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Review
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A REVIEW OF THE EFFECT OF CLEANER ENERGY TRANSITION ON FOOD PRICES AND CLIMATE CHANGE MITIGATION IN SUB-SAHARAN AFRICA: NIGERIA AS A CASE STUDY

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Abstract: Access to clean energy is crucial for achieving sustainable development goals, but investment in renewable energy has been unevenly distributed between developed and developing countries. Developed nations have seen significant growth in renewable energy investment since the Paris Agreement, while developing countries struggle to secure the necessary funds. This study focuses on Sub-Saharan Africa and explores the relationship between the transition to cleaner energy and its impact on food prices. By conducting a systematic literature review, the study highlights the challenges posed by investment disparities, particularly in Sub-Saharan Africa, where financial constraints and infrastructural deficits hinder progress in clean energy infrastructure. The findings suggest that, without appropriate policy reforms and consistent implementation, the transition to cleaner energy in the region may contribute to rising food prices and exacerbate food insecurity. Effective integration of agricultural and energy policies is essential to ensure that the energy transition supports food security objectives. Governments in Sub-Saharan Africa should prioritize policy reforms that promote renewable energy adoption while considering food security. Additionally, reintroducing transparent subsidy programs can help mitigate the impact of high energy costs during the transition to cleaner energy. This review emphasizes the importance of equitable investment and comprehensive policy strategies to balance renewable energy adoption with food security and economic equity in Sub-Saharan Africa.

Keywords: Renewable energy investment, Sub-Saharan Africa, Food prices, Policy reforms, Energy transition

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1. Introduction

According to the Global Hunger Index, there has been a steady increase in global hunger since 2014. The number of undernourished individuals increased from 628.9 million in 2014 to 687.8 million in 2019. The statistics remained unchanged in 2022, but there was a slight increase to 735 million in 2023. There is ample evidence indicating that severe hunger is particularly prevalent in South Asia and Sub-Saharan Africa (SSA), both of which have registered a Global Hunger Index of 27.0. This has posed an increasingly daunting challenge to improving productivity, especially in SSA. The 2020 Global Report on Food Crises highlighted SSA as the site for five of the ten worst food crises globally, with the number of victims of chronic hunger increasing from 234.7 million people in 2019 to 282 million people in 2023 according to IFPRI's 2023 Global Food Policy Report. This region, despite its abundant water and arable land resources, continues to grapple with rising food insecurity, accentuated by factors such as postharvest losses, inadequate deployment of ICT along agricultural value chains, conflict, climate change, economic downturns, pest infestations, increased food import costs, reduced agricultural investment, and Ebola and COVID-19 outbreaks, and the repercussions of the Russia-Ukraine war have collectively intensified in recent years (Matthew et al., 2023; Akpa et al., 2023; Li et al., 2024). The evidence that these shocks have led to soaring food prices and diminished food availability and accessibility and have driven millions into hunger and poverty is well documented in the literature (Swinnen et al., 2023).

In addition, the prevalent reliance on biomass fuels due to limited access to clean energy sources not only hampers economic growth and poverty alleviation efforts but also contributes to health and environmental hazards (Edafe et al., 2023; Li et al., 2024). HLPE (2021) and von Grebmer et al. (2023) reported that youth in this subregion are the most impacted by deteriorating and increasingly vulnerable food systems. The interplay of these factors sets a precarious stage for food security in SSA, amplifying challenges related to poverty, nutrition, health, and economic stability.

Therefore, the general consensus among experts and scholars is that understanding the intricate drivers behind food price fluctuations is paramount for designing effective policies that can safeguard food security, mitigate inflationary pressures, and promote sustainable development in SSA and beyond. Many scholars have explored the intersections between food prices and institutional quality to advance relevant policies and resolve conflicts (Rossignoli and Balestri, 2018); food prices and climate-related challenges (Brown, 2014); integrating climate change, food prices and population health (Bradbear and Friel, 2013); and food prices and the combined effects of global financial, energy and food crises (Lagi et al., 2012). Despite these and many policies developed to address the associated challenges, many puzzles around food security, particularly as it concerns rising food prices, in the subregion remain unresolved. More than 20% of the population remains significantly malnourished (FAO, IFAD, UNICEF, WFP, WHO, 2022). This poses a threat to the realization of sustainable development goals, especially those associated with poverty alleviation (SDG 1) and food security (SDG 2).

At the centre of the efforts of governments in the subregion is the compelling need to resolve the problem of availability and affordable sources of energy. Africa, despite being one of the regions most affected by climate change and home to one-sixth of the global population, accounts for less than 6% of global energy consumption and 2% of cumulative global emissions (International Energy Agency (IEA), 2014). However, extending clean energy access to millions is crucial for economic growth and achieving sustainable development goals. The continent's geographic diversity offers significant potential for renewable energy, particularly solar, wind, hydropower, and geothermal energy, which could propel Africa towards fulfilling the Paris Agreement and limiting the global temperature rise to 1.5 °C. However, the current state of energy security in the region shows a large energy deficit (Alemzero et al., 2021), and requires huge capital outlay to erect necessary infrastructure to achieve the desired results on energy for all in the sub-region.

This debate on cleaner energy and food prices receives significant attention recently because of its ecological and socioeconomic dimensions. Take for instance, lack of energy and power increases the potential for food waste. Food waste is a critical challenge that exacerbates food insecurity and environmental degradation. There are staggering statistics that one-third of all food produced for human consumption is lost or wasted, amounting to 1.3 billion tonnes annually. Global food waste has reached alarming 40%. And this loss not only represents a missed opportunity to feed nearly nine billion people by 2050 but also contributes significantly to greenhouse gas emissions, further aggravating climate change. The case of food waste in SSA is pathetic because of very low access to energy and power. Consequently, the potential for food wastes and/or costs of proper storage using cleaner energy create avenue for food producers and other actors along the food value chains to include risk premium in food prices. This puts pressure on countries in SSA, even as the population is rising, to provide energy infrastructure that will reduce the overhead cost of food production and distribution in order to increase food output.

Countries such as South Sudan, Burundi, Chad, and Malawi have the lowest electricity access rates in sub-Saharan Africa, ranging from 7.7% to 14.2%, and face significant challenges in providing clean cooking facilities (IEA, 2021a). In contrast, Ghana, Kenya, and Rwanda have made notable progress towards achieving full electricity access by 2030 (Climate Analytics, 2022b; IEA, 2021b). However, the COVID-19 pandemic has adversely affected the progress of energy and power access across the region. In Nigeria, despite a population increase from 120 million to over 200 million in the last decade, power generation has stagnated at 4000 MW over two decades. The country's national grid connects only 40% of households, with weak distribution infrastructure causing approximately 35% of generated power to be lost during distribution. This gap between electricity supply and demand is widening, exacerbated by an unstable grid prone to sabotage, leading many to rely on personal generators (Nucho, 2022). The overall situation underscores the significant disparities in energy access and the compounded difficulties in achieving reliable and sustainable electricity infrastructure in the region.

The Nigerian energy situation is presented in Figure 1. The International Energy Agency's data on Nigeria's energy consumption, with 77.9% used residential energy, 8.71% used industrial energy, and only 0.34% used agricultural energy, highlight significant energy security challenges. High residential demand strains infrastructure, leading to frequent outages and limited energy for crucial sectors such as industry and agriculture, hindering economic growth and development. Insufficient industrial energy allocation stifles expansion and increases reliance on imports, while negligible energy use in agriculture severely limits productivity and rural development. This disproportionate energy distribution increases vulnerability to disruptions and raises sustainability concerns (Olujobi et al., 2023). However, a number of countries have addressed these disruptions by implementing policies to balance energy distribution, invest in renewable sources, enhance residential energy efficiency, and allocate more energy to industry and agriculture, supported by targeted subsidies and incentives for renewable energy adoption (Alemzero et al., 2021).

Figure 2 reveals the per capita energy consumption and energy generation trends in selected sub-Saharan African countries, comparing them with continental and global averages. Energy consumption and generation are essential for economic development and quality of life, yet sub-Saharan Africa (SSA) exhibits significant disparities compared to global standards. In 2022, the global average per capita energy consumption was 21039 kWh, with South Africa having a slightly greater average of 22351 kWh, highlighting its advanced energy infrastructure. In contrast, Africa's average was only 3944 kWh, indicating widespread energy poverty. Ghana's consumption was 3483 kWh, while Nigeria's consumption fluctuated from 1250 kWh in 2009 to 2458 kWh in 2021, reflecting its energy instability. Globally, energy generation totalled 167788 TWh in 2022, with Africa contributing just 5627 TWh. South Africa generated 1339 TWh, whereas Nigeria's output was only 544 TWh, underscoring its inadequate generation capacity. This imbalance in SSA, with low per capita consumption and insufficient generation, hampers economic growth and quality of life (International Energy Agency, 2022). To improve energy security, SSA must invest in renewable energy sources and enhance energy infrastructure, particularly in transmission and distribution, to ensure sustainable economic development (IEA, 2022).

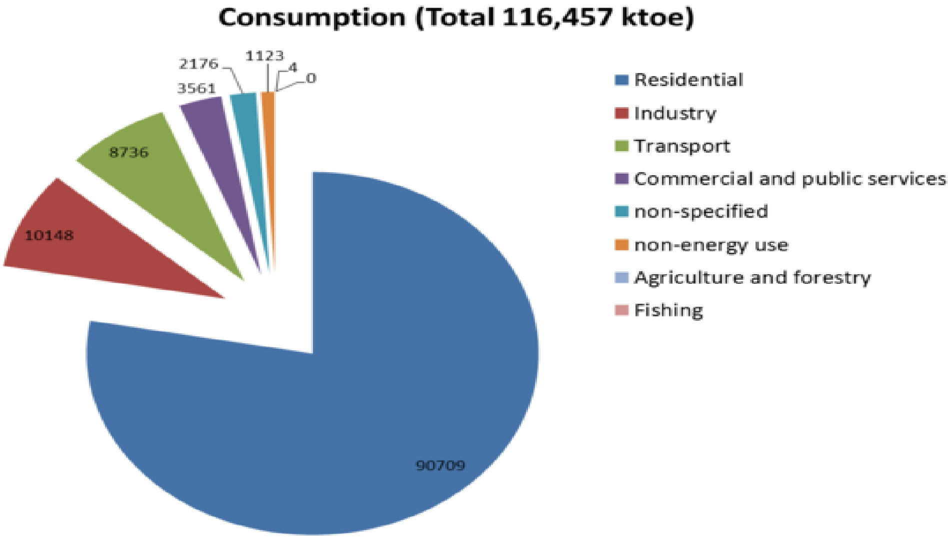

Figure 1. Nigerian energy situation (International Energy Agency, 2022).

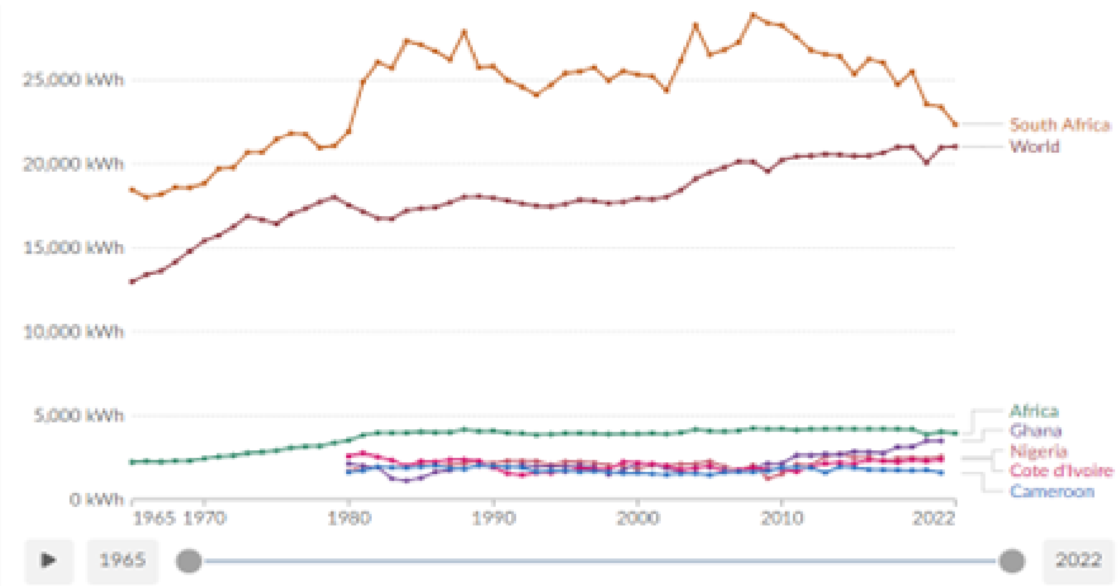

Figure 2. Trend in average energy consumption per person (Energy Information Administration, 2023).

The disparities in energy consumption and generation between sub-Saharan Africa and global averages have profound implications for sustainable development in the subregion (IEA, 2022). In view of this, there is concern that limited energy access, particularly in Nigeria and Ghana, hinders economic activities, educational opportunities, and overall quality of life. The stark contrast in energy generation between South Africa and Nigeria highlights the potential investment opportunity for substantial investment in energy infrastructure across the region. In Nigeria, the demand for energy significantly outweighs the energy supply (Olaoye et al., 2016); hence, the current reliance on traditional energy sources necessitates a strategic shift towards renewable energy (Nnaji et al., 2013; Climate Analytics, 2022a). Effective energy policies and regulatory frameworks are essential for enhancing energy production and distribution, reducing losses, and improving energy access, thereby driving economic growth and development (IEA, 2014). Enhancing energy infrastructure and expanding renewable energy capacities can attract foreign investment, boost industrial productivity, and create jobs, positioning sub-Saharan Africa as a competitive player in the global economy (Climate Analytics, 2022b).

The extensive body of literature and numerous advocacy efforts regarding the global shift from non-renewable energy, which poses threats to human habitats, to renewable and cleaner energy underscore the emerging paradigm in the energy sector. However, this transition is significantly impeded by high capital costs, which have widespread implications for the entire energy system (IEA, 2022). The UNCTAD's World Investment Report 2023 reveals a significant disparity in the distribution of international investment in renewable energy. Since the Paris Agreement's inception in 2015, investment in renewable energy has almost tripled, but the bulk of this growth has been concentrated in developed nations. In contrast, developing countries, which require approximately $1.7 trillion annually for renewable energy investments, only managed to secure $544 billion in foreign direct investment for clean energy in 2022. Moreover, the overall financial requirements for transitioning to sustainable energy systems in developing countries are considerably greater. These needs encompass investments in power grids, transmission lines, storage solutions, and energy efficiency improvements. UNCTAD Secretary-General Rebeca Grynspan emphasized that boosting investment in sustainable energy systems within developing nations is critical for achieving global climate targets by 2030.

Therefore, adopting renewable energy is a pressing concern in the global pursuit of a sustainable future. According to Demetrios Papathanasiou, Global Director of Energy and Extractives at the World Bank, "Poorer countries are caught in a vicious cycle where they end up paying more for electricity, cannot afford the substantial initial investment required for clean energy, and remain dependent on fossil fuel projects. Essentially, these countries face a triple penalty during the energy transition." This situation creates a poverty trap that transforms into an energy trap and, ultimately, a climate trap. The consequences are increasingly being felt in the agricultural industry. Interestingly, numerous scholarly works have demonstrated that varying energy costs, depending on the source, result in higher operational costs for agricultural production (Samson et al., 2005; Pimentel et al., 2008; Wood et al., 2010; Intergovernmental Panel on Climate Change [IPCC], 2022), while climate change increases the frequency of extreme weather events, alters growing conditions, and reduces crop yields, which ultimately influence rising food prices.

Similarly, there has been a concentration of studies on the positive effects of renewable energy adoption on enhancing people's welfare and economic well-being (Arraiz and Calero, 2015; Chakravorty et al., 2016; Bonan et al., 2017), leaving a critical gap in the implications of the unintended effects of the transition. For instance, little is known about the relationship between the transition to cleaner energy and food prices. However, the points of divergence and convergence in the narrative of sub-Saharan Africa's transition to cleaner energy, including the move to embrace biofuel energy as alternatives to fossil fuels, can be a necessary inflexion for policy considerations. This study delves into the complex relationship between the transition to cleaner energy and food prices in sub-Saharan Africa, shedding light on climate change mitigation. Therefore, by examining the related literature, this review aims to contribute to a comprehensive understanding of the impact of renewable energy adoption (cleaner energy) on rising food prices in sub-Saharan Africa.

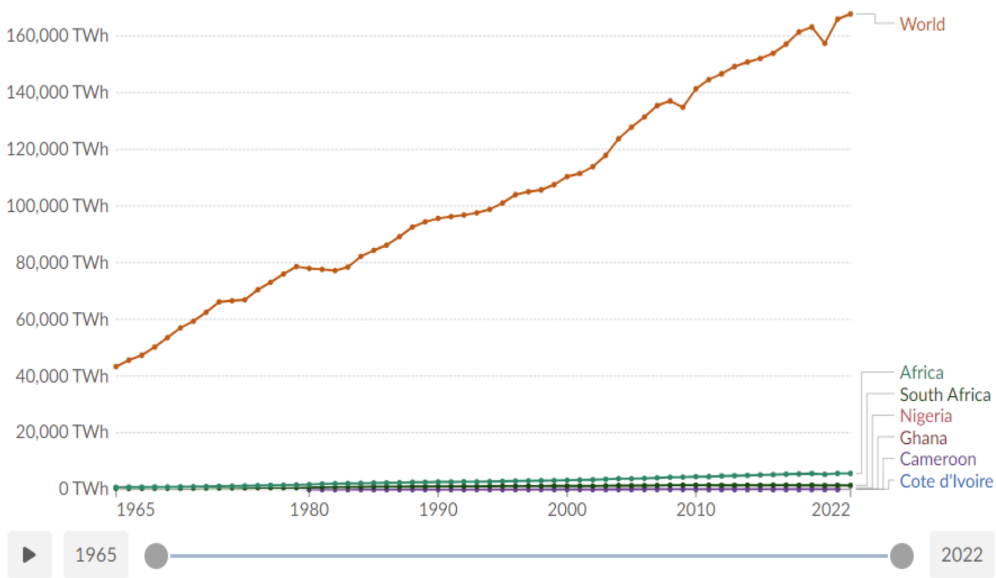

Figure 3. Trends in the quantity of energy generated each year across selected countries in sub-Saharan Africa

compared to Africa and the world average (Energy Information Administration, 2023).

1.1. Conceptual Framework

This conceptual framework illustrates the interactions and feedback loops between various sectors and their impacts on food prices and climate change mitigation in Sub-Saharan Africa. The diagram is centered on four main components: Food Production & Food Value Chain, Fossil Fuel, Renewable Energy, and Government Policy, with additional elements considering the economic and social effects of energy use.

Efficient farming practices and food systems are critical in determining the productivity and sustainability of food production. The outcomes of efficient farming and food systems are pivotal in reducing food prices and enhancing food security (Godfray et al., 2010). The economic and social effects of using fossil fuels in food production include increased costs, environmental degradation, and health impacts, which all play significant roles in the overall viability and sustainability of food production systems (Tilman et al., 2002; FAO, 2011).

Government policies influence the use of fossil fuels through regulations, subsidies, and taxes, directly affecting the fossil fuel industry and its integration into the power and energy sector (IEA, 2020). The fossil fuel industry supplies essential energy to the power sector, which supports various activities within the food production and food value chain. However, the economic and social effects of fossil fuel use are broad, including higher production costs, adverse environmental impacts, and negative social welfare implications (World Bank, 2014).

Policies aimed at promoting renewable energy can incentivize the transition away from fossil fuels, including investments, subsidies, and regulatory support for renewable energy sources (IRENA, 2022). The integration of renewable energy into the power sector can significantly reduce dependency on fossil fuels, leading to cleaner energy production and use (REN21, 2020). The shift to renewable energy sources brings substantial economic and social benefits, such as potential reductions in energy costs, creation of green jobs, and improved public health outcomes (UNEP, 2019).

Government policies play a critical role in supporting renewable energy development, driving the transition to cleaner energy and impacting the power sector and overall energy mix (IRENA, 2022). Regulatory frameworks can either constrain or promote the use of fossil fuels, affecting their role in the energy market (OECD, 2020; Lankoski and Thiem, 2020). Policies also influence food production through agricultural subsidies, food safety regulations, and support for sustainable practices, thereby shaping the sustainability and efficiency of the food production and value chain (FAO, 2018).

As renewable energy is integrated into the power sector, it can progressively replace fossil fuels, leading to cleaner energy production (IEA, 2021a). Traditionally reliant on fossil fuels, the power sector’s transition to renewable energy can significantly impact the sustainability and efficiency of energy use within the food production and food value chain (IRENA, 2022).

The economic and social effects of fossil fuel use include increased costs due to environmental damage, health impacts, and social disparities (World Bank, 2014). Conversely, the economic and social benefits of renewable energy use are substantial, including lower greenhouse gas emissions, reduced energy costs, and improved public health, all contributing to a more sustainable and equitable energy and food production system (UNEP, 2019).

Efficient farming and food systems lead to more sustainable and cost-effective food production, reducing prices and improving food security (Godfray et al., 2010). The positive outcomes of efficient farming practices are critical for achieving a sustainable and resilient food production system in Sub-Saharan Africa (FAO, 2011).

Feedback loops between government policy and the use of fossil fuels or renewable energy show that policies influence the energy mix, which in turn affects economic and social outcomes, feeding back into policy adjustments (IEA, 2020). The interaction between the power and energy sector and the food production and value chain indicates that the efficiency of energy use impacts food prices and availability (FAO, 2018). Furthermore, the economic and social effects of energy use influence farming practices and food systems, leading to more sustainable and efficient outcomes (Tilman et al., 2002).

This conceptual framework highlights the complex interactions between energy use, government policy, and food production, emphasizing the need for a multidisciplinary approach to address food prices and climate change mitigation in Sub-Saharan Africa. By transitioning to cleaner energy sources and promoting efficient farming practices, it is possible to achieve significant economic, social, and environmental benefits (UNEP, 2019; IRENA, 2022).

1.2. Significance of the Review

The proposed framework highlights crucial areas where our understanding of the food system and its energy use needs enhancement. Despite significant research, there are notable gaps, particularly in regional variability of energy inputs and the indirect contributions from fertilizers, pesticides, and machinery (Pelletier and Tyedmers, 2010; Finley and Seiber, 2014). Integrating renewable energy sources into agricultural practices remains underexplored, especially in developing countries, where it could significantly reduce costs and increase productivity (FAO, 2023). Additionally, most studies have focused on large-scale operations, neglecting the impact on small-scale and subsistence farmers (Haggblade et al., 1989; Cleaver, 1993). Developing robust economic and policy frameworks to support the transition to cleaner energy in agriculture is also essential (Stoneman and Robinson, 1987).

Agriculture's dependency on energy inputs varies significantly between industrialized and developing countries, impacting productivity and sustainability (Pelletier and Tyedmers, 2010). Mechanization has boosted productivity but increased energy consumption, requiring a balance between energy efficiency and environmental sustainability (Finley and Seiber, 2014). Conservation agriculture practices, such as reduced tillage and maintaining soil cover, can enhance soil health and reduce energy use but necessitate changes in traditional farming methods (FAO, 2023). Addressing these gaps involves comprehensive research, data collection, and the integration of renewable energy systems, alongside policies that consider both agricultural and rural energy needs (Stoneman and Robinson, 1987; Cleaver, 1993). This approach can enhance agricultural productivity and food security while minimizing environmental impacts.

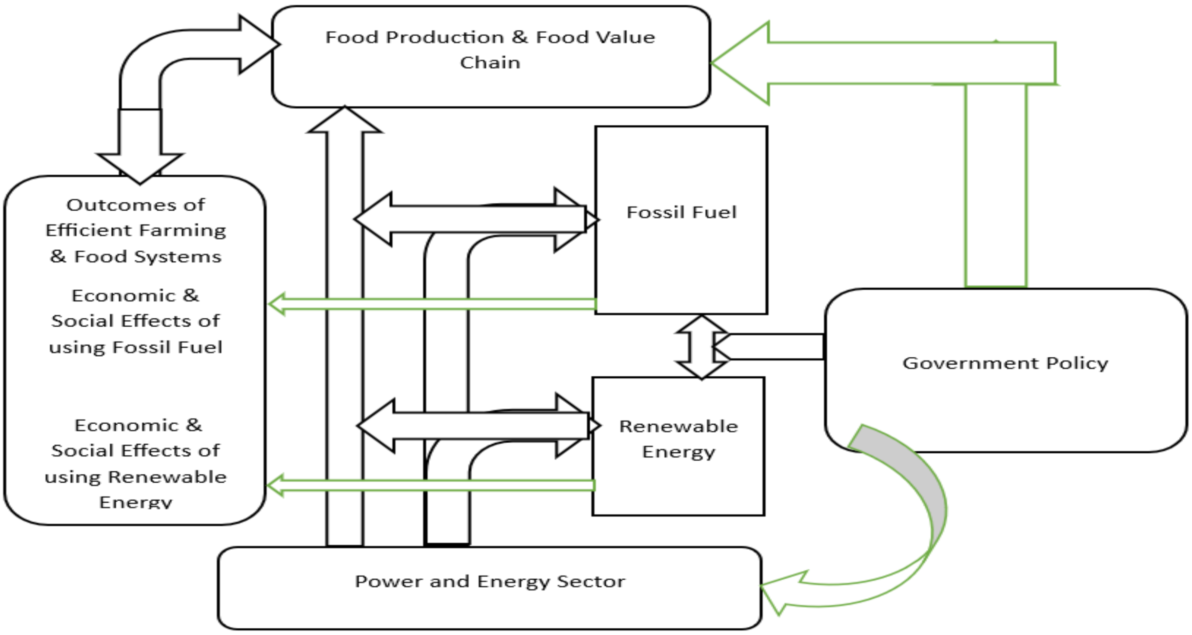

Figure 4. Conceptual framework.

This study addresses a critical gap in the literature concerning the relationship between the transition to cleaner energy and food prices in Sub-Saharan Africa (SSA). While existing research has extensively examined food security, energy access, and climate change individually, there is a lack of integrated studies that explore their combined effects on food prices in SSA. Previous studies have predominantly focused on the intersections between food prices and institutional quality, climate-related challenges, the integration of climate change with food prices and population health, and the impacts of global financial, energy, and food crises on food prices. However, the specific interplay between renewable energy transition and food prices remains underexplored, which is significant for policy-making and sustainable development.

The study aims to fill this gap by understanding how investments in energy infrastructure and the shift to cleaner energy sources affect agricultural productivity and food prices. It also seeks to assess the broader socio-economic consequences of energy transition policies on food security in SSA and provide insights into how renewable energy adoption can either mitigate or exacerbate food insecurity, considering the region's unique challenges. By exploring this complex relationship, the study intends to contribute to a comprehensive understanding of how renewable energy adoption impacts rising food prices in SSA, integrating themes of renewable energy investment disparities and food security issues to offer a novel perspective.

2. Methodology

The research question for the study was meticulously formulated and addressed using a structured approach. Initially, the study checked for existing reviews and protocols to determine if the review was still needed. This involved a comprehensive search of databases such as PubMed, Scopus, and Google Scholar to identify any recent reviews on the topic. Although there were some related reviews, none comprehensively covered the specific impacts of cleaner energy transitions on both food prices and climate change mitigation in Sub-Saharan Africa, highlighting a significant gap in the literature (Peters et al., 2015; Smith et al., 2018). This affirmed the necessity of this review and precluded duplicating previous efforts.

The study then clearly identified the research question: How does the transition to cleaner energy sources affect food prices and climate change mitigation in Sub-Saharan Africa? This question was formulated to be specific, focused, and of appropriate scope. To define our terminology, the study outlined key concepts such as "cleaner energy transition," "food prices," "climate change mitigation," and "Sub-Saharan Africa" (Jones et al., 2017). This step ensured clarity and consistency throughout the review process.

Next, the study defined inclusion and exclusion criteria to establish a review protocol. Studies were included if they focused on Sub-Saharan Africa, examined the transition to renewable energy sources, and assessed impacts on food prices or climate change mitigation. Exclusion criteria included studies not in English, those not peer-reviewed, or studies focusing on regions outside Sub-Saharan Africa (Higgins and Green, 2011). This step was crucial in ensuring the relevance and quality of the included studies.

The study conducted comprehensive searches in relevant databases, collaborating with a librarian to develop robust search strategies across various platforms (Briscoe, 2019). Gray literature was methodically approached to ensure comprehensive coverage. All retrieved records were collected into Endnote for organization and de-duplication before screening.

Study selection for inclusion involved a two-step process: an initial title and abstract screening to remove irrelevant studies, followed by a full-text screening based on our predefined criteria. Two independent reviewers conducted this process to ensure objectivity, resolving any disagreements through consensus (Liberati et al., 2009).

Data extraction from included studies was systematically performed using a spreadsheet. The study piloted the data extraction tool to refine and ensure all relevant data fields were included (Moher et al., 2009). This allowed for consistent and thorough data collection across studies.

Evaluating the risk of bias in included studies was done using the Cochrane Risk of Bias Tool, adapted as necessary to suit the study designs encountered (Higgins and Thompson, 2002). This assessment was crucial to understanding the potential biases and reliability of the study findings.

The results were then clearly presented, detailing our methodology including search strategies, selection criteria, and risk of bias assessments. Based on the evidence gathered, the study provided recommendations for practice and policy-making, emphasizing areas where high-quality evidence was sufficient. Additionally, the study outlined directions for future research to address existing knowledge gaps or strengthen the current body of evidence.

This structured approach ensured a thorough, objective, and comprehensive review of the impacts of cleaner energy transitions on food prices and climate change mitigation in Sub-Saharan Africa. By clearly defining our research question, establishing robust criteria, and systematically synthesizing the data, we provided valuable insights and recommendations to inform policy and future research in this critical area.

3. Discussion

3.1. Theoretical Argument Linking Transition to Cleaner Energy with Rising Food Prices in Sub-Saharan Africa

The energy sector in Sub-Saharan Africa (SSA) faces critical challenges that significantly impact long-term economic development. Rural electrification rates are as low as 14%, making access to energy a priority for governments and investors who see it as a means to alleviate poverty and boost productivity (Pueyo and Maestre, 2019a; Peters and Sievert, 2016). Inadequate power supply has been a major constraint on economic development across SSA. For example, many companies have cited poor power supply as a primary reason for relocating their factories from Nigeria. The limited number of companies operating in Nigeria and many commercial farm enterprises rely heavily on off-grid power generated by diesel, gas, or petrol-powered electric generators (Olaoye et al., 2016). This dependence results in substantial overhead costs and contributes significantly to greenhouse gas emissions and other environmental issues (Pueyo, 2018a).

The relationship between energy prices and food prices is critical in understanding the broader economic implications. The global shift from fossil fuels to cleaner energy sources is driven by the urgent need to address environmental, climate, and health concerns. While this transition is widely supported, SSA faces significant challenges in implementing it, including inadequate human capital, low levels of technology, insufficient funding, inconsistent policy support, insecurity, and corruption just as echoed by Gregory and Sovacool (2019). Despite these hurdles, the commitment to cleaner energy remains strong. However, the literature lacks substantial evidence on how the transition to cleaner energy exacerbates economic challenges, particularly rising food prices in SSA. This study aims to bridge that gap by exploring the theoretical underpinnings of this issue.

The transition to cleaner energy in SSA necessitates significant financial investments, which have implications for other critical sectors, particularly agriculture. This economic phenomenon can be critically examined using the theories of opportunity cost articulated by Spiller (2011), Buchanan (1978), and Harberger (1972). According to these theoretical perspectives, the transition to cleaner energy in SSA can be seen as a complex economic decision with significant opportunity costs. The substantial investments required for cleaner energy infrastructure and technology divert critical resources from agriculture, leading to decreased productivity and increased food prices. This is line with the thoughts of evidence in literature about economies in technology transition (Harberger, 1972; Buchanan, 1978; Spiller, 2011). Understanding these dynamics is crucial for policymakers in SSA to balance the urgent need for cleaner energy with the equally critical need for food security and agricultural development.

In distressed economies, budget constraints are a significant barrier to balanced development. The increased expenditure on cleaner energy projects inflates the budget without a corresponding increase in revenue, often due to stagnant or shrinking revenue portfolios. Theoretical insights from Pueyo (2018b), Gregory and Sovacool (2019), and Singh and Ru (2022) collectively demonstrate the complex relationship between renewable energy investment and food insecurity in SSA. Budget constraints, inefficient revenue collection, financial risks, and policy challenges intersect to limit investment in critical sectors such as agriculture. The resulting low food production exacerbates food insecurity (Pueyo, 2018a; Gregory and Sovacool, 2019; Singh and Ru, 2022).

The transition to cleaner energy in SSA is hindered by inadequate technology and infrastructure. The focus on developing energy infrastructure diverts resources from agricultural infrastructure, such as irrigation systems, storage facilities, and transportation networks. According to the theory of production, such deficits reduce the efficiency and productivity of agricultural inputs, leading to lower agricultural output and higher food prices (Harberger, 1972).

The shift to cleaner energy often entails high initial costs, which can translate into higher energy prices. Agriculture, an energy-intensive sector, is directly affected by these increased costs. Higher energy prices lead to increased costs for the production, processing, and transportation of food products. This situation aligns with cost-push inflation theory, where increased production costs result in higher prices for the final goods, in this case, food (Meyer and von Cramon-Taubadel, 2004).

Meyer and von Cramon-Taubadel (2004) discuss asymmetric price transmission, where changes in input costs do not always result in proportional changes in output prices. This theory highlights the potential for unequal price adjustments along the supply chain, often leading to greater price volatility and inefficiencies in the market. In the context of SSA, the high initial costs of transitioning to cleaner energy can increase energy prices, which in turn increase the costs of agricultural production. Due to asymmetric price transmission, these increased costs may not be fully absorbed by intermediaries and could be passed on to consumers, resulting in higher food prices.

Fiscal policies in SSA are strained by the need to balance increased expenditures on cleaner energy with limited revenue streams. Efforts to increase revenue through higher taxes can lead to reduced disposable income and lower economic activity. In some SSA countries, such attempts have failed to generate sufficient revenue while exacerbating economic distress among the population. As disposable incomes decrease, the demand for food remains inelastic due to its necessity, but higher production and distribution costs due to increased energy prices lead to higher food prices (Singh and Ru, 2022).

To boost domestic industries and cope with economic pressures, some SSA countries have imposed restrictions on food imports. While these policies aim to support local farmers, they can worsen food shortages, especially when domestic production is insufficient to meet demand due to reduced agricultural investment. Basic economic principles of supply and demand suggest that such imbalances lead to higher food prices (Gregory and Sovacool, 2019).

3.1.1. Energy costs and agricultural production

The interplay between food prices and energy costs is a significant concern, particularly in the context of agricultural production. The reliance on fossil fuels in traditional agricultural practices underscores the vulnerability of the sector to energy price fluctuations. Research by Majeed et al. (2023b), Li et al. (2020), and Zhao et al. (2022) highlights the extensive use of fossil fuels for machinery, irrigation, and transportation in agriculture. This dependency is notable, as approximately 30% of global energy consumption occurs within the agricultural and food sectors, with primary agriculture accounting for about 20% of this energy use (FAO, 2011).

The transition to renewable energy sources represents a potential shift in the cost dynamics of agricultural production. Renewable energy, such as solar and wind, can provide more stable and predictable energy costs compared to the volatility associated with fossil fuels (Griggs et al., 2013). This stability is crucial as it can help mitigate the risk of sudden increases in food prices driven by energy cost spikes. Moreover, decentralized renewable energy systems, such as solar panels on farms, offer significant advantages. They can reduce dependency on external energy supplies, thereby enhancing the resilience of food production systems. By generating their own energy, farmers can lower operational costs and protect themselves from market fluctuations in energy prices.

The integration of renewable energy into agriculture aligns with broader environmental and economic goals. For instance, reducing reliance on fossil fuels not only decreases greenhouse gas emissions but also supports sustainable agricultural practices. The potential for renewable energy to stabilize and even reduce energy costs in agriculture could lead to lower food prices, benefiting consumers and enhancing food security.

Furthermore, the literature suggests that the adoption of renewable energy in agriculture is not without challenges. Initial investment costs for renewable energy infrastructure can be high, which may pose a barrier for small-scale farmers. However, long-term benefits, such as reduced energy costs and increased energy security, can offset these initial expenditures. Policy support, in the form of subsidies or incentives, can play a critical role in facilitating this transition.

3.1.2. Energy inputs in food processing and distribution

Beyond production, the processing and distribution stages of the food supply chain also consume substantial amounts of energy. Together, food processing and transportation consume approximately 40%, making a substantial contribution to global energy consumption throughout agricultural value chains (FAO, 2011). Renewable energy can lower the operational costs of food processing facilities by reducing reliance on grid electricity and fossil fuels (Majeed et al., 2023b). This reduction in energy costs can translate to lower food prices for consumers. This is corroborated by Li et al. (2024). Furthermore, the integration of renewable energy in cold storage and transportation systems can help maintain the quality and safety of perishable goods, reduce food waste and improve overall food security.

3.1.3. Bioenergy and land use competition

The production of bioenergy, derived from organic materials, introduces significant competition for land and resources between energy crops and food crops. This dual-use scenario, as highlighted by Searchinger and Heimlich (2015), presents substantial challenges to food security by diverting food crops for biofuel production, such as ethanol and biodiesel. The literature outlines two primary ways this competition can elevate food prices. First, when arable land is repurposed from food production to bioenergy crops, the reduced supply of land for food crops can drive up prices. Second, diverting food crops like maize and sugarcane for bioenergy reduces their availability for human consumption, further increasing food prices. Currently, biofuels constitute about 2.5% of global transportation fuel, a figure projected to remain stable until 2050 by the FAO. This stability, however, exacerbates the crop calorie gap—the shortfall between future foods needs and projected crop production. The literature suggests that phasing out crop-based biofuels could reduce this gap from 70% to 60% by 2050, thereby enhancing food security. Conversely, ambitious biofuel targets, such as those set by the US and Europe, if adopted globally, could widen the gap to 90%, significantly undermining food security. Evidence from the literature emphasizes the importance of eliminating crop-based biofuels to narrow the crop calorie gap and ensure a sustainable food future. This provides critical insights for policymakers who must balance energy production and food security demands. In scenarios where bioenergy becomes inevitable, policymakers are advised to promote it judiciously, ensuring adequate land and resources remain available for food production.

3.1.4. Climate change mitigation and resilience

To combat climate change and mitigate its unequal impacts on societies, it is crucial to move away from unsustainable economic models reliant on fossil fuels (IPCC, 2022). This shift requires a well-planned industrial policy, as advocated by UNCTAD (2023), to expedite the transition to cleaner energy sources and restructure industries. Such a policy should prioritize innovation that supports sustainable development, ensuring economic growth without excessive use of natural resources or harmful environmental impacts. Renewable energy, as highlighted by Majeed et al. (2023a), plays a vital role in mitigating climate change, which has both direct and indirect effects on food prices. Climate change exacerbates extreme weather events like droughts and floods, disrupting food production and supply chains, leading to price volatility (Haile et al., 2017; Busnita et al., 2017). By reducing greenhouse gas emissions, renewable energy contributes to climate stabilization, helping to mitigate adverse effects on agriculture. Additionally, renewable energy systems can enhance the resilience of rural communities by providing reliable and sustainable energy sources, thereby reducing their vulnerability to climate-related disruptions.

3.1.5. The 2030 agenda for sustainable development and the Paris Agreement

The 2030 Agenda for Sustainable Development and the Paris Agreement address the interconnected challenges of climate change, social exclusion, and uneven economic development, necessitating a new development paradigm that respects planetary limits (UNCTAD, 2023). Central to this paradigm is a socioeconomic shift towards decarbonizing the economy, addressing distributional concerns, and investing in public goods. Economic policies and incentives for renewable energy development, such as subsidies and tax incentives, can significantly impact food prices by stimulating rural investment, creating jobs, and boosting local economies. However, poorly designed or implemented policies can lead to unintended consequences, such as increased land prices and displacement of small-scale farmers (Yang et al., 2020). Coordinated policy approaches that integrate agricultural and energy policies are essential to ensure the equitable distribution of renewable energy benefits and support food security goals (Arbex and Perobelli, 2010; Majeed et al., 2023a).

3.2. Current State of Energy Security in Sub-Saharan Africa

Access to energy is essential for addressing malnutrition and achieving broader development goals in sub-Saharan Africa (Pondie et al., 2023). The availability of modern energy services, particularly electricity, profoundly impacts economic development and quality of life (Bonan et al., 2017; IEA, 2014). The literature underscores that higher per capita energy consumption is associated with improved living standards and well-being (Sambodo and Novandra, 2019; Pondie et al., 2019). This research aligns with the broader understanding that enhancing energy access in sub-Saharan Africa is critical for advancing economic development, reducing malnutrition, and achieving the Sustainable Development Goals. Effective energy policies must therefore prioritize expanding access to clean and reliable energy sources to support sustainable development and improve quality of life across the region.

However, Sub-Saharan Africa remains the world's least electrified region, with only 48% of the population having access to electricity and a mere 17% having access to clean cooking facilities (IEA et al., 2022). The region's energy mix is heavily reliant on traditional biomass, which constitutes nearly half of its primary energy consumption (IEA, 2022; IRENA, 2022). The remaining energy needs are predominantly met by fossil fuels, with significant contributions from oil, coal (this is common in South Africa), and an increasing share of natural gas. Renewable energy sources, excluding traditional biomass, account for approximately one-fifth of the primary energy mix. Among renewables, solar, wind, and geothermal energy together represent approximately 1% of the energy mix, while hydropower contributes approximately 1.7% (IEA, 2021b). This outlook has been implicated as one of the significant drivers of rising food prices in the sub region.

3.2.1. Sectorial electrification rates

The low electrification rates across various sectors in sub-Saharan Africa significantly impact economic development and food security. As of 2017, the industrial sector had the highest electrification rate at 26%, while the transport and building sectors lagged behind with 1% and 4%, respectively (IRENA, 2022). Despite slight improvements in electricity access—from 46% in 2018 to 48% in 2020—the region's growing population has increased the number of people without electricity (IEA et al., 2022). Countries with the lowest electricity access, such as South Sudan, Burundi, Chad, and Malawi, experience higher food prices due to the high costs of production and transportation, which rely on inefficient and expensive energy sources. Conversely, countries like Ghana, Kenya, and Rwanda have made strides towards full electrification, which helps stabilize food prices by reducing production and transportation costs. The slow overall electrification rates, further exacerbated by the COVID-19 pandemic, continue to strain food supply chains and elevate food prices, underscoring the urgent need for comprehensive energy policies that address these challenges to improve food security and economic stability.

3.2.2. Regional disparities in energy access

Regional disparities in energy access within sub-Saharan Africa significantly impact food prices, reflecting the uneven distribution of infrastructure and resources. Southern Africa, which boasts the highest clean cooking access rate at 37% and an average electricity access rate of 49%, benefits from lower energy-related food production costs, contributing to more stable food prices (IRENA, 2022). In contrast, East and West Africa, with electricity access rates of 46% and 53%, respectively, suffer from very low clean cooking access rates of 7% and 13% (IRENA, 2022). This disparity forces reliance on inefficient cooking methods, driving up food prices due to higher energy consumption and costs. Central Africa, with the lowest electricity access rate at 32% and clean cooking access at 17%, faces the highest food prices (IRENA, 2020; IEA et al., 2022). The compounded challenges of inadequate energy infrastructure severely impact food production and preservation, exacerbating food insecurity. These regional disparities underscore the critical need for targeted energy policies to address infrastructure gaps, promote clean cooking technologies, and enhance overall energy access to stabilize food prices and improve food security across the region (IEA, 2022).

3.3. Transitioning to a Cleaner Energy and Cleaner Environment

3.3.1. Subsidy removal, a breach of social contact, and its implications for food prices

The removal of fossil fuel consumption subsidies, which globally amounted to over $400 billion in 2018, presents significant implications for food prices and social stability, especially in regions like sub-Saharan Africa (International Energy Agency, 2019; McCulloch et al., 2021). These subsidies, which often exceed key sources of domestic revenue, such as in the median country of sub-Saharan Africa where more than 1% of GDP is allocated to energy subsidies, have historically led to increased fossil fuel consumption, elevated levels of air pollution, and higher greenhouse gas emissions (McCulloch and Dom, 2019). Furthermore, fossil fuel subsidies contribute to societal inequities, disproportionately benefiting the wealthy while fostering environmental and public health issues, such as the 3 million premature deaths annually attributed to outdoor air pollution from fossil fuels (Coady et al., 2015). In nations like Nigeria, subsidies are part of an implicit social contract, providing affordable fuel in exchange for public support (Beblawi and Luciani, 1987; Hertog, 2017). The abrupt removal of these subsidies without adequate social protection measures can lead to public unrest and economic instability, exacerbating food prices by increasing production and transportation costs in the absence of affordable energy. This underscores the need for careful policy design that balances the environmental benefits of subsidy removal with measures to protect vulnerable populations and maintain social stability.

3.3.2. Economic implications of subsidy removal for food prices

The removal of fossil fuel subsidies in sub-Saharan Africa (SSA) has profound implications for food prices, primarily through increased production and transportation costs. Fossil fuel subsidies help keep the cost of energy, and by extension, the cost of agricultural production and transportation, artificially low (Ikuemonisan and Akinbola, 2019). When these subsidies are removed, fuel prices sharply increase, leading to higher costs for operating farm machinery, irrigation systems, and transporting goods to markets (Coady et al., 2015). In Nigeria, for example, the removal of petrol subsidies significantly raises the cost of agricultural inputs and transportation, thereby increasing the overall cost of food production and distribution (Alghalith, 2010; Okorie and Wesseh, 2024). This situation is further compounded by inadequate infrastructure in many SSA countries, making the energy supply less reliable and more expensive (McCulloch and Dom, 2019). Consequently, the increased cost of energy exacerbates existing challenges in the agricultural sector, resulting in higher food prices for consumers.

3.3.3. Social and political ramifications

The removal of subsidies on Petrol Motor Spirit (PMS), a major fossil fuel extract, presents significant social and political challenges in sub-Saharan Africa (SSA). In many SSA countries, these subsidies form a crucial part of the social contract, providing citizens with affordable fuel (Beblawi and Luciani, 1987; Luciani, 1990). Removing subsidies without enhancing social welfare protections can be seen as a breach of this contract, leading to widespread public protests and political instability (McCulloch et al., 2021; van Asselt et al., 2022). For example, previous attempts to remove fuel subsidies in Nigeria have faced strong popular opposition, underscoring the deep reliance on these subsidies for economic relief (Akov, 2015). To mitigate the adverse effects on food prices and maintain social stability, it is essential for governments to implement comprehensive social protection measures and transparently reinvest the savings from subsidy reforms into sectors directly impacting households, such as health, education, and infrastructure (Bodea and LeBas, 2016). This approach could help garner public support for subsidy reforms by demonstrating tangible benefits from the reallocation of resources.

3.4. The Need to Address Rising Food Prices in the Transition to Sustainable Agriculture in Sub-Saharan Africa

The transition to sustainable agriculture in sub-Saharan Africa is essential for addressing the region's rising food prices, which are exacerbated by an unsustainable reliance on fossil fuels, leading to high operational costs and adverse environmental impacts (Peters and Sievert, 2016; Pueyo and Maestre, 2019b). Jeuland et al. (2021) emphasized the need for agricultural practices to adopt renewable energy and efficient nutrient recycling to mitigate these impacts. Investing in renewable energy infrastructure, policy reforms, and enhancing farmer knowledge can reduce fossil fuel dependence, lower energy costs, and boost agricultural productivity (Lee et al., 2020). This aligns with sustainable development goals, helping to stabilize food prices and enhance resilience (Bernard, 2012). Empirical assessments by Okou et al. (2022) highlight the crucial role of staple foods in the region's caloric intake and the urgent need for investment in agricultural infrastructure. Long-term strategies focusing on agricultural development and economic diversification are vital for stabilizing food prices and ensuring sustainable growth (Vincent and Okowa, 2022). Balancing economic development with environmental quality through a renewable energy transition and effective environmental policies is essential for achieving this balance (Chem and Taylor, 2019; Udi et al., 2020; Adedoyin et al., 2020).

3.5. The Transition from Traditional Non-Renewable Energy Sources

The transition from traditional non-renewable energy sources to cleaner alternatives such as biofuels and green energy is imperative in Sub-Saharan Africa to mitigate carbon dioxide emissions, combat climate change, and promote sustainable power generation (Barreto et al., 2003; Bockris, 2003; Sangster, 2011; Kalyani et al., 2015; Hussain, 2015; Eluwa and Kilanko, 2024). However, the lack of coherent policies integrating renewable energy with agriculture has created a complex scenario. While renewable energy projects may benefit farmers economically, consumers often face higher food prices due to the associated costs, highlighting a policy gap that must be addressed to ensure equity (Eluwa and Kilanko, 2024). Renewable energy is crucial not only for reducing greenhouse gas emissions and air pollutants but also for improving air quality, stabilizing energy prices, and creating job opportunities (Midilli et al., 2006). Green energy, sourced from natural elements such as sunlight and wind, offers an environmentally friendly alternative to fossil fuels. However, concerns persist regarding the potential impact of this transition on food security and economic equity in Sub-Saharan Africa, where limited technology use and postharvest losses contribute to high production costs and food prices (FAO, IFAD, UNICEF, WFP, WHO, 2022; Akpa et al., 2023; Matthew et al., 2023). Therefore, comprehensive policies are essential for navigating the delicate balance between the economic benefits for farmers and the potential adverse effects on consumers during the transition to renewable energy. These policies should prioritize sustainability, inclusivity, and affordability to ensure a harmonious and equitable shift towards renewable energy adoption in sub-Saharan Africa.

3.6. Challenges to Clean Energy Transition

3.6.1. Investment disparities and their implications

The stark contrast in investment flows between developed and developing countries, as highlighted by the UNCTAD report, underscores a critical challenge in the global transition to cleaner energy. This investment gap has profound implications for sub-Saharan Africa (SSA), where financial constraints and infrastructural deficits are already significant hurdles. The limited foreign direct investment (FDI) in renewable energy for developing countries impedes their ability to make necessary advancements in clean energy infrastructure. This limitation directly impacts the capacity of these countries to mitigate climate change effectively and transition away from fossil fuels.

3.6.2. Impact on food prices

The financial burden of transitioning to cleaner energy in sub-Saharan Africa (SSA), in the absence of substantial foreign direct investment (FDI), can strain public finances and divert resources away from other vital sectors such as agriculture. Various theoretical frameworks, including opportunity cost considerations and cost-push inflation, suggest that redirecting funds to energy projects may reduce agricultural productivity. The high initial costs of renewable energy projects, combined with inadequate investment in agricultural infrastructure (such as irrigation and storage), can increase production costs and subsequently elevate food prices. This scenario aligns with cost-push inflation theory, where higher production costs lead to increased prices for end consumers, exacerbating food insecurity in the region. Such findings underscore the critical need for balanced investment strategies that simultaneously address the energy transition and support agricultural development to mitigate adverse impacts on food prices and security.

3.6.3. Climate change mitigation

From a climate change mitigation perspective, the emphasis on renewable energy investments in developed countries, as opposed to developing ones, poses a global risk. Developing countries, including those in sub-Saharan Africa (SSA), are often more vulnerable to the adverse effects of climate change, such as extreme weather events, which can exacerbate food insecurity and economic instability (Peters and Sievert, 2016; Pueyo and Maestre, 2019b). Therefore, a significant increase in investments in these regions is crucial not only for local sustainability but also for global climate resilience. Rebeca Grynspan's call for enhanced investment in sustainable energy systems in developing countries is pivotal, as it underscores the need for a more equitable distribution of resources to ensure these regions can contribute effectively to global climate goals. Such investments would help SSA mitigate climate change impacts while promoting economic growth and stability, aligning with sustainable development goals and addressing both local and global challenges. This approach advocates for integrated policy frameworks that support renewable energy adoption while ensuring economic and food security in vulnerable regions.

4. Conclusion and Recommendations

4.1. Conclusion

The transition to cleaner energy in sub-Saharan Africa (SSA) is essential for climate change mitigation but introduces significant economic challenges that impact food prices across the region. The high initial and operational costs associated with renewable energy projects strain public finances and divert resources from critical sectors such as agriculture, leading to increased production costs. These costs are then transferred to consumers through higher food prices, exacerbating food insecurity. Similarly, the intersection of food waste, cleaner energy transition, and food prices is a complex but critical area of study. Addressing food waste can contribute to food security and climate change mitigation, central to the study's goals. By adopting a holistic approach that incorporates energy and agricultural policies, SSA can advance towards sustainable development while ensuring food security and economic equity. This study provides a novel perspective by linking these interconnected issues and highlighting the importance of integrated policy solutions. The exploration of the interplay between the transition to cleaner energy and food prices in SSA presents an innovative approach to addressing sustainable development challenges in developing countries. This dual focus on energy and food security underscores the necessity of comprehensive and coordinated policies to achieve long-term sustainability and resilience in SSA.

4.2. Recommendations

The study highlights the critical role of food waste in climate change. Decomposing food waste in landfills produces methane, a potent greenhouse gas. By reducing food waste through better management and policies, greenhouse gas emissions can be significantly reduced. This aligns with the study's objective of climate change mitigation through cleaner energy transitions. Integrating food waste reduction strategies with energy policies can create synergies that enhance both food security and environmental sustainability. Therefore, a clearly defined timeline and transparency for the transition to cleaner energy can significantly reduce apprehension in the food and agriculture sector in sub-Saharan Africa. Establishing a well-communicated and realistic roadmap ensures that stakeholders, including farmers and agribusinesses, are aware of the upcoming changes and can plan accordingly. Transparency in the process fosters trust and allows for the anticipation and mitigation of potential disruptions. By outlining specific milestones and providing regular updates on progress, governments can demonstrate their commitment to a structured and manageable transition, which helps to stabilize market expectations and reduce the uncertainty that can lead to price volatility.

To mitigate the negative effects of the energy transition on food prices, governments across sub-Saharan Africa should adopt several practical measures. First, they should invest in modernizing agricultural infrastructure to improve efficiency and reduce energy costs. This includes developing irrigation systems, storage facilities, and transportation networks that are compatible with renewable energy sources. Second, governments should provide subsidies or financial incentives to help farmers and agribusinesses offset the initial costs of adopting cleaner energy technologies. Third, agricultural and energy policies must be integrated to ensure that the transition benefits of both sectors are crucial. Policies should aim to enhance food production capabilities while promoting sustainable energy use. Additionally, governments should facilitate access to affordable financing and technical assistance to support small-scale farmers in adopting new technologies. A more transparent subsidy regime should be reintroduced to cushion the effects of high energy costs resulting from the process of transitioning to cleaner energy.

4.3. Areas for Further Research

Based on the findings of this study, several areas for further research should be explored. One critical area is the long-term economic impact of the transition to cleaner energy on food security in sub-Saharan Africa. Research should examine the potential benefits of integrated policy approaches that simultaneously address energy and agricultural development. Another important area is the exploration of scalable and cost-effective renewable energy solutions specifically tailored to the agricultural sector in SSA. Finally, studies should investigate the effectiveness of various financial instruments and policy incentives in supporting smallholder farmers and agribusinesses during the transition period. Understanding these dynamics will provide valuable insights for policymakers and stakeholders to develop strategies that ensure a balanced and equitable transition to cleaner energy while safeguarding food security.

Limitations

The study could not conduct meta-analysis to synthesize data quantitatively. Although, the study considered some relevant literature and data across countries in Sub Saharan Africa, however, Nigeria being the most populous country in the subregion was more focused.

Author Contributions

The percentage of the author(s) contributions is presented below. The author reviewed and approved the final version of the manuscript.

	E.I.
C	100
D	100
S	100
L	100
W	100
CR	100
SR	100
PM	100

C=Concept, D= design, S= supervision, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management.

Conflict of Interest

The author declare that there is no conflict of interest.

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