]. Nevertheless, the opponents highlight some trade-offs and challenges that food security may bring to the resource allocation system, which put into context, may pose problems in realizing this goal [6].

The context that describes the performance of democracy and renewable energy on carbon emissions in sub-Saharan African countries is more broad than specific [16]. This issue may be aggravated as a result of absence of complete studies performed humbly concerning the relationship of democracy, renewable energy and carbon emission in this area. Vegetable scientists claim there are mixed consequences of green economy on food security, reflecting differences in opinions [18]. Besides that, no attention is paid to the comprehensive needs of the farmers for food agriculture as well as the resource configuration in the food-energy nexus and to the integrated solutions that are required to tackle the multifaceted problems that Africa agriculture and energy systems are currently facing [18].

The adoption of renewable energy has been highlighted in Africa, as it has the ability to neutralize the effects of global warming and to enhance agricultural productivity [17; 18]. Sustainable and improved access to energy encourages mechanization, irrigation, and post-harvest processing particularly due to availability of the green energy [16]. Kenya and South Africa have seen better productivity in agriculture as the countries turned to renewable sources like solar, geothermal, hydropower for energy [17]. Nevertheless, there is a hiccup, including the initial expensive renewable infrastructure and intermittent energy supply, which may upset the agriculture. Moreover, the interruption of the agricultural operations is a potential problem [16].

New public management and democratic governance positively influences food security by fostering transparency, accountability, and citizen participation [3; 11]. Stable democratic institutions, as seen in countries like Ghana and Botswana, correlate with improved food security indicators [36]. However, political instability within democracies can lead to policy fluctuations and disruptions in agricultural development, posing challenges to maintaining effective policy continuity [9].

Strategic government spending, fight against corruption, and ease of doing business can address food security challenges amidst Africa's rapid population growth [3; 15]. However, critics contend that excessive population growth strains resources, hindering food security [36]. The transition to renewable energy is seen as pivotal, yet skeptics argue that initial costs may divert funds from immediate needs [16]. Democracy is viewed as beneficial for governance, but detractors highlight potential instability affecting policies [3]. Scientifically, statistics show a complex interplay, demanding nuanced strategies [5].

Economic growth stimulates resources for effective governance, aiding food security and renewable energy transition [13]. However, critics contend that uneven wealth distribution can exacerbate food insecurity [13]. The transition to renewable energy is viewed favourably for environmental sustainability, but skeptics question its feasibility amidst economic constraints [16]. Democracy is seen as fostering responsible governance, yet detractors highlight potential policy fluctuations [9]. Africa's challenge lies in harmonizing economic growth and resource allocation which is expected to positively affect such issues like food security, renewable energy adoption, and democratic governance [17; 19].

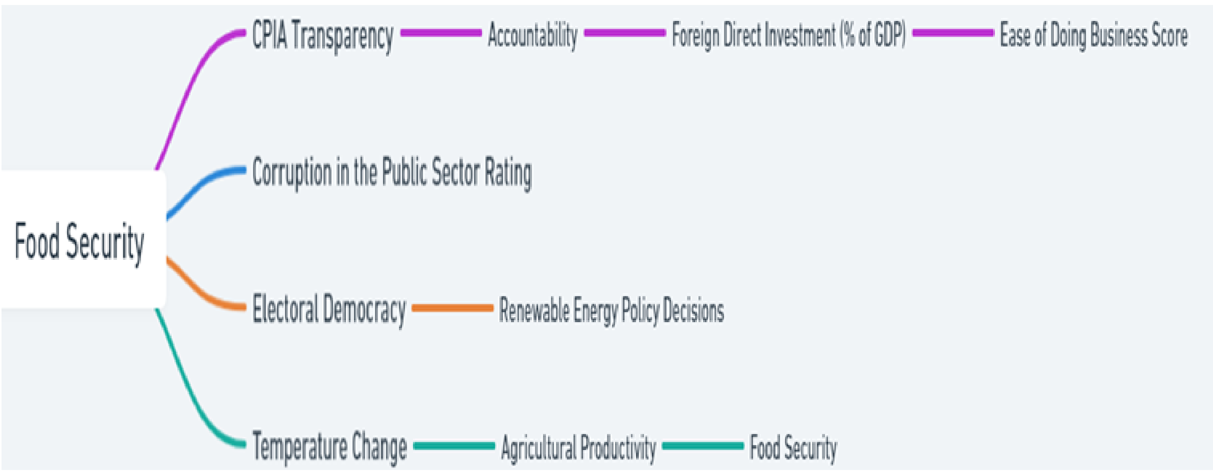

Fig. 1. Conceptual framework
Source: developed by the authors

Foreign Direct Investment (FDI) can spur economic growth, benefiting government spending, food security, and renewable energy transition [11; 16; 19]. However, critics caution against exploitation risks, potential misalignment with local needs, and economic inequality [17]. FDI is seen as promoting democracy, but skeptics highlight its influence on policy autonomy [13]. 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

Also, the ease of doing business is often advocated for its potential benefits in diversifying food sources and fostering economic growth and this can improve food security and support the transition to renewable energy [14; 20]. However, the vulnerability to global market fluctuations and unequal distribution of benefits, potentially exacerbate food insecurity [20]. Trade openness, although aligned with democratic principles, faces criticism for potential exploitation and policy challenges [20]. Trade statistics reveals both positive and negative impacts, necessitating nuanced strategies to optimize trade openness in Africa [20].

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 [20]. To address food security in Africa, reducing delays in documentation and border compliance is identified as a critical factor [14]. The study by Bonuedi, et al. [14] indicates that poor trade facilitation is a significant driver of food insecurity in Africa, with reductions in delays promising 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 under-supported by state responses [18]. This emphasizes the need for a new valuation of the informal sector, recognizing and building on its contributions to society [19].

The impacts of climate change, particularly carbon emissions, pose a significant threat to food security in Africa [17]. Transitioning to renewable energy can mitigate these impacts and enhance resilience [18]. However, economic challenges hinder this shift, as highlighted by detractors [17]. Africa faces increased vulnerability due to climate change, affecting agriculture [13]. The impact on food security is evident in Northern and Eastern African regions, where climate change negatively influences food security levels [13]. 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 [13].

The study in Central Africa conducted a population-based analysis and forecast that extreme droughts caused by climate change and the rising mean temperature will increase cases of hunger in the region [13] In fact, this research stipulates that food insecurity, childhood malnutrition, mortality, and infectious diseases become more likely to occur due to climate effect of economics and health sector [13]. It is understood that the role of democracy in policy that promotes the fight on climate change is participatory but political instability is risk [17]. Balanced government budgeting in the face of the climate challenge requires making trade-offs which means that resources are limited [17]. The issue is to find the sweet spot of fast-tracking renewable energy consumption, appealing democracy and choosing the best budgets to address food security implications as well as environmental sustainability problems in Africa.

Conceptual framework

FAO [16] defined food security as a condition whereby individual and community members any time have both the physical, social, and economic access to adequate, safe, and nutritionally well balanced foods to fulfil their daily needs and food preferences bearing with them active and healthy life path. Regardless the unrelenting efforts in food and nutrition security measures, developing countries, in particular, African countries appear to remain vulnerable to various challenges of hunger and malnutrition. Firstly, the key is not simply this availability of all eatable things. If food security must be attained there can only be active cooperation between the governments some policies, and the private agency [1; 11]. The agriculture sector in African countries has none-stop extension programs over the years, and essentially, they are each meant to ensure that a greater number of people within a state are able to have access to appropriate amount of safe and nutritious food for their consumption.

In West Africa, for example, Nigeria has the Life and Non-Life Insurance Bill, National Micro-Finance Policy, Micro-Finance Act, Micro-Finance Policy, Micro-Finance Regulation, and others. Ghana also has Agricultural Diversification Project (ADP), National Agriculture Research Project (NARP), National Agriculture Extension Project (NAEP), Food and Agriculture Sector Development Policy (F In East Africa for instance, in Kenya there have been programs like the NAAIAP, the FNSP, and the NALEP. Rwanda had the NAES, the NAPTTA, and the Ubudehe, among others. In the Southern Africa regions, countries like Zimbabwe have the Pfumvudza programs and Tagine Integrated Agricultural Development Project for Tunisia among many others

The networking operation between food security, energy transition to renewable, democracy and governance make Africa so complicated as it involves the correlation of different elements is represented in fig. 1.

Renewable energy can be defined as those energy sources that are massive, ever-rising, and naturally replenished, such as solar, biomass, the heat of the inner crust of the earth, tides, and wind. Science and technology play a vital role in the clean-energy segment as they help avoiding air pollution, water pollution, and global warming problems through converting these renewable energy sources into different kinds of clean and usable energy such as bioenergy, geothermal energy, hydropower, marine energy, solar energy, wind energy, hydrogen, and renewable fuels. In developing countries, over the years, emphasis has been on non-renewable energy sources like coal, natural gas, and crude oil as means of attending to such needs as energy generation, transportation, and most industrial activities. It has been argued that government and the private sector in developing countries of Africathrough commitment to policies and programmes can initiate a shift from reliance on non-renewable energy sources to renewable energy sources especially as it affects agricultural activities. Thereby helping reduce cases of carbon emission and resultant air pollution from energy production, ensuring lower energy costs, expanding access by rural communities, and ensuring enhanced reliability of the power grid, all aimed at promoting and sustaining agricultural activities[21].

Government and governance mean an institution and a process to ensure that the welfare of the citizens is realized. This well-being can also be achieved through external assistance. In particular, Astratova and Toshpulotov in their study [11] emphasize that external assistance to developing countries can be effective if such levers as: 1) the application of the "two-deficit economic growth" model; 2) the application of institutional regulation of direct investment; 3) the provision of external assistance to developing countries that adhere to the "right policy course". At the same time, Ejiofor & Udeogu [22] explains that in a democracy through effective representation, the power of decision-making is impliedly in the hands of the people at large, whose voices are heard and felt on issues affecting the greater populace through their representatives, elected into political office. Ndubuisi and Onuama [23], summarised human security with the 1994 UNDP Human Development Report as safety from such threats demeaning humanity like hunger, disease, crime, repression, and other sudden and hurtful disruptions affecting day-to-day living in homes and outside homes. It is a fact that the issue of food security if not addressed by a society can eventually resultin other threatsdiffering from hunger as mentioned above. Demands made into the policy boxwhich can be summarised as human security needs or welfare needs of the citizenryeventually come out as programmes and policies which can affect such issues as food security positively or negatively.

In most African countries, corruption, political instability, economic mismanagement, and security concerns among others over the years have had gross effect on issues like food security. In Nigeria between 2011 and 2023, earnest demands were continually made by the Nigerian populace for the government to show commitment to decisively addressingthe increasing security challenges experienced across the nation in cases of kidnappings, killings, destruction of means of livelihood, and others. The lack of commitment by government to address these concerns eventually resulted inthe inability of farmers in affected areas to go to farm thus impliedly affecting farming activities resulting in food scarcity and high cost of food items [3; 17; 24; 25].

Governments have remained primary actors in the physical, social, and economic aspects of a nation's food security [1; 11]. Therefore, any focused attempt to improve agriculture and impliedly food security must also consider first and foremost the role of governance. There must be in play certain principles of governance, which include participation, accountability, transparency, effectiveness, and the rule of law. These should be integral parts of programmes for agriculture and food security if such are purpose-driven and targeted to ensure food security.The relationship between food security and governance can be supportive or destructive. a food-secure population can bolster stable governance, whereas a population faced with food insecurity can destabilize governance.

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 [3; 13]. 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.

Representative democracy, a gauge of political stability and citizen engagement, can mould governance efficacy and policy choices pertaining to food security and renewable energy endeavours [9]. 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 Ease of Doing Business Score shapes investment climates, thereby impacting the inflow of Foreign Direct Investment (FDI) and, subsequently, economic stability and food security [20]. 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.

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.

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 [11]. The choice of fixed effects estimation stems from its capacity to give dependable assessments of the relationshipbetween food security, the transition to renewable energy, democracy, and governance in Africa, while considering unobserved effects unique to time and country [26; 27]. This approach aids in alleviating bias arising from variables omitted, thereby fortifying the resilience of our analysis [9].

To ensure the validity and reliability of our empirical results, we conduct the Hausman test [28] to determine the appropriate panel model – fixed effects or random effects. The Hausman test assists in assessing whether the fixed effects model is more suitable for our analysis, contributing to accurate and valid estimation.

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.

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 [29]. 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. Political ecology emphasizes how governance structures influence resource distribution, access, and sustainability.

Using the political ecology framework proposed by Anser, et al. [30], we argue that communication, information, and technology adoption (ICT) as well as governance are the main factors that determine food security in the West Africa region. The research focuses on the governing factors, specifically government effectiveness and corruption control, as the key contributors in the improvement of food security. Within the scope of renewable energy transition, the study of Zakari, et al. [6] mentions the agenda of securing energy and it should be the point of attention for policymakers. Political ecology provides an avenue of analysis of power relationships in energy resources availability where socio-economic domains and politics of one country are factors that influence the energy choices [3; 26; 31]. The people (citizens) remain stakeholders in governance and their demands considering the changing nature of the society represent input made into the policy system. These inputs after consideration come out as outputs reflecting policies and programmes engaged by the government. Considering this, it is obvious that food security remains one of the earnest demands of the populace.

Therefore, political ecology will undoubtedly offer an analytical framework to take cognizance of drivers that affect the way decision support tools will merge into decision-making process characterized by food security. The political ecology framework will also enlighten on the relationship of democratic governance structure and the impact of economic processes and policies as well as evaluate the political dimensions of energy policies and laws and their effect on economic growth. Political Ecology is a robust conceptual foundation for analysing the many dimensions and inter-relations of food security, renewable energy transition, democracy and governance in Africa. With the help of this approach we can better figure out power dynamics, political processes and environmentally social complexities which give us the knowledge on problems and opportunities of the given system.

Empirical model

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

$$FSK = f\,(CPIA, DEM, EDB, FDI, REN, TMP) \ldots \quad (1)$$

$$FSK_{it} = g_{it}\beta + \varepsilon_{it} \ldots \quad (2)$$

$$\varepsilon_{it} = \alpha_i + \gamma_t + h_{it} \ldots \quad (3)$$

From equation (2), g_{it} contains the variables to be used in the model:

$$FSK_{it} = \beta_0 + \beta_0 CPIA_{it} + \beta_0 DEM_{it} + \beta_0 EDB_{it} + \beta_0 FDI_{it} + \beta_0 REN_{it} + \beta_0 TMP_{it} + \varepsilon_{it} \ldots \quad (4)$$

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

$CPIA_{it}$ is the CPIA transparency, accountability, and corruption in the public sector rating for country i at time t.

EDB_{it} is the Ease of doing business score for country i at time t.

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

TMP_{it} is the Temperature change for country *i* at time *t*.

DEM_{it} is the Representative Democracy for country *i* at time *t*.

REN_{it} is the Renewables – % electricity for country *i* at time *t*.

ε_{it} β is the error term.

The error term ε_{it} β can be decomposed as follows:

$$\varepsilon_{it} = + h_{it}\beta ... \quad (5)$$
$$\alpha_i = 0.$$
$$\gamma_t = 0.$$

$$FSK_{it} = \alpha_i + g_{it} + h_{it} ... \quad (6)$$

$$FSK_{it} = \gamma_t + g_{it} + h_{it} ... \quad (7)$$

Where:

α_i is the unobservable specific cross-section effects;

γ_t Unobservable specific time effects;

h_{it} β is the mutual cross-section time series effect.

Hence, if $\gamma_t = 0$ 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:

$$FSK_{it} = +\alpha + \mu_i + h_{it} ... \quad (8)$$

Equation (8) denotes the stochastic effects paradigm, wherein 'a' signifies the shared intercept, and the error term is $\varepsilon_{it} = \alpha_i + h_{it}$. 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 β_0, β_1,…, β_6 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 [28] 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 [28] statistic is derived through the following computation:

$$H = (\beta\hat{}\ RE\text{-}\beta\hat{}FE)'[Var(\beta\hat{}\ E\beta)-Var(\beta\hat{}FE)]-1(\beta\hat{}RE-\beta\hat{}FE) ... \quad (9)$$

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.

Table 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*
Representative Democracy	*Index or score measuring the level of democracy in a country. 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*

Table 2
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: Authors Computation, 2024.

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 [28] 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.

Justification of the methodology

The chosen methodological approach for this study, which involves quantitative panel data analysis with fixed effects, is well-suited to address the research questions and objectives related to food security, renewable energy transition, democracy, and governance in Africa. Several key justifications support the selection of this method.

Capturing Temporal and Cross-Country Variations: Panel data analysis allows for the examination of relationships between variables over time and across different countries in Africa. By incorporating fixed effects, this method captures unobserved effects unique to each country and period, providing a more comprehensive understanding of how food security, renewable energy transition, democracy, and governance interact within and across nations.

Robustness and Control for Endogeneity. Fixed effects estimation method in panel data analysis neutralizes the endogeneity by specifying a system in which time-invariant country-specific factors act in order to complicate the dynamic associations which are investigated. This way increases the model's sturdiness; it minimizes the chance of preferences being formed because of omitted variables or unobserved heterogeneity.

Comparative Analysis. Pooling of panel analysis data facilitates a hedonic approach towards the comparison of regions in Africa. By doing this, researchers will be able to find patterns, trends, and variations in the relationships between food security, renewable energy transition, democracy, and governance. This comparative outlook widens the generalizability of results and gives an opportunity to look into regional differences as well as similarities.

Theoretical Framework Alignment. The methodological approach aligns well with the theoretical framework drawing on political ecology to understand the complex interactions between social, political, economic, and environmental factors. By employing quantitative panel data analysis, the study can empirically test and validate the theoretical concepts derived from political ecology, contributing to a deeper understanding of the dynamics at play.

Validity and Reliability. Conducting the Hausman test [28] to determine the appropriate panel model (fixed effects or random effects) enhances the validity and reliability of the results. This methodological step ensures that the chosen model is suitable for the analysis, contributing to the accuracy of the estimation and interpretation of the relationships between the variables of interest.

Data sources, variable description and empirical results

The study led to the development of data selection criterion, which focused on African countries, in a certain time frame, with assurance of data availability, quality, consistency, and relevance to governance, democracy, renewable energy, and food security variables for a holistic and reliable analysis. The data quality was assured through the use of trusted sources, a consistent measure of units, and rigorous validation methods; this notwithstanding, the data limitation might be the data gaps and the inadequacy of the data in various countries as well as periods which might affect analysis robustness.

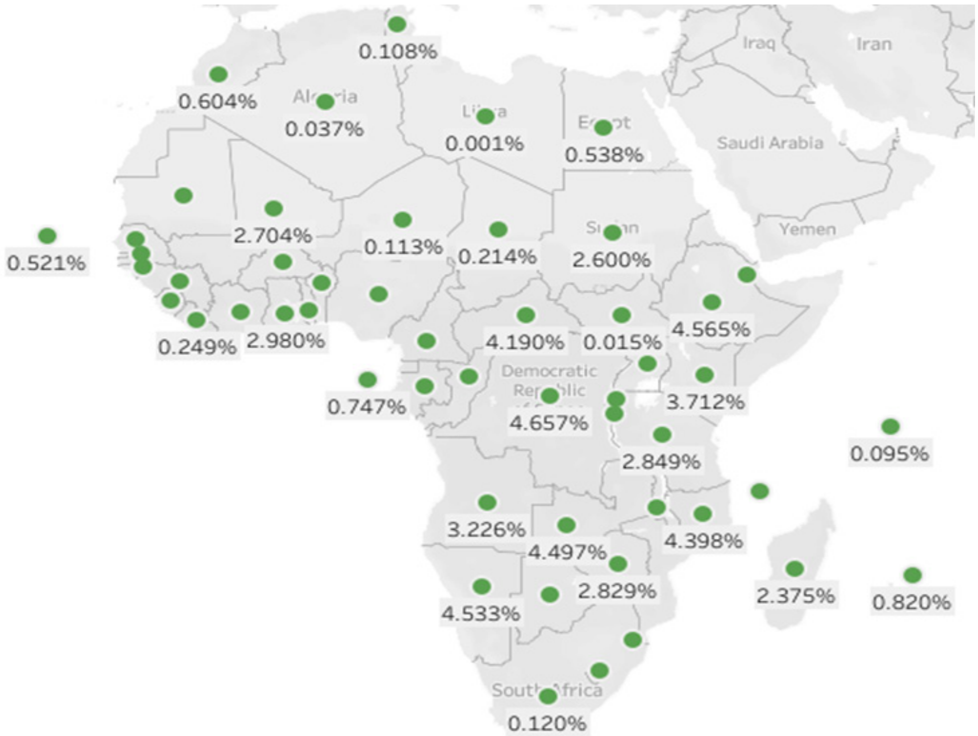

Fig. 2. Percentage Distribution of Renewable Energy Generation in Africa
Source: Authors Computation, 2024

The work concentrated on overcoming the limits that are caused by missing data through imputation, employing robustness checks, being transparent about limitations, and making sure the assumptions are clear for a correct analysis. Given that the rate of missing data was less than 5 %, they were substituted with zeros as this substitution has little bearing on regression results.

This study data include information collected from multiple sources covering 51 African countries, covering the years between 2000 to 2022. It should be stressed that the panel comprised from these data is actually unbalanced and it depicts each country (and the campaign) in the whole 15 years from the beginning of the country's creation. 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 study took into account the specific variables mentioned in table 1, as depicted in the table below. The approach to data collection involves the process of information collecting from several reliable secondary data sources with an aim of having holistic and typical data analysis for an in-depth analysis.

Analysis and discussion of results

This section represents the first part of our data analysis, and it is dedicated to the presentation of the variables used in the study, focusing on their minimum, maximum, average, standard deviations, and the number of observations for each one of them. This kind of analysis offers, of course, invaluable insights into the current challenges of sustainable food, renewable energy, democracy, governance, and related issues within Africa.

Table 2 provides a comprehensive yet understandable summary of the descriptive statistics of the variables: Food Supply (FSK), Corruption Rating on Transparency and Accountability (CPIA), Representative Democracy (DEM), Ease of Doing Business Scores (EDB), Foreign Direct Investment (FDI), Renewable Energy Amounts as Part of Total Electricity Generation (REN).

At the very beginning, food available to consumers (FSK) is the mean value which stands at 2188.139 kcal per capita per day and median of 2348.788 kcal. The lowest value that we have recorded here is 0.000 kcal, which shows the times of very severe food insecurity, but the maximum kcal value is 3588.146. The SD 836.358 signifies significant assortments of food supply between the representative African countries.

Concerning the CPIA, the mean score for waste disposal, accessibility, and anticorruption in public administration is 1.596, whereas the median is 2.000. The results demonstrate a diverse variety of scores, from the lowest score of 0.000 to the highest score of 4.500, on a SEM of ±1.440.

Table 3

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: Authors Computation, 2024.

Table 4

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)*

Note. I (0) and I (1) stationary at level and first difference. Value are Levin, Lin & Chu.

Source: Authors Computation, 2024.

The Mean score for Representative Democracy (MEAN) of the countries in the region stands at 0.423 which implies Public governance in the countries of the region. The data is based on a score of zero to zero point eight, with a lower score as 0.072 and a higher one of 0.806 and standard deviation is 0.187. In regard to Ease of Doing Business Score (EDB) there is a greatly large fluctuation with 10.818 of median value and 21.446 as standard deviation. The range goes from 0.000 to 81.468, which signals different to business and investment climate in African countries.

FDI show an average percentage of 4.432 of GDP, corresponding to fluctuation as shown by a standard deviation of 8.712. The examined range is from –17.292 % to 103.337 % of GDP so there are noticeable amount of different values among the observed countries. The Average of Renewables as a Percentage of Electricity generated gives us a mean value of 40.195%, meaning a reasonable integration of renewable energy in the electricity sector. Data varies between 0.000 % and 100.000 %, with a standard deviation of 37.907 displays the difference in renewable energy adoption.

Temperature Change (TMP) has the central value of 1.441 bugs with quite a high deviation of 3.636. Fig. 2 shows values ranging from –1.305 to 27.370 degrees, suggesting extreme climatic conditions in Africa different from one another.

Skewness and kurtosis show into the distributional nature of the variables. Skewness and kurtosis deviations from zero more than ordinary indicate non-normality in the distribution thus, a careful statistical analysis should be warranted.

Besides, the Jarque – Bera hypotheses test checks the normality of the data distribution. The numerical values assigned to each explanatory variable show that the null hypothesis of the normal distribution gets rejected at a significant value, indicating non-normal distribution patterns.

The distribution of renewable energy components amongst the continent of Africa, represented as depicted in fig. 2, indicates some heterogeneity as compared to the adoption of, and access to, renewable energy sources. Some countries show commitment in renewable energy figures particularly, Burundi, it has generated an impressive 4.29 %, and the rest Lesotho, Malawi, Mozambique, Namibia, and Zambia, reach more than 4 % renewable energy generation. These set of statistics determine the laudable work that way given that the energy sourcing method come close to meeting global environmental goals.

Nevertheless, the world appears to be shaping quite the picture, which is less bright for some countries than for others since the majority of them add up to as they have very minimal efforts put into transitioning into renewable energy. For instance, Botswana, Comoros, Gambia, Libya and South Africa have percentages ranging from 0.00 % to 0.12 %. Therefore, the different policy landscapes and the implementation issues throughout the continent to this inequality form the basis.

Table 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: Authors Computation, 2024.

Table 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

Note. Values in () and [] are standard errors and t-values respectively. t-values with *,**, *** are statistically significant at 10 %, 5 % and 1 % respectively.
Source: Authors Computation, 2024.

As for cases with low originator volumes, the hurdles of the renewable energies implementation can be rooted in the limited budgets, ineffective infrastructure, and dependence on the traditional energy resources. While some countries with the highest percentage of renewable energy use are known to give equal emphasis to renewable energy policy of their nations, invest in infrastructure on a wide scale and make use of renewable resources for energy production, there are some which are small on the same.

Correlation analysis

The table 3 correlation analysis shed a bright light on the underlined issues, connected to the food security, renewable power, democracy and government shortcomings in Africa. The correlation coefficients are usually ranging from -1 to 1 which are then used to measure how strong the relationship between pairs of variables is and how these relationships are directed.

Looking at the category of food supply (FSK), usually the correlations with other elements show low levels of significance with coefficients close to 0. This indicates that food supply does not dependent correlated significantly on variables studied in this analysis for instance – CPIA, democratic governance (DEM), and ease of doing business (EDB), foreign direct investment (FDI), renewables (REN), and temperature change (TMP).

The interrelationship among food supply and CPIA transparency, integrity, and corruption is clearly weak, and its value is even almost zero (–0.005), suggesting that food security has no significant linkage with the degree of public governance. Also, food supply and other governance relevant indicators, for example, democratic governance (DEM) and ease of doing business (EDB) have negligible relationships, pointing at how these elements might not be of great importance to the food security outcomes.

The process of FDI and REN bears hardly any relation to food production, since the amounts of coefficient are close to zero. This essentially means that the case of the foreign direct investment in renewable energy sources may not translate to food security of African nations intermediary

Under temperature rising or the decreasing (TMP), food security indicates a slight positive co-occurrence (0.094). Hence, this depicts the weak link between climatic variation and food security outcomes. Nevertheless, the value of the relationship is not huge which apparently implies that the increase in temperature may not be the major cause of food supply fluctuations.

Overall, even though the link found would provide insights on the possible associations, the weak associations seen, however, indicate that food security trends in the African continent are multifactorial and are not limited to issues covered in this analysis. There is a few more research that could be done by apart of different factors to share a more fine tune view of the relationship between food security and the renewable energy and how they relate to the democracy and governance in the African context.

Pre-estimation analysis: unit root test

Table 4 presents the unit root tests which are essential whatsoever because they are helpful in the determination of the stationarity of the time series data and also they are important in the analysis of the food security, democracy, governance and renewable energy variables in the whole of Africa. It is shown that there are units roots that indicate whether it is a non-stationarity or not. This information is important because the order of differencing requires is only determined when the data is stationary.

For each variable, two statistics are provided: the first will be categorized into the series level while the second will be classified into the first difference. The statistical representation is made in terms of Sign *t*-Test of Levin, Lin, and Chu (with the corresponding *t*-values); those t-values imply stationarity at the relevant levels of the data series and differenced data.

Food Supply (FSK): at level, the statistic value is 24.2331, but in first difference, the statistic is 87.2978. The values imply that the FSK series is there both level wise and the first difference, notated as I (0) and I (1) respectively.

CPIA, DEM, EDB, FDI, REN, TMP: Yet, the variables CPIA, DEM, EDB, FDI, REN, and TMP, have negative statistics on the unit root test, when assess it for the original level and the first difference. This suggests that the variables in the first difference are not with stationary behaviours according to I (0) or I (1).

Time series analysis requires stationarity of variables because it allows statistical attributes to keep the same level as time pass, resulting in less misleading procedures. The findings mean that the changing variables do not show any unit root following the first-difference so they remain stationary. This lays the ground for in-depth analysis by making the identification of the correlation between different variables, the establishment of causal links, and the development of predictive models become possible.

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 5) 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.

The panel regression results presented in table 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 representative 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 the food supply.

Notably, East Africa exhibits a particularly strong positive relationship between representative 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 the 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.

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 representative 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.

Increased transparency and accountability in governance will thus strengthen public trust and confidence in the government institutions. It may also result in such things as prioritizing agricultural development funding, improved management of food distribution, and reduction of corruption among players of the food supply chain.

Besides advocating for transparency and good governance, we do not think that this is enough addressing root causes to food insecurity. Corresponding challenges like inadequate infrastructure, little representation in markets, and uneven distribution of resources also need our attention.

Reinforcing democratic representation will enable community members to voice their opinions and will expose them to participatory decision making which values food security issues. Democratic institutions can make it possible to carry out policies that are aimed at addressing the needs of members of vulnerable population and promote sustainable agriculture opportunities.

Overdependence on representative democracy only by paying less attention to strong institutions and the importance of institutional continuity. Disorder of political and leadership changes may precede the development of long-term policy whose aim is the improvement of the food security. This may lead to inconsistency and efficiency of the policy.

Simplifying business environment for better performance might help to draw investment, accelerate economic development, generate jobs and eventually improve the food security status. Enhancing administrative procedure and having less onerous regulation can foster entrepreneurship and innovation of the agriculture sector.

Putting simplicity of doing business reforms at the top of the list may worsen the inequality, and marginalize the small-scale farmers and the rural communities. Policies which target mainly the needs of big corporations or wealthier investors can be ineffective since they may not address the problems grassroot farmers' face and the structural impediments to agricultural productivity.

Higher inflows of FDI cause capital, technology, and know-how to come in; this is needed to update agricultural methods supported with better infrastructures and increased market access. Through strategic partnerships as well as knowledge transfer and innovation collaborations with foreign investors can promote sustainable agricultural development rate.

The problem is that this search might choose the benefit of earnings over those of society and the environment. One possible negative effect of foreign direct investment projects is land grabbing, environmental degradation and displacement of local communities if FDI projects do not carry out regulation and are not brought in line with national development priorities.

From eliminating fossil fuels to attenuating the effects of climate change, and to consequently improve energy security, which is a key to agricultural sustainability, investing in renewable energy infrastructure does all of these. Using renewable energy like solar-based irrigation practice enhances capacities and the ability to adapt to changing climate patterns.

On one side, renewable energy integration appears to be a necessary shift, but there might be implementation constraints like higher initial capital costs, technical limitations, and poor investment incentives in place. The unbalance of renewable energy resources and the lack of efficient grid infrastructures contribute to the marginalization between urban and rural regions.

Awareness of the influence of heat on food security will guide for the adoption of appropriate adaptation measures and the strengthening of resilience. To alleviate the negative impacts of temperature variance on agricultural production, investing in the implementation of climate-approved agriculture methods such as crop diversification and early warning systems will be very helpful.

Although implementing adaptive measures can lead to the prevention of temperature change caused by local changes but the international factors such as global greenhouse gas emissions is the root reason of the climate change. The efficient act against climate change relies on international cooperation, policy synchronization, and the collective effort of everyone to cut down emissions and control the increase of the global warming.

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. Set in place policies to guarantee effective mechanisms for checks and balances to transform and build institutions in countries. Ensure anti-corruption measures that exist in the food distribution chain, restore trust at the public institutions, and provide for equitable resource allocation for agriculture.

Promote Democratic Institutions. Emancipate democratic frameworks that put to the front those who are vulnerable in society and use lasting agricultural policies as an example. Incorporate local people and other stakeholders in participatory decision-making features to reflect the disparate needs and perceptions of the diverse population in the local communities.

Streamline Business Regulations. Initiate reforms aimed to support the business environment primarily in agricultural sector. Present more simple administrative processes, less regulation and offer various programs that can sustain cooperation to small-scale farmers and rural entrepreneurs in order to give them an access to markets, finance and technology.

Attract Responsible Foreign Investment. Support the investment that downplays the consequences on the national priorities and produces for a development scholarship in agriculture. Assure sufficient legal mechanisms and precautions of land grabbing, environmental degradation, and social displacement.

Promote Renewable Energy Integration. Set up renewable energy networks for the purposes of sustainability in powering agricultural operations and ensure energy security for farming activities. Place more emphasis on embracing climate-smart agriculture technologies for sustainable farming, like solar-powered irrigation systems and agroforestry practices, as they help to withstand the impacts of climatic hazards.

Invest in Climate Resilience. Conceive adaptive strategies and resilience-based techniques tailored to the severity of temperature variations and climatic instabilities on crop yields and production. Provide financial support to climate-honouring crop seed lines, rainwater harvesting setups and crop loss prediction systems to be prepared to the climate-related hazards.

References

1. Astratova G. V., Toshpulotov A. A. Financial Management in the Public Administration of Developing Countries: The Challenges of Aid Effectiveness. *Bulletin of the Samara State University of Economics*. 2023; 11 (229): 85–106. DOI: 10.46554/1993-0453-2023-11-229-85-106.

2. Bellezoni R., Meng F., He P., Seto K. Understanding and conceptualizing how urban green and blue infrastructure affects the food, water, and energy nexus: A synthesis of the literature. *Journal of Cleaner Production*. 2021; 289: 125825. DOI: 10.1016/j.jclepro.2021.125825.

3. Rushchitskaya O. A., Zagurskiy A. O. State development institutions as the basis of the developed institutional environment of the national agro-industrial complex. *Agrarian Bulletin of the Urals*. 2021; 12: 98–102. DOI: 10.32417/1997-4868-2021-215-12-98-102.

4. Nitescu D., Murgu V. The Bioeconomy and Foreign Trade in Food Products – a Sustainable Partnership at the European Level. *Sustainability*. 2020; 12 (6): 2460. DOI: 10.3390/su12062460.

5. Ahmed S., Warne T., Smith E., Goemann H., Linse G., Greenwood M., Stoy P. Systematic review on effects of bioenergy from edible versus inedible feedstocks on food security. *NPJ Science of Food*. 2021; 5:9. DOI: 10.1038/s41538-021-00091-6.

6. Van Dijk M., Morley T., Rau M., Saghai Y. A meta-analysis of projected global food demand and population at risk of hunger for the period 2010–2050. *Nature Food*. 2021; 2: 494–501. DOI: 10.1038/s43016-021-00322-9.

7. Fontan Sers C., Mughal M. From Maputo to Malabo: public agricultural spending and food security in Africa. *Applied Economics*. 2019; 51 (46): 5045–5062. DOI: 10.1080/00036846.2019.1606411

8. Ndubuisi U., Onuama E. C. Human Security and Sustainable Regional Development in West Africa: Fanning the embers. *Icheke Journal of the Faculty of Humanities*. 2022; 20 (4): 69–80.

9. Hemed I. The impacts of political regime and governance on growth of East African economies. *EPRA International Journal of Research & Development (IJRD)*. 2019; 4 (1). DOI: 10.36713/epra3732.

10. Ogunniyi A., Mavrotas G., Olagunju K., Fadare O., Adedoyin R. Governance quality, remittances and their implications for food and nutrition security in Sub-Saharan Africa. *World Development.* 2020; 127 (104752). DOI: 10.1016/j.worlddev.2019.104752.

11. Astratova G. V., Klimuk V. V., Ruzshitskaya O. A., Ivliev I. V., Ruchkin A., Yurchenko N. Institutional Designing of Food Security by Instruments of Matrix Modelling and Value Flows Synchronization. *Journal of Environmental Management and Tourism (JEMT)*. 2019; 10 (7). DOI: 10.14505//jemt.v10.7(39).23.

12. Adelle C., Kroll F., Losch B., Görgens T. Fostering communities of practice for improved food democracy: Experiences and learning from South Africa. *Urban Agriculture & Regional Food Systems*. 2021; 6 (9): e20007. DOI: 10.1002/uar2.20007

13. Hassan M., Saif K., Ijaz M. S., Sarfraz Z., Sarfraz A., Robles-Velasco, K., ...Chérrez-Ojeda, I. Mean Temperature and Drought Projections in Central Africa: A Population-Based Study of Food Insecurity, Childhood Malnutrition and Mortality, and Infectious Disease. *International Journal of Environmental Research and Public Health*. 2023; 20 (3): 2697. DOI: 10.3390/ijerph20032697.

14. Bonuedi I., Kamasa K., Opoku E. Enabling trade across borders and food security in Africa. *Food Security*. 2020; 12: 1121–1140. DOI: 10.1007/s12571-020-01095-y.

15. *FAO Report Food Security. Paris: FAO Policy Brief* [Internet]. 2006 [cited 2024 Feb 09]. Available from https://www.fao.org/fileadmin/templates/faoitaly/documents/pdf/pdf_Food_Security_Cocept_Note.pdf.

16. Adams S., Acheampong A. Reducing carbon emissions: The role of renewable energy and democracy. *Journal of Cleaner Production*. 2019; 240: 118245. DOI: 10.1016/j.jclepro.2019.118245.

17. Pickson R. B., Boateng E. Climate change: a friend or foe to food security in Africa? *Environment, Development and Sustainability*. 2021; 24: 4387–4412. DOI: 10.1007/s10668-021-01621-8.

18. Shirley R. Energy for food, livelihoods, and resilience: An integrated development agenda for Africa. *One Earth*. 2021; 4 (4): 478–481. DOI: 10.1016/J.ONEEAR.2021.04.002.

19. Wegerif M. "Informal" food traders and food security: experiences from the Covid-19 response in South Africa. *Food Security*. 2020; 12: 797–800. DOI: 10.1007/s12571-020-01078-z.

20. Asongu S., Odhiambo N. Challenges of Doing Business in Africa: A Systematic Review. *Journal of African Business*. 2018; 20 (2): 259–268. DOI: 10.1080/15228916.2019.1582294.

21. Zakari A., Toplak J., Tomažič L. M. Exploring the Relationship between Energy and Food Security in Africa with Instrumental Variables Analysis. *Energies*. 2022; 15 (15): 5473. DOI: 10.3390/en15155473.

22. Ejiofor C. C. Udeogu C. U. Political culture of impunity and the challenges of democratic consolidation in Nigeria. *South East Journal of Political Science*. 2007; 3 (1): 70–85.

23. Ndubuisi U., Emma-Onyero C., Ukandu S. Terrorism and Boko-Haram Insurgency in North East Nigeria. *Lapai Journal of Humanities (LJH)*. 2020; 11 (1): 195–206.

24. Mérel P., Gammans M. Climate Econometrics: Can the Panel Approach Account for Long-Run Adaptation? *American Journal of Agricultural Economics*. 2018; 100 (1): 259–278. DOI: 10.1111/AJAE.12200.

25. Murshed S., Badiuzzaman M., Hasan R. Food Insecurity and Conflict Events in Africa. *Peace Economics, Peace Science and Public Policy*. 2018. DOI: 10.1515/PEPS-2018-0007.

26. Adams S. O., Klobodu E. K. M., Apio A. Renewable and non-renewable energy, regime type and economic growth. *Renewable Energy*. 2018; 127: 1011–1025. DOI: 10.1016/J.RENENE.2018.02.135.

27. Das P. Panel Data Static Model: Testing of Hypotheses. *In: Econometrics in Theory and Practice*. Springer, 2019. Pp. 499–511. DOI: 10.1007/978-981-32-9019-8_16.

28. Iwedi M., Onwusiribe N. C., Edeh B. The Impact of Cost of Capital on Market Value of Manufacturing Companies in Nigeria. *Eurasian Journal of Management & Social Sciences*. 2023; 4 (1). DOI: 10.23918/ejmss.V4i1p11.

29. Blanton R. E., Kirsch S. *Political ecology: A critical introduction*. Wiley-Blackwell: John Wiley & Sons. 2019. 304 p.

30. Anser M. K., Osabohien R. A., Olonade O., Karakara A. A.-W., Olalekan I. B., Ashraf J., Igbinoba A. Impact of ICT Adoption and Governance Interaction on Food Security in West Africa. *Sustainability*. 2021; 13 (10): 5570. DOI: 10.3390/SU13105570.

31. Dijkshoorn-Dekker M., Linderhof V., Pinto V., Hennen W., Oudendag D., Kuiper M., Shutes L. *Transition support system approach for urban food security in the future: The case of Ghana*. 2019. DOI: 10.18174/476203.

32. Balázsi L., Mátyás L., Wansbeek T. The estimation of multidimensional fixed effects panel data models. *Econometric Reviews*. 2018; 37 (4): 361–384. DOI: 10.1080/07474938.2015.1032164.

33. Braimoh A. Building Resilient Food Systems in Africa. *One Earth*. 2020; 3 (3): 282–284. DOI: 10.1016/j.oneear.2020.08.014.

34. Fusco G. Climate Change and Food Security in the Northern and Eastern African Regions: A Panel Data Analysis. *Sustainability*. 2022; 14 (19): 1266410. DOI: 3390/su141912664.

35. Giller K. The Food Security Conundrum of sub-Saharan Africa. *Global Food Security*. 2020; 26: 100431. DOI: 10.1016/j.gfs.2020.100431.

36. Hill T. D., Davis A., Roos J. M., French M. Limitations of Fixed-Effects Models for Panel Data. *Sociological Perspectives*. 2020; 63 (1): 77–101. DOI: 10.1177/0731121419863785.

37. Itodo F. From crisis to conflict: The environmental threats amplifying Nigeria's National security challenges. *Icheke Journal of the Faculty of Humanities*. 2020; 20 (4): Pp. 39–58.

38. Kinda S. Does the green economy foster food security in Sub-Saharan Africa? *Cogent Economics & Finance*. 2021; 9 (1): 1921911. DOI: 10.1080/23322039.2021.1921911.

39. Ndubuisi U. Environmental Pollution and Climate Change. *In: B. A Otunko and J. M Ibeh (eds.). Trends and Concepts in Social Sciences*. Owerri: Hysab Publishers, 2023. Pp. 113–158.

40. Khodaverdian S. The African tragedy: the effect of democracy on economic growth. *Empirical Economics*. 2021; 62: 1147–1175. DOI: 10.1007/s00181-021-02049-9.

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