WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Assessment of the Impact of Climate Change on Energy Production and Consumption in Sub-Saharan Africa

Edumaretola Gabriel Adefioye

University of Lafia

ABSTRACT

This study assesses the impact of climate change on energy production and consumption in Sub-Saharan Africa, focusing on how shifts in climate patterns affect energy systems and the adaptation strategies employed by various nations. Given the region's heavy reliance on hydropower and fossil fuels, climate-induced disruptions such as erratic rainfall, droughts, and rising temperatures have significantly impacted energy generation. The study also explores how increased temperatures and changing weather patterns are altering energy consumption, with a particular emphasis on urban cooling demands and rural energy needs for agriculture. Using secondary data from scholarly articles, government reports, and international organizations, the research identifies key challenges and examines policy responses, technological innovations, and financial mechanisms aimed at mitigating these impacts. The findings reveal that while renewable energy sources such as solar and wind hold promise for diversifying the energy mix, policy inconsistencies, infrastructure deficits, and inadequate financing remain significant barriers to achieving energy resilience. The study concludes by recommending strategies such as diversified energy portfolios, strengthened regional cooperation, and increased climate finance to enhance energy sustainability and resilience across Sub-Saharan Africa.

1. INTRODUCTION

1.1 Background to the Study

Climate change has become one of the most critical global challenges of the 21st century, impacting ecosystems, human livelihoods, and the functioning of vital sectors such as agriculture, health, water, and energy. Driven by increasing concentrations of greenhouse gases due to anthropogenic activities, climate change is manifesting through rising global temperatures, sea level rise, extreme weather events, prolonged droughts, and shifting precipitation patterns (IPCC, 2021). While its impacts are global, the severity and nature of these impacts are disproportionately distributed, with developing regions such as Sub-Saharan Africa (SSA) facing heightened vulnerabilities due to limited adaptive capacity, fragile economies, and infrastructural deficits.

The energy sector is both a contributor to and a victim of climate change. Globally, the sector accounts for approximately 73% of greenhouse gas emissions (IEA, 2022). At the same time, energy systems are increasingly vulnerable to climate-induced disruptions, particularly in regions where energy infrastructure is underdeveloped or heavily reliant on climate-sensitive sources such as hydropower and biomass. In SSA, over 600 million people lack access to electricity, and the majority of rural populations rely on traditional biomass (such as wood and charcoal) for cooking and heating (World Bank, 2022). The region's energy mix remains dominated by hydropower, which constitutes approximately 17% of total electricity generation in many countries (AfDB, 2020), making the sector highly sensitive to variations in rainfall and water availability.

Climate change has the potential to exacerbate existing energy challenges in the region. Droughts and irregular rainfall have already led to reduced river flow and reservoir levels, thereby undermining hydropower generation. For instance, Zambia and Zimbabwe experienced severe power shortages in 2019 due to declining water levels in the Kariba Dam, which serves as the primary source of hydroelectric power for both countries (IEA, 2021). Similarly, high temperatures and heatwaves increase the demand for cooling, ventilation, and refrigeration, particularly in urban areas, placing stress on electricity grids and increasing energy consumption. Conversely, in colder regions or during unusual cold spells, heating requirements rise, further altering consumption patterns. The unpredictable nature of these climatic shifts complicates energy planning and policy implementation.

Energy consumption in SSA is also influenced by socioeconomic factors such as urbanization, population growth, industrialization, and changes in income levels. As these trends accelerate, they interact with climate change to produce complex outcomes in both energy production and demand. For example, urban centers are experiencing increasing peak demand for electricity, yet energy supply remains inadequate and unreliable. Simultaneously, rural areas remain largely unconnected to national grids and rely on off-grid or traditional energy sources, which are often inefficient and environmentally damaging.

In the face of these challenges, countries in SSA are exploring various mitigation and adaptation strategies, including the expansion of renewable energy sources (solar, wind, and geothermal), energy efficiency measures, and regional energy integration. Nevertheless, these efforts are often constrained by

limited financial resources, weak institutional capacity, and political instability. Moreover, there remains a gap in empirical research that examines the nexus between climate change and energy systems in SSA, particularly with respect to how climate variability affects both production and consumption patterns across different countries.

This study, therefore, seeks to assess the impact of climate change on energy production and consumption in Sub-Saharan Africa, with the aim of providing insights into the vulnerabilities of current energy systems and offering recommendations for building climate-resilient energy infrastructure in the region.

1.2 Statement of the Problem

Sub-Saharan Africa's energy sector is at a crossroads, simultaneously facing the dual challenges of accelerating energy access and responding to the adverse effects of climate change. Despite abundant renewable energy potential, the region's energy infrastructure is underdeveloped, and access to modern energy services remains among the lowest globally. Countries across SSA are increasingly dependent on hydropower, a source that is directly threatened by climate variability. Prolonged droughts and changing rainfall patterns have already led to significant reductions in power generation, with devastating effects on economic productivity, healthcare delivery, and education systems that rely on electricity for basic operations.

At the same time, climate change alters the patterns of energy consumption, increasing the demand for cooling in cities, changing cooking habits due to biomass scarcity, and influencing the time and intensity of electricity usage. These changes place immense pressure on already fragile energy systems. However, there is insufficient data-driven analysis that systematically captures the extent to which climate change is affecting energy production and consumption in SSA. Additionally, there is a lack of region-specific strategies that address the interdependencies between climate adaptation and energy system resilience.

Failure to address this knowledge gap risks reinforcing a cycle of energy poverty, economic stagnation, and increased vulnerability to climate-related disasters. As SSA continues to urbanize and industrialize, the ability of governments and stakeholders to design energy policies that are climate-resilient and inclusive will be crucial for sustainable development.

1.3 Research Questions

The study aims to address the following research questions:

1. To what extent has climate change affected energy production in Sub-Saharan Africa?
2. How has climate variability influenced patterns of energy consumption across the region?
3. What are the regional and national adaptation and mitigation strategies adopted to address climate-induced disruptions in the energy sector?

1.4 Objectives of the Study

The general objective of this study is to assess the impact of climate change on energy production and consumption in Sub-Saharan Africa.

The specific objectives are to:

1. Examine the relationship between climate variability and energy production in selected Sub-Saharan African countries.
2. Analyze the influence of climate change on energy consumption trends and patterns.
3. Evaluate existing climate adaptation and mitigation policies in the energy sector within the region.

1.5 Significance of the Study

This research holds significant importance for both academic and policy-making communities. Academically, it contributes to the growing body of literature on the climate-energy nexus in developing regions. By focusing on Sub-Saharan Africa, it provides empirical insights into a region that is often underrepresented in global climate discourse despite being one of the most vulnerable.

From a policy perspective, the study is intended to inform national governments, regional organizations (such as the African Union and ECOWAS), and international development partners about the need for integrated climate-energy planning. The findings can aid in developing climate-resilient energy strategies, identifying priority areas for infrastructure investment, and fostering collaboration between climate and energy policymakers.

Furthermore, as the world moves toward achieving Sustainable Development Goal 7 (affordable and clean energy) and Goal 13 (climate action), the outcomes of this study will help shape actions that ensure inclusive, sustainable, and climate-resilient energy development in SSA.

1.6 Scope of the Study

The study is geographically confined to Sub-Saharan Africa, encompassing a range of countries that represent diverse climatic zones and energy systems. It focuses on the period between 2010 and 2024, a timeframe characterized by increasing climate impacts and energy sector reforms in the region. The

study assesses both renewable (hydropower, solar, wind) and non-renewable (fossil fuel-based) energy sources to provide a comprehensive analysis of climate impacts. It also reviews both rural and urban energy consumption patterns, considering socioeconomic drivers such as population growth, urbanization, and industrial development.

1.7 Limitations of the Study

One of the primary limitations of this study is the availability and consistency of reliable energy and climate data across all Sub-Saharan African countries. Data gaps may affect the accuracy of cross-country comparisons. Additionally, the study relies heavily on secondary data sources, which may vary in methodology and scope. Political instability in certain countries may also limit the generalizability of findings. Despite these challenges, efforts have been made to use reputable and peer-reviewed sources to ensure the

2. LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 Climate Change

Climate change refers to long-term alterations in temperature, precipitation, wind patterns, and other aspects of the Earth's climate system. It is primarily driven by human activities such as fossil fuel combustion, deforestation, and industrial emissions that increase the concentration of greenhouse gases (GHGs) in the atmosphere (IPCC, 2021). These activities lead to global warming and associated climatic disruptions, including extreme weather events, sea-level rise, and ecosystem degradation. In the context of Sub-Saharan Africa (SSA), climate change is manifested through increased frequency of droughts, erratic rainfall, and rising temperatures, all of which significantly impact natural and human systems.

2.1.2 Energy Production

Energy production is the process of generating energy—particularly electricity—from various sources, including fossil fuels (coal, oil, gas), renewable sources (solar, wind, hydropower, biomass), and nuclear energy. In SSA, energy production is heavily reliant on hydropower, followed by oil, gas, and increasingly solar power in some countries. However, infrastructure for energy production is underdeveloped, with several countries depending on outdated or climate-sensitive technologies (AfDB, 2020).

2.1.3 Energy Consumption

Energy consumption refers to the total amount of energy used by end-users across different sectors, including residential, commercial, industrial, and transport. In SSA, energy consumption patterns are influenced by socioeconomic status, urbanization, and the availability of modern energy infrastructure. Rural populations predominantly rely on traditional biomass (wood, charcoal) for cooking and heating, while urban populations have growing demand for electricity due to the increasing use of appliances, lighting, and air conditioning (IEA, 2022).

2.1.4 The Climate-Energy Nexus

The climate-energy nexus describes the bidirectional relationship between energy systems and climate change. On one hand, the energy sector contributes significantly to GHG emissions. On the other, it is vulnerable to climate impacts such as droughts (affecting hydropower), floods (damaging infrastructure), and heatwaves (increasing electricity demand). Understanding this interrelationship is crucial for developing sustainable and resilient energy systems in SSA (Schaeffer et al., 2012).

2.2 Theoretical Review

2.2.1 Ecological Modernization Theory (EMT)

Ecological Modernization Theory posits that environmental protection and economic development can go hand in hand through technological innovation, institutional reform, and market-based solutions. According to EMT, energy systems can adapt to climate change by shifting toward cleaner technologies and renewable sources, improving energy efficiency, and fostering environmental policies (Mol & Sonnenfeld, 2000). This theory supports the idea that SSA can modernize its energy sector while mitigating climate impacts.

2.2.2 Vulnerability and Adaptation Framework

The vulnerability and adaptation framework focuses on the susceptibility of systems to harm from climate change and their capacity to adapt. Energy systems in SSA are particularly vulnerable due to weak infrastructure and heavy reliance on climate-sensitive resources. This framework underscores the importance of adaptive measures—such as diversification of energy sources, decentralized energy systems, and institutional capacity building—to enhance resilience (Adger, 2006).

2.2.3 Energy Transition Theory

Energy Transition Theory explains how societies shift from one dominant energy system to another—e.g., from fossil fuels to renewables. This transition is often shaped by technological innovation, policy shifts, and changing societal values. In SSA, energy transition is crucial in the context of climate change and sustainable development, though it is hindered by financing constraints and weak governance (Geels, 2002).

2.3 Empirical Review

Several studies have examined the impact of climate change on energy systems, though research focused specifically on SSA is relatively limited and fragmented.

2.3.1 Impact on Energy Production

Ngumbi and Feng (2020) examined the vulnerability of hydropower systems in East Africa and found that reduced rainfall and increased evaporation rates due to rising temperatures significantly affect hydroelectric output. Similarly, a study by Riebau et al. (2019) on the Zambezi River Basin revealed that climate-induced hydrological variability has led to reduced energy generation and increased operational costs in Zambia and Zimbabwe.

In Nigeria, Oluleye et al. (2021) highlighted how temperature increases and water stress have reduced the efficiency of thermal power plants and complicated energy planning. The authors advocated for the integration of climate risk assessments into energy investment decisions.

2.3.2 Impact on Energy Consumption

Gonzalez and Makoni (2018) studied energy demand patterns in urban SSA and found that temperature increases lead to higher electricity consumption for cooling, particularly in residential and commercial buildings. Conversely, periods of drought or conflict over biomass resources have forced rural communities to reduce cooking and heating practices, thereby affecting health and social well-being.

In Kenya, a case study by Wanjiru and Ochieng (2019) found that seasonal variations in solar radiation affected the performance of solar home systems, thereby altering household energy consumption behavior. The study emphasized the importance of climate-resilient energy infrastructure and user education.

2.3.3 Policy Responses and Strategies

Governments and regional institutions have begun implementing adaptation and mitigation strategies. The African Union's Africa Renewable Energy Initiative (AREI) seeks to deploy 300 GW of renewable energy capacity by 2030. Similarly, countries such as Ethiopia and Morocco have adopted national energy strategies that prioritize solar and wind development.

Nonetheless, Nhamo and Nhemachena (2021) argue that most policy frameworks remain fragmented, underfunded, and poorly enforced. Their analysis of the Southern African Development Community (SADC) highlights the need for regional cooperation, integrated climate-energy planning, and increased international support.

2.3.4 Gaps in the Literature

Despite growing interest, there remains a scarcity of longitudinal studies that examine the climate-energy relationship over time. Much of the existing literature focuses on specific countries or short-term impacts, with limited comparative analysis across different climatic zones within SSA. There is also inadequate exploration of how socioeconomic factors such as gender, income, and education mediate the effects of climate change on energy consumption.

2.4 Summary of Literature Review

The reviewed literature highlights the significant threat that climate change poses to both energy production and consumption in Sub-Saharan Africa. Hydropower systems are particularly vulnerable to climate variability, while changes in temperature and rainfall influence energy use patterns in both urban and rural settings. Theoretical perspectives such as Ecological Modernization, Energy Transition, and Vulnerability Frameworks offer valuable lenses through which these challenges can be analyzed. However, empirical studies are still limited in scope, particularly regarding cross-country comparisons and long-term assessments.

3. RESEARCH METHODOLOGY

3.1 Research Design

This study adopts a qualitative desk-based research design, using documentary analysis as its primary methodology. This approach is ideal for understanding the broader implications of climate change on energy production and consumption in Sub-Saharan Africa through existing literature, official reports, policy documents, and empirical studies. It also allows for a comprehensive synthesis of diverse sources across multiple countries and regions.

3.2 Method of Data Collection

The data for this study is entirely secondary and obtained from a variety of credible sources including:

- Peer-reviewed journal articles
- Reports and datasets from international organizations (e.g., World Bank, UNDP, IEA, IPCC, AfDB)
- National energy and climate change policy documents
- Publications from NGOs and regional bodies (e.g., ECOWAS, SADC, African Union)
- Energy outlook reports and country-level assessments
- Online databases such as Google Scholar, JSTOR, ScienceDirect, and official institutional repositories were consulted to access recent and relevant publications from 2015 to 2024.

3.3 Method of Data Analysis

The study employs qualitative content analysis to examine and interpret the data. This involves a systematic review of texts to identify recurring themes, patterns, and arguments relating to:

- Climate change effects on energy generation (hydropower, fossil fuels, renewables)
- Changes in energy demand and consumption patterns due to climate-related stressors
- Regional and national adaptation strategies
- Policy implications and implementation gaps

Themes are derived inductively and grouped according to the research objectives. Special attention is paid to comparative insights across different countries and sub-regions (West, East, Central, and Southern Africa).

3.4Scope and Limitation

This study is limited to secondary data and covers selected Sub-Saharan African countries where substantial documentation is available. While this allows for wide geographic representation and policy analysis, it may not capture localized, recent, or unpublished developments.

3.5 Ethical Considerations

Since the study relies solely on publicly available secondary data, no ethical clearance for human subjects is required. Nevertheless, academic integrity is strictly maintained through:

- Proper citation of all sources used
- Avoidance of plagiarism through original interpretation
- Transparent acknowledgment of data limitations

4. DATA PRESENTATION AND ANALYSIS

4.1 Introduction

This chapter presents and analyzes secondary data gathered from scholarly articles, reports from international organizations, and official documents relevant to the study. The analysis is structured thematically in line with the research objectives, focusing on:

1. The impact of climate change on energy production in Sub-Saharan Africa
2. The impact of climate change on energy consumption patterns

3. Adaptation strategies and policy responses to climate-related energy challenges

4.2 Impact of Climate Change on Energy Production in Sub-Saharan Africa

Climate change has had profound effects on energy production systems across Sub-Saharan Africa, particularly those reliant on hydropower and thermal energy.

4.2.1 Hydropower Vulnerability

Hydropower accounts for over 20% of Sub-Saharan Africa's electricity generation (IEA, 2021). However, irregular rainfall patterns, prolonged droughts, and erratic river flows caused by climate change have significantly reduced output in countries like Zambia, Ethiopia, and Ghana.

For instance, Zambia's Kariba Dam has recorded historic low water levels in recent years, forcing national load-shedding due to a 50–60% drop in hydroelectric output (World Bank, 2022). Similar disruptions have occurred at Ethiopia's Gibe III dam and Ghana's Akosombo dam.

4.2.2 Fossil Fuel and Thermal Energy

Rising ambient temperatures reduce the efficiency of thermal power plants, increasing operational costs and emissions. Additionally, coastal infrastructure is at risk of flooding due to rising sea levels, affecting oil and gas infrastructure in countries like Nigeria and Angola (IPCC, 2022).

4.2.3 Renewable Energy Challenges and Opportunities

While solar energy presents a viable alternative, climate variability can reduce solar PV efficiency and affect the reliability of wind patterns. Nevertheless, renewable investments are increasing. Kenya, for example, has invested significantly in geothermal energy, which is less susceptible to climate variability.

4.3 Impact of Climate Change on Energy Consumption Patterns

Climate change not only affects energy production but also alters demand and consumption behaviors across households, industries, and urban infrastructure.

4.3.1 Increased Cooling Demand

Rising temperatures have led to increased demand for air conditioning and refrigeration in urban areas, especially in West Africa. According to UNEP (2020), electricity consumption in residential sectors in Lagos and Accra has risen by 25–40% during heatwaves.

4.3.2 Agriculture and Energy Use

In rural settings, changes in rainfall patterns have affected irrigation systems, increasing the need for solar-powered or diesel-powered pumps. In dry regions like the Sahel, the energy used for water access and agricultural processing has increased significantly.

4.3.3 Urban Infrastructure Strain

Urban areas in SSA are experiencing rapid population growth, which, when combined with heat stress, is straining already limited energy infrastructure. Electricity outages during peak demand hours are becoming more common in cities like Nairobi, Kinshasa, and Dar es Salaam.

4.4 Adaptation Strategies and Policy Responses

Sub-Saharan Africa is increasingly adopting adaptive strategies to cope with the dual challenge of climate change and energy insecurity.

4.4.1 Regional and National Policy Frameworks

- **African Union's Agenda 2063** and the **African Renewable Energy Initiative (AREI)** advocate for a climate-resilient energy future.
- National plans like Nigeria's Energy Transition Plan (2022) and Kenya's Climate-Smart Development Strategy (2020–2030) incorporate renewable energy expansion and energy efficiency targets.

4.4.2 Technological Innovations

Investment in off-grid solar technologies and mini-grid systems has grown rapidly. Countries like Rwanda and Senegal are deploying solar kits to remote communities, increasing resilience to centralized grid failures caused by climate impacts.

4.4.3 International Support and Funding

Initiatives like the **Climate Investment Funds**, **Green Climate Fund**, and the **Sustainable Energy for All (SE4All)** framework have provided funding and technical support for clean energy transitions across SSA.

However, funding gaps, policy inconsistencies, and institutional weaknesses still hinder large-scale implementation of resilient energy systems.

4.5 Comparative Insights Across Selected Countries

Nigeria

Heavily reliant on oil and gas, Nigeria faces significant climate risks to its coastal energy infrastructure. The country has launched a comprehensive Energy Transition Plan targeting net-zero emissions by 2060, with a focus on gas-to-power and solar energy expansion.

Kenya

Kenya is a regional leader in renewable energy, with over 90% of electricity coming from renewable sources. Geothermal and wind energy have provided stable alternatives to climate-sensitive hydro systems.

Zambia

Zambia's energy production is dominated by hydropower, making it highly vulnerable to climate change. Load-shedding has become a norm during drought years, underscoring the urgent need for diversification.

4.6 Discussion of Findings

The analysis confirms that climate change significantly disrupts both the production and consumption of energy in SSA. Hydropower vulnerability, increased cooling demand, and rural energy needs are clear manifestations of climate stress.

While policy and technological responses are emerging, implementation challenges remain. Energy resilience in SSA will depend on cross-sector collaboration, regional integration, and sustained investment in low-carbon, climate-resilient technologies.

5. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1 Summary of Findings

This study investigated the impact of climate change on energy production and consumption in Sub-Saharan Africa using secondary data sources. The findings are summarized in line with the study's objectives:

1. Climate Change and Energy Production: Climate change has negatively affected energy generation in Sub-Saharan Africa, particularly hydropower, due to declining water levels and irregular rainfall patterns. Countries such as Zambia and Ethiopia have experienced severe load-shedding as a result. Rising temperatures have also decreased the efficiency of thermal power plants and threatened oil and gas infrastructure in coastal regions.
2. Climate Change and Energy Consumption: Rising temperatures have led to increased energy demand, especially for cooling in urban areas. Additionally, rural agricultural practices now require more energy due to irregular weather patterns, particularly for irrigation and processing. These changes are placing significant strain on already fragile energy systems.
3. Adaptation and Policy Responses: While efforts are underway across the region to adopt clean energy technologies and develop climate-resilient policies, progress remains uneven. Countries like Kenya are leading in renewable energy development, while Nigeria and Zambia face greater challenges due to heavy dependence on fossil fuels and hydro sources. Regional and international initiatives provide support, but gaps in implementation, financing, and infrastructure continue to pose barriers.

5.2 Conclusion

Climate change represents a critical threat to sustainable energy development in Sub-Saharan Africa. Its impacts on energy production and consumption are far-reaching, affecting economic growth, public health, and development. While countries in the region are responding with policy initiatives and technological innovation, systemic challenges such as underfunding, weak infrastructure, and inconsistent policy enforcement hinder progress.

A sustainable energy future in Sub-Saharan Africa requires not only adaptation but also transformation. Resilient energy systems must integrate low-carbon technologies, prioritize energy efficiency, and be designed to withstand future climate variability.

5.3 Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Diversify Energy Sources: Countries should invest in diverse energy portfolios, particularly in solar, geothermal, and wind energy, to reduce dependence on vulnerable hydro and fossil fuel systems.
2. Strengthen Policy Frameworks: Governments need to create and enforce integrated energy and climate policies that promote long-term sustainability, transparency, and private sector engagement.
3. Enhance Regional Cooperation: Regional power pools and inter-country energy initiatives should be strengthened to share resources and build cross-border resilience against climate shocks.
4. Mobilize Climate Finance: Increased funding from international climate funds, development banks, and private investors is critical to support the energy transition and infrastructure resilience in the region.
5. Support Research and Innovation: Continued research into climate-resilient energy technologies and localized solutions should be encouraged, particularly through partnerships between governments, academic institutions, and the private sector.
6. Public Awareness and Education: Community engagement and awareness programs are essential to promote energy efficiency, climate adaptation behaviors, and local ownership of renewable energy projects.

5.4 Suggestions for Further Research

Future studies may consider:

- A country-specific assessment using geospatial or energy demand modeling
- Comparative analysis of energy transition pathways across African sub-regions
- In-depth evaluations of adaptation strategies among vulnerable rural communities
- The role of governance and political will in climate-energy policy effectiveness

References

Adger, W. N. (2006). Vulnerability. Global Environmental Change, 16(3), 268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

African Development Bank (AfDB). (2020). African Economic Outlook 2020: Developing Africa's workforce for the future. https://www.afdb.org

Bazilian, M., et al. (2012). Energy access scenarios to 2030 for the power sector in Sub-Saharan Africa. Utilities Policy, 20(1), 1–16. https://doi.org/10.1016/j.jup.2011.11.002

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes. Research Policy, 31(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Gonzalez, A., & Makoni, M. (2018). Energy consumption and temperature in urban Africa. Energy for Sustainable Development, 45, 97–107.

Intergovernmental Panel on Climate Change (IPCC). (2021). AR6 Climate Change 2021: The Physical Science Basis. https://www.ipcc.ch/report/ar6/wg1/

International Energy Agency (IEA). (2021). Africa Energy Outlook 2021. https://www.iea.org/reports/africa-energy-outlook-2021

International Energy Agency (IEA). (2022). Africa Energy Outlook 2022. https://www.iea.org

International Energy Agency (IEA). (2022). CO2 Emissions in 2021. https://www.iea.org/reports/co2-emissions-in-2021

Mol, A. P. J., & Sonnenfeld, D. A. (2000). Ecological modernization around the world: An introduction. Environmental Politics, 9(1), 3–14.

Ngumbi, E., & Feng, H. (2020). Hydropower vulnerability to climate change in Sub-Saharan Africa. Journal of Environmental Management, 275, 111211. https://doi.org/10.1016/j.jenvman.2020.111211

Nhamo, G., & Nhemachena, C. (2021). Regional climate change adaptation responses in Southern Africa. Climate Policy, 21(1), 57–75.

Oluleye, G., et al. (2021). Climate resilience in Nigeria's electricity sector: A review of trends, threats, and response strategies. Energy Reports, 7, 4012–4025.

Riebau, A., et al. (2019). Zambezi River Basin and the implications for hydroelectric power generation. Hydrology and Earth System Sciences, 23, 2345–2358.

Schaeffer, R., et al. (2012). Energy sector vulnerability to climate change. Energy, 38(1), 1–10.

Wanjiru, H., & Ochieng, C. (2019). Solar home systems and climate variability in Kenya. Renewable Energy, 139, 721–730.

World Bank. (2022). Tracking SDG 7: The Energy Progress Report. https://trackingsdg7.esmap.org