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A STUDY REVIEWED ON CLIMATE CHANGE ADAPTATION TECHNIQUES FOR HYDROPOWER EXPANSION IN SUB-SAHARA AFRICA

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ABSTRACT

The UN Environment Programme argues that advancing economic development can increase resistance to climate change and enhance coping strategies. The majority of Sub-Saharan African nations generate a greater proportion of their electricity from fossil fuel-based energy sources. Hydropower energy can be added to this to meet national demand and the increased interest in addressing climate change on a global scale. Sub-Saharan Africa is home to many nations that are seriously concerned about climate change. Among the top African nations with an abundance of renewable energy resources are Nigeria, Cameroon, and Liberia. The main issues with climate change and hydropower energy in African nations are lack of enthusiasm and unbalanced policy. Hydropower supplies more than 50% of all energy in Sub Sahara Africa. Having problems with supply reliability could be caused by a warmer environment. Adoption of energy-efficient appliances, water heating technologies, and water pumping systems are just some of the strategies that could result in a notable rise in green jobs. Greater frequency and intensity of extremes are anticipated, regardless of the absolute change in gross technical potential. Even if some of the biggest river basins have suffered a considerable amount of drying over the past century, this will still happen. The effects of climate change are particularly dangerous for those living in sub-Saharan Africa. Effective adaptation strategies would mitigate the adverse effects on agriculture, health, livelihood, and the environment. Climate change adaptation is hampered by a lack of comprehensive information about the vulnerabilities, a failure to consider the needs of local populations, and an insufficient integration of policies and programmes. The purpose of the study was to examine climate change adaptation strategies for hydropower expansion in sub-Saharan Africa.

Key Words: *Climate Change, Hydropower Energy, Environment Preservation, Technologies*

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INTRODUCTION

In sub-Sahara African, mostly in the Sahel region, climate change and global warming have a significant negative influence on agriculture, food security, quality of life, human health, economic growth, and development (Hongbing et al., 2022). The adaptation and mitigation of climate change are topics of continuing international debate. Despite these efforts, there is little information on how the region is addressing the impact that climate change will have on its economies and its population (Falchetta et al., 2019).

Climate change has a 50% negative impact on agricultural yields in rain-fed agriculture (Rockson SaiBoqiang Lin, 2022). Crop yields could be reduced by 10–20% by 2050 due to warming and dryness (Obahoundje & Diedhiou, 2022).

Conversely, the development of agricultural production and supply is being slowed down by hydropower. Having problems with supply reliability could be caused by a warmer environment with more frequent and violent extremes (Omar et al., 2019). Here, a strong framework to emphasize the connections between climate change, water availability, and hydropower is proposed. The most recent research on the predicted effects of climate change on hydropower in sub-Saharan Africa is reviewed.

On the other hand, a development plans for hydropower generation in Sub-Sahara Africa which aim to make the country an industrialised, middle-income nation by 2030, identify energy as one of the key enablers. In the Sahel region of Africa, more than half of all energy is required for food security (Ibrahim et al., 2021). Only a small number of countries have implemented a diversification strategy away from hydroelectricity. The productivity of smallholders, who produce 95% of the nation's agricultural output, is crucial to a nation's ability to combat climate change (Willis et al., 2022).

Appiah (2019), the governments of Ghana saw a need to implement creative adaptation plans for long-term food security. Climate change must be included in development planning by government bodies. Climate-smart agricultural sector development is necessary for both job growth and food security. Coordination of ideas across sectors and the deliberate provision of resources are essential.

Ofori (2021) examined the effects of climate change on food, land, and water. The study reviewed that there is no doubt that humans are both the cause of the earth's present and future warming as well as its victims. Sub-Saharan Africa is thought to be the region most sensitive to climate change due to its highly limited ability to adapt to or prevent climate change.

Woldie (2019) considered agricultural strategies for coping with famine in connected Sub-Saharan African regions as climate change adaptation tactics. According to the data, farmers who have access to credit are less likely to raise yields since finance is not employed for agricultural investment. Being single (unmarried), soil erosion, and infertile soil can adversely affect adoptees' yields. Asset creation and access to climate data should be taken into consideration when planning and implementing adaptation strategies. Hence, the study aims to shed light on the present and potential effects of climate change adaptation techniques for hydropower expansion in Sub-Saharan Africa. It provides methods for addressing these problems from a multidisciplinary standpoint during the policy-making process.

Climate Change Adaptation

Climate change adaptation (CCA) is becoming accepted as a viable alternative to traditional approaches to addressing food poverty in the face of climate change (Guerra et al., 2019). Many emerging nations have come to the conclusion that the notions that have been advocated are inappropriate for them (Omar J.Guerraa1Diego A.TejadabGintaras V.Reklaitisa, 2018). The availability of food poses a danger to at least 20 different countries between March and July 2021 to present (Ochieng & Christopher, 2022). The idea of the norm illustrates the symbiotic relationship between the farmer's element and the societal aspects. Particularly

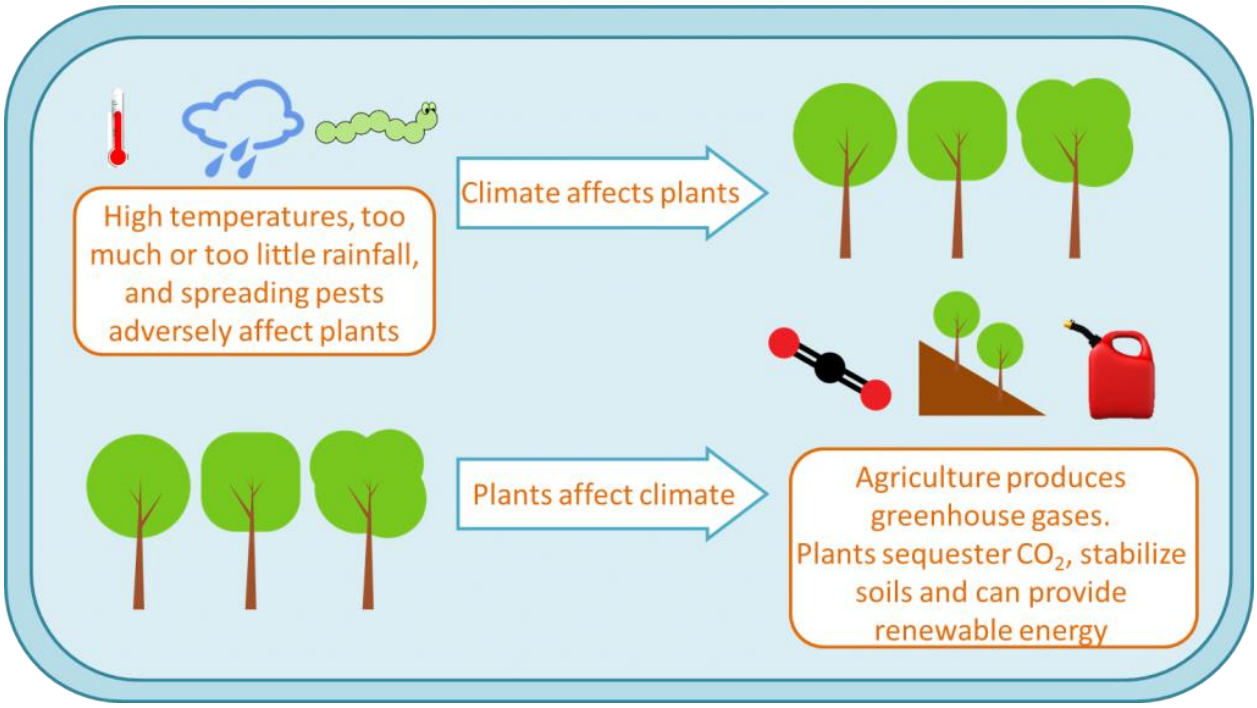
when the technology demands a paradigm shift, farmers do not want to be perceived as deviating from the standard (Falchetta et al., 2019).

Although farmers can always access and use agriculture technology, how it is used is negatively influenced by cultural and religious beliefs in thinking and mindset (Mathe et al., 2019). Examples of farming practises where farmers may find it challenging to depart from their established conventions include organic farming and digital farming.

The economic policies of different nations may have an impact on the idea of climate adaption (Hongbing et al., 2022). Usually, climate conditions and adaptation are linked to agriculture and farming operations.

Finding and filling the gaps in the goals to foster innovation and promote economic growth are the main difficulties. The way that humans interact with the land through forestry and agriculture has a big impact on how well the Earth system works. At least seven of the 17 Sustainable Development Goals are impacted by climate change and agricultural outcomes (Reklaitisa, 2018). Accotding to UN Climate summit report (2017) one hundred and three nations had made the commitment to lessen agricultural greenhouse gas emissions as of 2015.

Climate-smart agriculture can benefit production, adaptation, and mitigation (Ibrahim et al., 2021). For global warming to be limited to 2°C over pre-industrial levels by 2100, we must move outside the agriculture industry (The World Bank, 2022). The study uses information about food, land, and water in Sub- Sahara Africa to examine climate change adaptation strategies for hydropower expansion.



Source: Bing Searched (2022)
Figure 1: *Climate Change and Adaptation Impact*

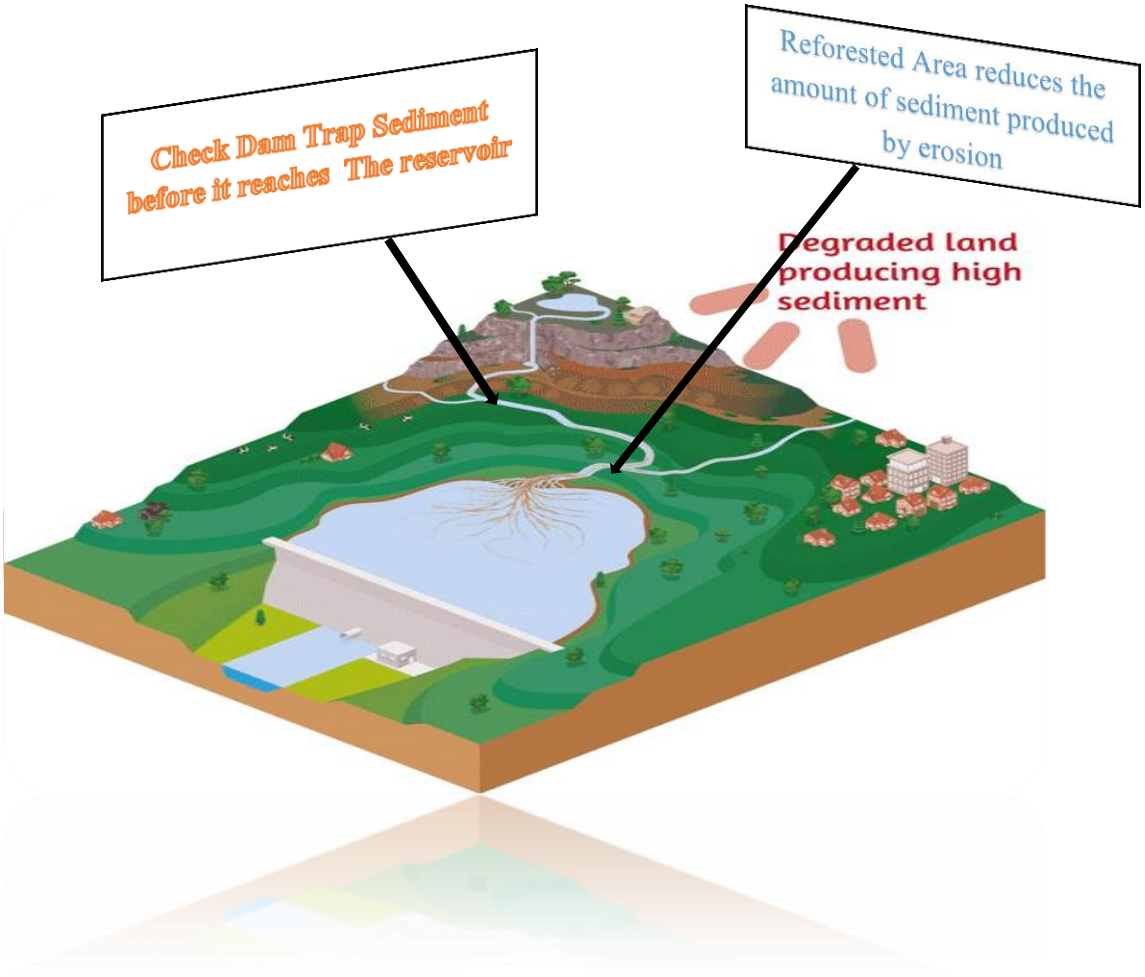
Techniques for Hydropower Expansion

As part of the Paris Agreement on Climate Change, countries around the world will have to develop new strategies for the development of the energy sector. More systematic tools are required to enhance decision-making processes in the context of the implications of climate change and adaptation techniques (Raimi et al., 2021).

However, if Sub-Saharan African countries do not adapt to climate change and hydropower expansion policies, they would likely see a reduction in the capacity factor of hydropower output of 5.5–17.1% from 2015 to 2029 (Loboguerrero et al., 2019). Reducing sediment output by upstream sediment trapping and erosion prevention managing flows to reduce silt trapping in reservoirs during times of high sediment production applying a number of methods to remove sediment that has already become lodged in reservoirs (M.Azamac, 2022). Structural and functional adjustments (Chen Si-Han et al., 2022). The ideal expansion strategy involves reallocating capital and boosting expenditures on carbon-management technologies and renewable energy sources (De Angelis et al., 2021).

The contribution of hydropower to achieving energy and climate policy goals may be impacted by long-term climatic changes. The impact of climate change on the amount of runoff is mainly unknown (Energy Research and Social Science, 2021). Hydropower is the most significant source of renewable electricity generation in South America (Mathe et al., 2019). Hydropower and climate policies must be considered as well as the impact of climate change on hydroelectricity production and use in agricultural and food production (Falchetta et al., 2019). Countries in Sub – Sahara Africa are expected to play a big part in meeting their Nationally Determined Contributions (NDCs) under the Paris Agreement (Nadia S. Ouedraogo, 2019).

Diagrammatic Display of Hydropower Techniques



Source Author: International Association of the Year (2022)

Figure 2: Diagrammatic Display of Hydropower Techniques: *This is a demonstration of demographic techniques used in the planning and development of hydropower facilities for the production of electricity*.

Case Explanation of Hydropower Techniques

The most effective tactics will typically be a combination of strategies, and as climate conditions change over time, so will these techniques (International Commission On Large Dams, 2022). The following categories are used to group the case studies presented in this review.

- ***Reduce the output of upstream sediment***

The objective of managing hydropower is to decrease the quantity of sediment from the contributing catchment that enters and departs the reservoir.

This can be accomplished by utilising erosion management methods to lower the catchment's sediment production and by capturing material upstream (Chen Si-han 1 et al., 2022). Examples of structures that collect sediment by stopping water flow and settling it are check dams and detention basins.

- ***Route Sediment***

Hydropower methods that make use of the time wise variation in water output are referred to as "sediment routing (De Angelis et al., 2021)." In order to minimise deposition in the reservoir, flows must be managed during times of maximum yield. Sluicing, bypass tunnel, and bypass channel/tunnel are examples of routing techniques (Chen Zeng et al., 2022).

Research Problem

In Sub-Saharan Africa, more than half the energy is generated by hydropower. A warmer atmosphere could result in issues with supply reliability. Adoption of energy-efficient home appliances and water heating innovations are just a few of the measures that could lead to a significant increase in green jobs. Research by the World Bank and United Nation Environment Programme (UNEP) looks at how hydropower projects in sub-Saharan Africa might be modified to account for an uncertain future climate (Mathe et al., 2019). Due to the nearly forty-year lifespans of the infrastructure and power plants, choices regarding hydropower investments have significant lead times and lasting effects.

Estanislao (2022) establishing the connections between climate change and hydropower within the context of the country is necessary, as is identifying the widespread risks and practical problems of the sub-Saharan African countries that are climate-sensitive. The work of current professionals in climate science and health research can be supported by the money that is now available. For disease burden modelling and predictions in particular, deliberate capacity development is required.

Bank for Asian Development (2012) generally speaking, engineering and non-engineering solutions can be used as adaptation measures. It may be preferable in a variety of situations to advocate for low- or no-risk adaptation measures that enhance development regardless of the type and severity of climate change. This is a viable and realistic option wherever there is significant uncertainty about climate change and large financial investments in climate proofing cannot be easily justified. Such climate-proofing measures can make sense in other situations. On the other hand, there are times when doing nothing is both more suitable and practical.

Opperman (2022), WWF Global Lead Freshwater Scientist and study lead author, hydropower projects have long been considered low-risk investments in renewable energy. Risks from floods and droughts are projected to increase dramatically in many river basins due to climate change. 20% of planned and 32% of existing hydropower dams are located in areas where there is a higher danger of water scarcity by 2050.

Considering the risk to rivers and biodiversity is essential when making decisions about new dams. Poorly planned hydropower has already had an adverse effect on freshwater fisheries and contributed to the extinction of many species. Now, nations may invest in power grids that are low-Cx3—low carbon, cheap, and in conflict with communities and waterways (Jeff Opperman, 2022). However, inadequate integration of policies and programmes, a lack of comprehensive information about the vulnerabilities, and a failure to take into account the needs of local populations all hinder climate change adaptation. Examining climate change adaptation tactics for sub-Saharan African hydropower expansion is the study's goal.

Aims of the Study

The Aim of this study was to review the literature on climate change adaptation techniques for hydropower expansion in sub-sahara Africa. Peer-reviewed articles, project reports, and other documentation are analysed in order to accomplish these goals. The background context of climate change adaptation and methods for increasing hydropower are explored in the introduction and problem description. Concepts are introduced, and a method for evaluating the climate change adaptation approaches' resistance to hydropower augmentation is suggested in the research methodology. Then, a brief explanation of adaptation practises at the farm, institutional, and policy levels follows. The study comes to a close by outlining its key conclusions and their consequences for national governments, climate policy, development policy, cooperation, and research.

Study Objectives

The main objective of the study was to review the climate change adaptation techniques for hydropower expansion in sub-sahara Africa. The study was guided by the following specific objectives;

- To review the community policy on climate change adaptation techniques for hydropower expansion in sub-sahara Africa.
- To determine the Influence climate change adaptation techniques for hydropower expansion in sub-sahara Africa.

LITERATURE REVIEW

The study examined numerous scholarly literature on hydropower and climate change in Sub-Saharan Africa. The researcher based this study's selection of numerous highly cited publications on this note.

Sai et al., (2022) Kenya is one of the fastest-growing economies in Sub-Saharan Africa and relies heavily on energy to sustain its growth. However, there is a strong and rising need for energy, as well as unreliability and high costs. The study analyses the dynamics of productivity at Kenya's hydro and thermal power facilities from 2013 to 2020. The study examined how changes in the productivity index are impacted by environmental conditions. The empirical results show that the technical efficiency change index (TIE) is mostly responsible for the decline in hydro productivity. Future power plant construction and operation is given specific policy implications for the UK energy sector.

Godsmark (2022) emphasised that confronting one of our time's most pressing issues may be too much for some Indeed, the study urges action to mitigate climate breakdown. Personal climate action is required, as well as action at the individual level and at the global level. It might be difficult to get people to take personal climate action. Providing people with information and encouraging them to plant trees on purpose could be one method to increase their appreciation for the environment and spur more individual climate action.

O'Reilly et al., (2022) Study investigates extent to which paediatric settings in Germany are prepared for the effects of climate change on children's health. The study combines the findings of two studies that looked at the level of knowledge among doctors and parents about climate change-related health effects on children's health. Climate change and health are not sufficiently covered in German paediatric settings, a study has found. As a result, there is a gap that needs to be filled between the demand for information and the absence thereof. The communication of the complicated health impacts should be easily accessible and target group-focused.

Talukder et al., (2022) Ocean biodiversity loss brought on by climate change has unknown effects on the health of the planet. In order to take preventive, restorative, and remedial measures for the ocean and its biodiversity, it is essential to understand the causes and effects of climate change. These include food and nutrition security, livelihoods, disaster risk reduction, and for pathogenic organisms for people. Future strategies for reducing the loss of ocean biodiversity caused by climate change are considered. For preventive, restorative, and sustainable steps to be taken to preserve ocean biodiversity and its services, it is essential to understand the causes and effects of climate change.

Chowdhury et al., (2022) Climate change adaptation is a term used to describe the state of affairs in countries and regions affected by climate change - i.e. when obstacles caused by both nature and humans prevent sustainable adaptation. The vulnerability of Bangladesh's citizens to the effects of climate change has increased due to their geographic position and socioeconomic circumstances. Effective adaptation measures will lessen the negative consequences on the environment, agriculture, health, and way of life. Many people are moving to

Salazar et al., (2021) The Philippines' government has identified funding for research in this area as a top priority. To aid the government in including stakeholders in both government and research, a stakeholder analysis was conducted. The relationship between climate change and health in the context of the nation must be established, and it must be determined whether common health problems are climate-sensitive.

Talukder et al., (2022) Foodborne zoonotic illnesses and pathogens linked to climate change are of significant concern for public health. All of these effects have the potential to impede growth and sustainable socioeconomic development. To model this intricate problem, numerous multidimensional variables, data management systems, and sophisticated techniques are needed. A model based on complex adaptive systems and agent-based modelling enabled by blockchain technology is proposed to evaluate the public health effects of foodborne zoonotic illnesses and pathogens associated to climate change. The risks and weaknesses associated with the diseases and pathogens found in food systems can be determined using this model.

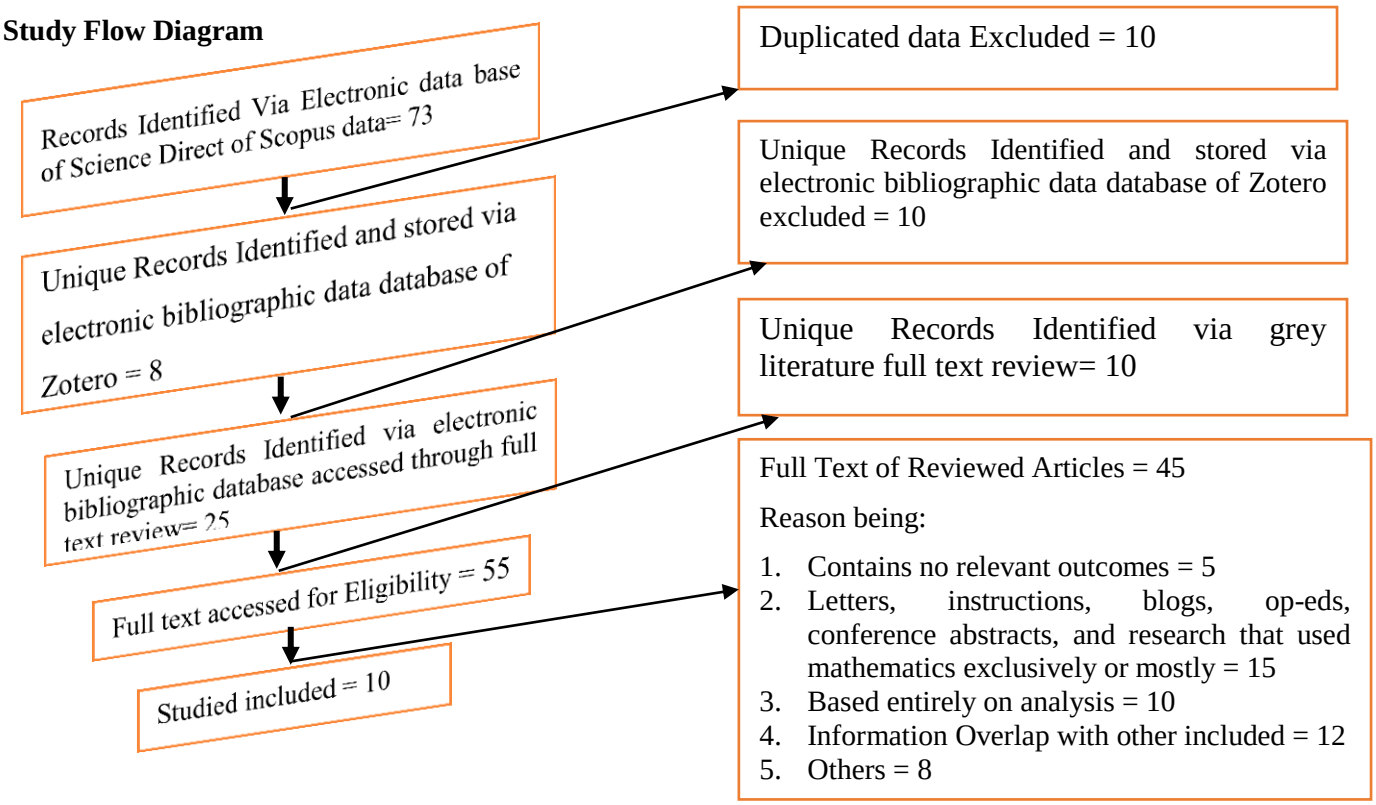
Falchetta (2019) there is consensus regarding the likelihood of climate change having negative effects in West and Southern Africa and positive effects on the hydropower potential of East Africa. Greater frequency and intensity of extremes are anticipated, regardless of the absolute change in gross technical potential. Even if some of the biggest river basins have suffered a considerable drying over the past century, this will still happen.

Lumbroso (2015) noted in his studies that in sub-Saharan Africa, there are more than 580 million people without access to electricity. Significant unrealized hydropower potential exists in the area, which might help increase domestic access and economic growth. Climate change is most likely to have an impact on hydropower production because it depends on water quantity and timing. Climate change can be incorporated into hydropower plans at a river basin scale - researchers from the University of British Columbia and China's National University of Water and Power (UNW). The natural fluctuation of the current hydrological regime is within the variability of the projections for climate change.

Brown (2011) Understanding the current effects of climate change on economic growth is required to develop climate change adaptation strategies. Case studies from the literature show that, historically, Sub-Saharan Africa's climate has had a large and unfavourable impact on household income, agricultural output, and economic progress. With temperature and precipitation variability both having a major impact, drought is determined to be the climate factor that has the greatest impact on GDP per capita growth in Sub-Saharan Africa. This result is in direct opposition to the premise of many climate change effect estimates, which emphasise temperature increases as the main issue.

METHODOLOGY AND MATERIALS

In order to build a database and extract relevant data, Talukder et al. (2022) provided guidelines for a comprehensive literature review. The majority of this study focuses on the climate change adaptation of hydropower and expansion in Sub Sahara Africa. The study examined a model for developing nations' economies, in order to develop their power infrastructures. It also looked at literature relating to sustainable hydropower adaptation and techniques in India, Brazil, United State of America, Australia and emerging nations.



Source: Author (2022)

Figure 3: *Diagrammatic flow of citations and articles*

Table 1: Geographic Representation of Included Studies

Region and Sub – region	Total Number	Countries Represented (Numbers of Studies in a country)	References
United State of America	8	16	Springer Link
Canada	5	13	Bulletin of the World Health Organization
Switzerland	4	12	Annual Review of Economics
Nigeria	3	10	Springer Link
Australia	3	11	Bulletin of the World Health Organization
China	3	13	Elsevier Enhanced Reader
United Kingdom	2	15	Humanities and Social Sciences Communications
South Africa	2	10	Journals IJERPH
Pakistan	2	10	Research Gate
Spain	1	5	Current Trauma Reports
Burkina Faso	1	10	Research Gate
Zimbabwe	1	8	Academia
Kenya	1	5	Elsevier
Poland	1	4	Sexual and Reproductive Health Matters,
India	1	8	Elsevier

Source: Author (2022)

This is the total number of articles that have been cited in various publications from different countries. Topic titles, citation counts, and geographical representations of the table are used to determine the concentration of the topic title.

Database Creation

Using a mix of keywords, a thorough literature search was conducted on the Web of Science, Google Scholar, Researcher, and Science Research Assistant etc., to build a database of papers. A predetermined study protocol was created that outlined the stages of identification in Table 1 below, screening, and eligibility as well as clearly stated inclusion and exclusion criteria. Climate change and ocean biodiversity was screened by looking through the titles and abstracts. Empirical research using primary or secondary data, in-situ (in a natural setting), and in-vitro (in a controlled environment like a laboratory) were the admission criteria to examines the intricacy and adaptation of hydropower generation in sub-Saharan Africa.

To determine the connections between climate change and hydropower, it was necessary to look at climate change adaptation, water generation, ocean biodiversity, and planetary health. Studies on climate change that did not include a component relating to hydropower generation were removed. In the end, 45 and 10 items were determined to be first- and second-nexus eligible. All 73 papers were determined to be significant and valuable, so no additional screening was done.

Data Extraction

Given that in the statement above, the table below has shown more research data of the study criteria (45 versus 10 qualified papers), the intersection of climate change, hydropower adaptation, and expansion is a developing field that needs additional study. Africa's Sub-Saharan region and the Atlantic and Pacific oceans were the main research areas. To date, the majority of research attention has been focused on two of the three relevant stressors: food and water supplies and power generation.

Table 2: The Sub set Approach to Identify Relevant Studies

Approach	Sources Searched	Requirement Around Timing of Publication
Searching eight electronic bibliographic databases	Sage, Springer, BMJ, Taylor and Francis, Google Scholar. +research, Elsevier, and Research Gate.	An electronic bibliographic database search strategy was used to locate the study, which was deemed suitable for this investigation because it had to be published between now (2022), when the database search strategy was used, and December 31, 2019, when a cluster of amazon deforestation occurred.
Finding appropriate sources by visiting websites for scientific research assistant literature and contacting Google Scholar documents	Important institutions that produce or aggregate data relating to climate change adaption and hydropower techniques, conduct surveys, and provide energy and livelihood. The Bill and Melinda Gates Institute for Population and Reproductive Health, the Population Council, United Nations, the WHO's global literature collection on coronavirus illness, and African Journals Online.	A literature search technique on relevance and cited ranking on Google Scholar and other websites as a component must have been submitted. When the study literature searches were finished, on or after December 31, 2019, to the present (2022), the study had been completed.
The study reviewed the references for the papers that were included.	A full-text review of the studies was conducted. Phase and encompassed research throughout the data extraction phase.	When reviewing the complete text and when extracting the data.

Source: Author (2022)

Table 2 d*emonstrate the methodology, sources searched, and timing of the articles that have been cited in various publications. Topic titles, citation counts, and after searching eight electronic websites for scientific research assistant literature and contacting Google Scholar documents, the study reviewed the references for the papers that were included.*

RESULT

Food scarcity and drought have protected people in Sub-Saharan Africa from the worst effects of climate change by absorbing more than 90% of the excess global temperature increase and roughly 25% of CO2 emissions. However, climate change is causing the oceans to warm, acidify, and lose oxygen. As shown in Fig. 2, the impacts represent serious challenges to marine organism biodiversity at both the individual and population level.

Temperature Rise

Increasing greenhouse gases are making it harder for heat emitted from the Earth's surface to escape into orbit as easily as it did before the industrial revolution (Guerra et al., 2019). Over 90% of the extra heat from the atmosphere has returned and been absorbed by the surface water (Garry Stevens ; et al., 2022). For instance, the top ocean's heat content has dramatically increased recently. Around the world, sea levels are rising as a result of the thermal expansion of warming ocean waters. Localized maritime heat waves are predicted to become decadal to centennial events if the global average temperature climbs by 1.5 °C (Obahoundje & Diedhiou, 2022). And if the global average temperature rises by 3 degrees Celsius, these are expected to shift from yearly to decadal events.

Ganguli (2021), the two thermally connected roles that climate change currently plays in Earth's systems are (i) the storage and seasonal release of heat and (ii) the flow of heat through their circulation systems. As a result of rising temperatures, species variety is being affected and modified in places like Ethiopia, Tanzania, Kenya, and Uganda, as well as in the wild animals' migration to Burundi and Rwanda. Population size, habitat alteration, and habitat degradation are just a few of the variables that might affect how much and how quickly a species' distribution shifts in response to stressors brought on by climate change (Energy Research & Social Science, 2021).

Livelihood Impacts of Climate Change

Many areas of human welfare and ways of life depend on water. The livelihoods of nearby populations, particularly those most reliant on natural resources, are at risk due to the degradation of ocean biodiversity and ecosystems (Morufu Olalekan Raimi et al., 2021). For instance, 80 percent of all tourism is centered near the sea, but tourism and recreation that rely on coral reefs are being impacted by coral reef loss (Nadia S. Ouedraogo, 2019). The return or collapse of fisheries could be caused by climate change-induced oceanic fish migration (Nadia S. Ouedraogo, 2019). The capacity of coastal water areas to store carbon is also impacted by changed precipitation patterns and rising ocean temperatures (Sofia Olsén Jonsson Cornelius Peterson, 2022). Ocean acidification can potentially worsen respiratory conditions by releasing poisons into the air (Rockson SaiBoqiang Lin, 2022).

Discussion

Sub-Saharan Africa's current energy production is insufficient to meet the energy needs of nearly all African nations (Hongbing et al., 2022). The amount of hydropower-produced energy at a nation's disposal is somewhat correlated with its development and industrial expansion. Nigeria, Cameroon, and Liberia are three countries under review for potential renewable energy projects (Ibrahim et al., 2021). The geographical locations of these countries determine the possible sources of renewable energy. Countries along the coastal region will have access to tidal or wave energy, while those along the equator or in the Northern Hemisphere will have high solar radiation (Obahoundje & Diedhiou, 2022).

Nigeria stands out as one of the countries with shockingly little power. Due to the majority of her residents making less than $1 per day, a sizable portion of her population lives in poverty (Mathe et al., 2019). The broader population's extremely limited access to hydropower is the cause of the economy's current lack of substantial development and support. Only 40% of the nation's population, according to a report by Ogundari and Otuyemi (2021), is wired into the national electrical infrastructure. 54.4% of Nigeria's population had access to electricity as of 2017, according to the most recent World Bank report.

The majority of the nation's electrical energy is produced by hydroelectric power facilities. The study also offers an evaluation of the continent's energy situation, standard of living, and support for sustainable power. On the other hand, in Cameroon, barely 28% of the population lives directly near an electric power source (Rockson SaiBoqiang Lin, 2022). The vast energy potential that the nation possesses does not change this. According to Abubakar et al. (2021), the insufficient production of power was a result of the lack of a defined policy on renewable energy. Despite having a comparatively high level of social and political stability,

Noticing that Sub-Saharan Africa is transitioning from a low-income to a lower-middle-income economy has resulted in a 20% reduction in poverty over a 14-year period (Nadia S. Ouedraogo, 2019). Higher electrical energy demand is a result of the urbanisation rate being driven by economic expansion. This is notably reflected in the continent's power consumption of electricity. For example, in Liberia today, it is obvious that less than 1% of the electricity is produced from renewable sources (Falchetta et al., 2019). One of the most promising choices for alternative energy sources is hydropower. The performance of a hydroelectric generator increases with height (Chen Zeng, 2022). According to the Liberian Energy Commission, the river water flow at a height of 12 metres along the east and west of the region is between 4.8 and 5.5 m/s in the urban and upper interior regions of Liberia.

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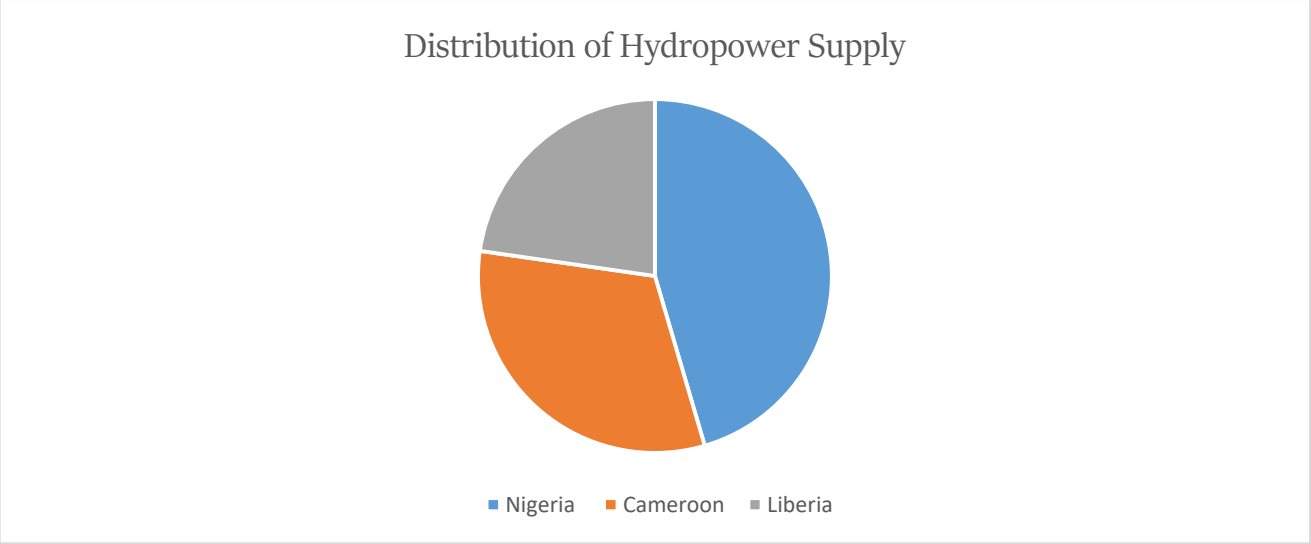
Nevertheless, more than 1.3 billion people worldwide still lack access to reliable electricity. Any nation that is genuinely interested in industrial expansion must have access to electricity (Mathe et al., 2019). The number of people without access to electricity fell below 1 billion in 2017, according to the 2019 Renewable Energy Global Status Report (Olaka, 2022). Countries in sub-Saharan Africa must immediately look into this matter and decide consciously to use climate change adaption strategies for hydropower expansion throughout the continent (Hongbing et al., 2022).

Health concerns, detrimental environmental effects, and the potential exhaustion of fossil fuels are some of these changes (coal, natural gas, and oil) (Loboguerrero et al., 2019). The study provides an assessment of the nation's standard of living, support for renewable energy, and energy situation. The study's findings support the idea that energy production and energy sources may coexist as long as they are both used to the utmost. It is concluded that energy sources and energy production may coexist as long as they are both utilised to their fullest extent.



Source: Author (2022)

Figure 4: *Chart Distribution of Hydropower Supply: Is a geographical representations of the chart are used to determine the concentration of the topic title.*

FINDINGS

If adopted by a country in sub-Saharan Africa, hydropower energy is said to provide significant advantages. Creating green jobs, advancing technology, having a strong economy, and luring in international investment are all advantages. The hydropower industry could create thousands of green jobs over the next few decades. Adoption of energy-efficient appliances, water heating technologies, and water pumping systems are just some of the techniques that could lead to a significant increase in green jobs. A general estimate and projection based on models can be established, but the precise number is still to be determined.

CONCLUSION AND RECOMMENDATION

According to research, hydropower energy would help Sub-Saharan African nation's progress in terms of GDP, spur regional prosperity, ease social crises, end poverty, and eliminate unemployment. According to the literature review, Sub-Saharan Africa has taken a number of different approaches to the development of climate change adaptation strategies for the spread of hydropower in the region.

The study recommended that green farming, environmental awareness, and school-based systems for early learning should be adapted along with climate change adaptation approaches for hydropower expansion in sub-Saharan Africa. The study also urges other academics to pay close attention to the nations affected by the drought because famine and hunger have been issues in the Sahel region, particularly in the Horn of Africa, and the study thinks it's crucial to look into them.

Declaration of Competing Interest

I certify that the research provided in this paper was not impacted by any known financial or interpersonal conflicts.

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REFERENCES

Abegunde, V. O., Sibanda, M., & Obi, A. (2019). The Dynamics of Climate Change Adaptation in Sub-Saharan Africa: A Review of Climate-Smart Agriculture among Small-Scale Farmers. *Climate*, *7*(11), Article 11. https://doi.org/10.3390/cli7110132

Chen Si-Han, Wang Bing, Fang Pan-Bo & Han Yan-cheng, (2022). *Research on the Composite Drainage and Pressure Reduction Effect of Combining Pipes and Wells in High Groundwater Level Canal Sections* [Research on the Composite Drainage and Pressure Reduction Effect of Combining Pipes and Wells in High Groundwater Level Canal Section]. China Rural Water and Hydropower. http://www.irrigate.com.cn/EN/Y2022/V0/I9/36

Chen Zeng, Zhou Li-Ye, Zhao Guo-Qiang , Chen Jin-Jian, (2022). *Shaking Table Test Design and Numerical Analysis of Pool Structure in High Filled Site* [Research Article]. Shaking Table Test Design and Numerical Analysis of Pool Structure in High Filled Site. http://www.irrigate.com.cn/EN/Y2022/V0/I9/49

De Angelis, P., Tuninetti, M., Bergamasco, L., Calianno, L., Asinari, P., Laio, F., & Fasano, M. (2021). Data-driven appraisal of renewable energy potentials for sustainable freshwater production in Africa. *Renewable and Sustainable Energy Reviews*, *149*, 111414. https://doi.org/10.1016/j.rser.2021.111414

Energy Research & Social Science. (2021). *Hybrid power systems for off-grid locations: A comprehensive review of design technologies, applications and future trends—ScienceDirect* [Science Direct - Elsevier]. Scientific African. https://www.sciencedirect.com/science/article/pii/S2468227621001885

Falchetta, G., Gernaat, D. E. H. J., Hunt, J., & Sterl, S. (2019). Hydropower dependency and climate change in sub-Saharan Africa: A nexus framework and evidence-based review. *Journal of Cleaner Production*, *231*, 1399–1417. https://doi.org/10.1016/j.jclepro.2019.05.263

Garry Stevens ;, Dimitrios Emmanouloudis, Nichole Georgeou, Surendra Shrestha, Nikolaos Katopodes, & Nidhi Wali. (2022). *Humanitarian Engineering for Renewable Energy and Flood Early Warning in Remote Communities: A Scoping Review of Enabling Factors and Sustainability* [Spyros Schismenos orcid id orcid.org/0000-0002-0494-2180]. Journal of Sustainable Development of Energy, Water and Environment Systems. https://hrcak.srce.hr/278897

Guerra, O. J., Tejada, D. A., & Reklaitis, G. V. (2019). Climate change impacts and adaptation strategies for a hydro-dominated power system via stochastic optimization. *Applied Energy*, *233–234*, 584–598. https://doi.org/10.1016/j.apenergy.2018.10.045

Hongbing M., Lulu Q., Yi Z., & Guangxue L. (2022). Evolution of tidal system and material transport off the Huanghe River Delta induced by human activities and natural evolution. 海洋学报, *44*(9), 73–86. https://doi.org/10.12284/hyxb2022071

Ibrahim, I. D., Hamam, Y., Alayli, Y., Jamiru, T., Sadiku, E. R., Kupolati, W. K., Ndambuki, J. M., & Eze, A. A. (2021). A review on Africa energy supply through renewable energy production: Nigeria, Cameroon, Ghana and South Africa as a case study. *Energy Strategy Reviews*, *38*, 100740. https://doi.org/10.1016/j.esr.2021.100740

International Commission on Large Dams. (2022). *Strategies* [Definition of a Large Dam" https://www.icold-cigb.org/GB/dams/definition_of_a_large_dam.asp]. Iha. https://www.hydropower.org/sediment-management/sediment-management-strategies

Jeff Opperman. (2022). *Hydropower projects threatened by increasing floods and droughts due to climate change, warns W* [Https://wwf.panda.org/wwf_news/?5168466/Hydropower-projects-threatened-by-increasing-floods-and-droughts-due-to-climate-change-warns-WWF-study]. WWF -Panda. Org. https://wwf.panda.org/wwf_news/?5168466/Hydropower-projects-threatened-by-increasing-floods-and-droughts-due-to-climate-change-warns-WWF-study

Loboguerrero, A. M., Campbell, B. M., Cooper, P. J. M., Hansen, J. W., Rosenstock, T., & Wollenberg, E. (2019). Food and Earth Systems: Priorities for Climate Change Adaptation and Mitigation for Agriculture and Food Systems. *Sustainability*, *11*(5), Article 5. https://doi.org/10.3390/su11051372

Mathe, K., Ntebo, N., & Ayorinde, E. O. (2019). A Review of Power Infrastructure Financing: The Brazil and India Approach. *E3S Web of Conferences*, *122*, 03003. https://doi.org/10.1051/e3sconf/201912203003

Mohamed A.EltawilabAli M.AlamriaMostafa M.Azamac. (2022). *A holistic risk management framework for renewable energy investments—ScienceDirect* [Science Direct - Elsevier]. Renewable and Sustainable Energy Reviews. https://www.sciencedirect.com/science/article/pii/S1364032122002210

Morufu Olalekan Raimi, Odubo Tonye Vivien, & Omidiji Adedoyin Oluwatoyin. (2021). *Creating the Healthiest Nation: Climate Change and Environmental Health Impacts in Nigeria: A Narrative Review by Morufu Olalekan Raimi, Odubo Tonye Vivien, Omidiji Adedoyin Oluwatoyin: SSRN* [SSRN]. Climate Change and Environmental Health Impacts in Nigeria: A Narrative Review. Scholink Sustainability in Environment. ISSN 2470-637X (Print) ISSN 2470-6388 (Online) Vol. 6, No. 1, 2021 Ww. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3782416

Nadia S. Ouedraogo. (2019). *Opportunities, Barriers and Issues with Renewable Energy Development in Africa: A Comprehensible Review | SpringerLink* [SpringerLink]. Regional Renewable Energy – Africa. https://link.springer.com/article/10.1007/s40518-019-00130-7

Obahoundje, S., & Diedhiou, A. (2022). Potential impacts of climate, land use and land cover changes on hydropower generation in West Africa: A review. *Environmental Research Letters*, *17*(4), 043005. https://doi.org/10.1088/1748-9326/ac5b3b

Omar J.Guerraa1Diego A.TejadabGintaras V.Reklaitisa. (2018). *Climate change impacts and adaptation strategies for a hydro-dominated power system via stochastic optimization—ScienceDirect* [Scopus]. Applied Energy. https://www.sciencedirect.com/science/article/abs/pii/S0306261918315915?dgcid=rss_sd_all

Omar J.Guerraa1Diego A.TejadabGintaras V.Reklaitisa. (2019). *Climate change impacts and adaptation strategies for a hydro-dominated power system via stochastic optimization—ScienceDirect* [Science Direct]. Applied Energy. https://www.sciencedirect.com/science/article/abs/pii/S0306261918315915?dgcid=rss_sd_all

Rockson SaiBoqiang Lin. (2022). *Productivity assessment of power generation in Kenya: What are the impacts? | Elsevier Enhanced Reader* [Elsevier]. Energy. https://doi.org/10.1016/j.energy.2022.124200

Sofia Olsén Jonsson Cornelius Peterson. (2022). *Energy storage for peak shaving: Case study for the distribution grid in Björnarbo* [Digitala Vetenskapliga Arkivet]. Uppsala University, Disciplinary Domain of Science and Technology, Technology, Department of Civil and Industrial Engineering. https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1672417&dswid=-7449

The World Bank. (2022). *Operation and Maintenance Strategies for Hydropower: Handbook for Practitioners and Decision Makers* [Text/HTML]. World Bank. https://www.worldbank.org/en/topic/energy/publication/operation-and-maintenance-strategies-for-hydropower

Willis Owino Ochieng , & 1 Christopher Oludhe,1 Simeon Dulo,2 and Lydia Olaka1. (2022). *Climate Change Adaptation Strategies for Hydropower Development in Sondu Miriu Basin* [Hindawi Advances in Meteorology Volume 2022, Article ID 6485960, 11 pages https://doi.org/10.1155/2022/6485960]. Research Article Climate Change Adaptation Strategies for Hydropower Development in Sondu Miriu Basin. https://www.hindawi.com/journals/amete/2022/6485960/