

The Role of Renewable Energy in Enhancing Climate Smart Agriculture in Nigeria

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ABSTRACT

The integration of renewable energy sources in agriculture has emerged as an innovative strategy to enhance climate-smart agriculture in Nigeria. The adoption of renewable energy technologies, such as solar power, wind energy, and biogas, offers opportunities to mitigate greenhouse gas emissions, reduce reliance on fossil fuels, and improve energy access for rural farmers. By harnessing renewable energy, farmers can enhance irrigation systems, mechanize farming operations, and implement precision agriculture techniques, leading to increased productivity and resilience to climate change impacts. Through literature review and participant observation, this study identifies the role of renewable energy in enhancing climate smart agriculture in Nigeria. This study also highlights the potential benefits and challenges associated with the integration of renewable energy in agriculture and emphasizes the need for supportive policies, capacity building, and investment to scale up renewable energy solutions in the Nigerian agricultural sector.

Keywords: Agriculture, Climate Smart, Education, Renewable Energy, Sustainable Development

Introduction

Climate change is a global challenge which is affecting Nigeria's agricultural sector in a profound way. Thus, there is great need to educate farmers in Nigeria especially in the rural areas on climate change adaptation strategies for sustainable development [1]. Researchers have identified the impacts of climate change on soil fertility which calls for improvement in the soil fertility management practices in Nigeria [2]. Researchers have also identified the impacts of climate change on crop production in Nigeria. They further highlighted the processes, mechanisms and traits that will ensure future sustainability of crop quality and yield in Nigeria [3]. Researchers have also identified the impacts of climate change on poultry production and sustainable economic growth in Nigeria [4,5]. This highlights the great need for environmental education and green entrepreneurship education for enhancing climate resilience in Nigeria [6,7]. There is great need for communities, cities, campuses and companies across

Nigeria to understand and maximize the green entrepreneurial opportunities in the use of renewable energy for sustainable development in Nigeria [8]. Climate change is a major threat to Nigerian agriculture, affecting both subsistence and commercial farming. Rainfall patterns are changing, with longer and shorter periods of rainfall. In the north, declining rainfall is causing desertification. Rising temperatures are disrupting growth cycles and increasing water stress. The frequency of extreme weather events is increasing, including floods, droughts, and severe storms. Rainfall and temperature fluctuations increase the severity and occurrence of plant diseases and insect outbreaks. The shrinking size and water-holding capacity of Lake Chad is a challenge. Crops also require more water. The length and onset of the farming season is uncertain. Crop yields, farm profits, and agricultural employment are likely to decrease. However, Some measures that can be taken to mitigate the effects of climate change on agriculture in Nigeria include: Using irrigation, Cover cropping, Planting hybrid crops, and Cloud seeding. The innovative use of renewable energy is one of the climate change mitigation strategies for sustainable development in Nigeria.

Renewable energy will also help in advancing climate smart agriculture in Nigeria. This study vividly identifies the role of renewable energy in enhancing climate smart agriculture for sustainable development in Nigeria.

Materials and Methodology

Data used for this study is derived from literature review of published works including academic articles, journals, conference papers, textbooks and internet materials. The researchers gathered much materials for the research but summarized the characteristics that centered more on “The Role of Renewable Energy in Enhancing Climate Smart Agriculture in Nigeria”. This enabled the researchers to generate the synthesis of various researchers’ views on the subject matter.

Result and Discussion

A 2023 study published in the Journal of Agriculture and Crops examined the impact of renewable energy on farm productivity in South-South Nigeria [9]. Another study identified solar and biomass as the most prevalent renewable energy resources in Nigeria. The study also discussed the challenges associated with implementing renewable energy in Nigeria, such as policy hurdles and ineffective grid integration [10]. Nigeria's Renewable Energy Master Plan (REMP) aims to increase the supply of renewable electricity from 13% in 2015 to 36% by 2030 [11]. In recent years, the intersection of renewable energy and agriculture has gained significant attention as a promising approach to address the challenges of climate change and food insecurity. Nigeria, like many other developing countries, is increasingly recognizing the importance of integrating renewable energy technologies into its agricultural practices to enhance sustainability and resilience in the face of a changing climate [8]. Although small-scale subsistence agriculture is a minor contributor to climate change, the impacts that climate change has on it become increasingly visible and understood. Without proper adaptation, these negative impacts will lead to increased numbers of undernourished people [12]. The reason why small-scale farming systems are highly susceptible to climate change and variability is that they are predominantly rainfed and climate dependent [13]. Looking at the pivotal role that renewable energy plays in advancing climate-smart agriculture in Nigeria, focusing on the opportunities and benefits it offers to farmers, the environment, and the economy is very important. By leveraging renewable energy sources such as solar, wind, and biomass, Nigerian farmers can not only reduce their carbon footprint but also improve their productivity, reduce operational costs, and adapt to climate variability. The stage for a comprehensive exploration of how renewable energy can revolutionize agricultural practices in Nigeria, contribute to a more sustainable and climate-resilient future for the country's agricultural sector is overemphasized. Renewable energy can be used in agriculture in many ways, including: Pumping water for irrigation and Drying food to increase its shelf life. Renewable energy can help overcome problems associated with fossil fuels, such as rising costs, diminishing fossil fuel reserves, and negative environmental impacts.

Understanding Climate Smart Agriculture

Smart agriculture, also known as precision agriculture or digital agriculture, refers to the use of modern technologies, data analytics, and innovative practices to optimize agricultural

production, improve efficiency, and enhance sustainability in farming operations. Smart agriculture integrates information and communication technologies (ICT), sensors, drones, GPS technology, artificial intelligence, and automation to monitor, manage, and control various aspects of agricultural processes. By leveraging real-time data and advanced analytics, smart agriculture enables farmers to make informed decisions, optimize resource use, minimize environmental impact, and increase productivity. This approach allows for precise and targeted application of inputs such as water, fertilizers, and pesticides, leading to improved crop yields, reduced costs, and enhanced resilience to climate change and other challenges in agriculture. Smart agriculture represents a transformative shift towards more efficient, sustainable, and technology-driven farming practices that aim to meet the growing demand for food while minimizing the negative impacts on the environment.

Climate-smart agriculture is derived from the acronym SMART, where S stands for specific, M stands for measureable, A for achievable, R for reliable and T for timely [14]. Climate Smart Agriculture (CSA) is an approach to farming that aims to increase productivity and resilience while reducing greenhouse gas emissions. CSA involves practices and policies that increase agricultural productivity, adapt and build resilience to climate change, mitigate. CSA strategies may include crop diversification, improved water management, agroforestry, conservation agriculture, integrated pest management, and the use of climate information services to inform agricultural decisions. The goal is to create sustainable agricultural systems that can thrive in the face of climate challenges. Climate-smart agriculture (CSA) is one approach that has been championed as the “holy grail” of agricultural development, ensuring that climate smart agriculture is key to climate change adaptation and mitigation [15-17]. According to the Food and Agriculture Organization (FAO), CSA is a method of agriculture that sustainably increases productivity and climate resilience while enhancing the achievement of national food security and sustainable development goals [18]. There are three main pillars to any CSA approach: the sustainable increase in agricultural productivity and incomes; adapting and building resilience to climate change; and reducing and/or removing greenhouse gases emissions. As such, agriculture is considered to be “climate-smart” when it achieves these three objectives. This concept is therefore a good way to unite the agendas of agriculture, development and climate change under one brand [19]. has been championed as the “holy grail” of agriculture As such, agriculture is considered to be “climate-Nigeria, a predominantly agricultural country (70% of its population are engaged in farming) with a largely subsistence- based agricultural sector (88.4% are small holders) and a very rapidly growing population [20,21]. Nigeria is one of the eight countries in the world that will concentrate more than half of the increase in world population projected by 2050 [21]. Indeed, Nigeria’s population, among the ten largest in the world, is expected to become the third largest in the world by 2050, resulting in further pressure on the farming sector and natural resources [22]. Climate Smart Agriculture in Nigeria is gaining momentum as the country seeks innovative solutions to address the challenges faced by its agricultural sector. With a growing population, changing climate patterns, and limited resources, the adoption of smart agriculture practices is becoming increasingly important to enhance productivity, sustainability, and resilience

in Nigerian farming. In Nigeria, climate smart agriculture initiatives are leveraging technology such as precision farming, IoT (Internet of Things), drones, satellite imagery, and data analytics to optimize agricultural processes. These technologies enable farmers to monitor soil conditions, crop health, and weather patterns in real-time, allowing for precise decision-making and resource management. For example, IoT sensors can be used to monitor soil moisture levels and automate irrigation systems, ensuring efficient water use and improved crop yields. The use of drones and satellite imagery provides farmers with valuable insights into crop health, pest infestations, and field mapping, enabling early detection of issues and targeted interventions. This data-driven approach helps farmers optimize input use, reduce waste, and increase profitability. Climate Smart agriculture practices in Nigeria also encompass digital platforms and mobile applications that provide farmers with access to market information, weather forecasts, agricultural best practices, and financial services. These digital tools empower farmers to make informed decisions, connect with buyers, and improve their overall efficiency and competitiveness in the market. Climate-Smart Agriculture presents a transformative pathway for Nigeria's agricultural sector in several key ways

Enhancing Productivity

Developing and distributing drought-resistant and high-yield crop varieties help maintain and boost agricultural productivity despite changing climate conditions. Efficient farming techniques such as precision farming and conservation agriculture increase efficiency, reduce input costs and maximize outputs.

Building Resilience

Crop diversification reduces the risk of total crop failure due to climate extremes and pests. By implementing water-saving technologies and efficient irrigation systems and ensuring reliable water supply even during droughts will help build resilience.

Reducing Greenhouse Gas Emissions

Practices like agroforestry and reduced tillage improve soil carbon sequestration and reduce emissions from land-use changes. Also enhancing feeding practices and waste management in livestock systems lowers methane emissions.

Strengthening Food Security

By increasing productivity and resilience, CSA ensures a stable food supply, thus enhancing food security at the household and national levels. Better storage and processing facilities reduce food losses and waste, ensuring more produce reaches the market.

Economic Benefits

Higher productivity and better market access improve incomes for smallholder farmers, reducing poverty. Adoption of new technologies and practices can create jobs in agricultural services, research, and extension which also improves economic benefit.

Policy and Institutional Support

Enabling environment policies that promote CSA, such as subsidies for sustainable practices and investment in research, provide a conducive environment for transformation. Access

to climate insurance and credit facilities helps farmers manage risks and invest in CSA technologies.

Community Engagement

Training and knowledge dissemination empower farmers with the skills needed to adopt CSA practices. Engaging communities in planning and implementation also ensures that CSA interventions are context-specific and widely accepted. Also to promote the adoption of climate-smart agriculture practices, farmer education and capacity-building initiatives are crucial. Training programs, knowledge-sharing platforms, and farmer field schools help disseminate information on sustainable farming techniques, weather forecasting, and climate risk management. Empowering farmers with knowledge and skills strengthens their resilience and facilitates the wider adoption of climate - smart agriculture across Nigeria.

Environmental Benefits

CSA practices that promote biodiversity, such as agroforestry, enhance ecosystem services and resilience should be encouraged and also conservation agriculture and organic farming that improve soil structure and fertility, leading to more sustainable land use should be implemented to enhance environmental benefits. By incorporating these strategies, CSA helps make Nigeria's agricultural sector more sustainable, productive, and resilient to climate change.

Health Benefits

Researchers have also identified the health benefits in the innovative use of renewable energy sources for enhancing climate smart agriculture in Nigeria [23].

The Role of Renewable Energy in Enhancing Climate Smart Agriculture

On the other hand, the role of renewable energy in enhancing Climate-Smart Agriculture (CSA) in Nigeria can never be ignored. The following are various roles played by renewable energy:

i). Powering Irrigation Systems

By providing reliable and sustainable water supply for irrigation through solar powered pumps reduces dependence on erratic power grids or expensive diesel generators.

ii). Supporting Processing and Storage

Using solar energy for drying crops and cooling storage facilities reduces post-harvest losses and preserves food quality.

iii). Enabling Off-Grid Solutions

Bringing electricity through micro-grids and solar home systems to remote farming areas, powering agricultural equipment improves overall productivity.

iv). Reducing Operational Costs

Lowering the cost of energy for farmers, makes it more economical to adopt CSA practices and technologies.

v). Reducing Emissions

Using renewable energy sources like solar, wind, and biogas reduces greenhouse gas emissions compared to fossil fuels, contributing to climate mitigation.

vi). Enhancing Livelihoods

Providing reliable energy access that supports agricultural activities, improves living standards, and creates new business opportunities in rural areas.

vii). **Supporting Innovation**

Facilitating the use of advanced agricultural technologies, such as automated irrigation systems and precision farming tools, which rely on consistent and clean energy sources.

Recommendations

The Nigerian government can implement climate-smart agricultural practices in a number of ways, including:

- A). **Educating Farmers:** The government can provide training programs, knowledge-sharing platforms, and farmer field schools to help farmers learn about sustainable farming techniques, weather forecasting, and climate risk management.
- B). **Promoting renewable energy:** The government can encourage the use of renewable energy sources like solar-powered water pumps and biogas digesters to reduce reliance on fossil fuels.
- C). **Distributing subsidized agricultural inputs:** The government can distribute subsidized agricultural inputs to farmers to help them adapt to rainfall variability.
- D). **Implementing policies:** The government can fully implement relevant policies, such as the Benue State Open Grazing Prohibition and Ranches Establishment Law of 2017.
- E). **Establishing information channels:** The government can establish adequate information and communications channels to pass weather forecast information to farmers.
- F). **Considering socio-economic characteristics:** The government can consider the socio-economic characteristics of farmers when making agricultural policies.

Conclusion

Renewable energy is pivotal in advancing Climate-Smart Agriculture (CSA) in Nigeria. This is achieved by powering irrigation systems, processing, and storage facilities, and providing off-grid energy solutions for sustainable development. Renewable energy sources such as solar, wind, and biogas enhance agricultural productivity and resilience [8]. They reduce operational costs and greenhouse gas emissions, contributing to both economic and environmental sustainability. Additionally, reliable access to clean energy supports technological innovation and improves rural livelihoods, creating a more sustainable and resilient agricultural sector [24-27]. Integrating renewable energy in Nigeria can enhance the efficiency, sustainability, and resilience of its agricultural sector, aligning with the goals of Climate-Smart Agriculture Nigeria

References

1. Anabaraonye B, Okafor JC, Hope J. Educating Farmers in Rural Areas on Climate Change Adaptation for Sustainability in Nigeria. In: Leal Filho W. (eds) Handbook of Climate Change Resilience. Springer Cham. 2020.
2. Anabaraonye B, Okafor JC, Ewa BO, Anukwonke CC. The impacts of Climate Change on Soil Fertility in Nigeria. In D. K. Choudhary, A. Mishra, & A. Varma (Eds.), Climate Change and the Microbiome. Soil Biology. 2021. 63: 607-621.
3. Anabaraonye B, Okonkwo U, Ewa BO. The impact of climate change on crop production in Nigeria. International Journal of Research in Civil Engineering and Technology. 2021. 3: 36-39.
4. Anabaraonye B, Onnoghen UN, Orji EI, Olisah NC, Ewa BO. The impacts of climate change on poultry production in Nigeria. Journal of Civil Engineering and Applications. 2024. 5: 20-22.
5. Onnoghen NU, Orji EI, Olisah NC, Anabaraonye B. The impacts of climate change on sustainable economic growth in Nigeria. Journal of Civil Engineering and Applications. 2024. 5: 12-15.
6. Onnoghen UN, Ojong AA, Omang TN, Obibessong V, Asor LJ. Environmental Education: A Potent Tool for the Attainment of Sustainable Development Goals (Good Health and Wellbeing, Clean Water and Sanitation, Affordable and Clean Energy and Sustainable Cities and Communities) in South-South Nigeria. PalArch's Journal of Archaeology of Egypt/Egyptology. 2020. 17: 1198-1210.
7. Anabaraonye B, Okon OE, Ewa BO, Adeniyi TF, Nwobu EA. Green entrepreneurship education for sustainable development in Nigeria. International Journal of Research in Civil Engineering and Technology. 2022. 3: 16-19.
8. Anabaraonye B, Onnoghen NU, Orji EI, Ewa BO, Olisah NC. Disruptive innovation and green entrepreneurial opportunities in the use of renewable energy in Nigeria. International Journal of Research in Civil Engineering and Technology. 2024. 5: 01-04.
9. Ifeoma AA, Enete AA, Bridget AE. Determinant and Impact of Renewable Energy Utilization on Farm Productivity in South-South Nigeria Journal of Agriculture and Crops, Academic Research Publishing Group. 2023. 9: 105-113.
10. Majeed Y, Khan MU, Waseem M, Zahid U, Mahmood F, et al. Renewable energy as an alternative source for energy management in agriculture. Energy Reports. 2023. 10: 344-359.
11. Irena. Nigeria Renewable Energy Master Plan. 2013.
12. IPCC. Climate Change and Land: An IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. 2019. 906.
13. Cohn AS, Newton P, Gil JDB, Kuhl L, Samberg L, et al. small holder agriculture and climate change. Annu Rev Environ Resour. 2017. 42: 347-75.
14. McCarthy N, Winters P, Linares AM, Essam T. Indicators to Assess the Effectiveness of Climate Change Projects. Inter-American Development Bank. Impact Evaluation Guidelines: Technical. 2012. 398: 1-37.
15. Naess LO. Climate-smart agriculture: The new holy grail of agricultural development? Future Agricultures. 2011.
16. Wollenberg E, Higman S, Seeberg-Elverfeldt, C, Neely C, Tapio- Biström ML, et al. Helping Smallholder Farmers Mitigate Climate Change. CCAFS Policy Brief CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. 2012. 5: 1-6.
17. Beddington J, Asaduzzaman M, Clark M, Bremauntz AF, Guillou M, et al. what next for agriculture after Durban. Science. 2012. 335: 289-290.
18. Food and Agriculture Organization. Climate-smart agriculture: Policies, practices and financing for food security, adaptation and mitigation. Food and Agriculture Organisation of the United Nations, Rome, Italy. 2010.
19. Neufeldt H, Jahn M, Campbell BM, Beddington JR, DeClerck F, et al. Beyond climate-smart agriculture: Toward

- safe operating spaces for global food systems. *Agriculture & Food Security*. 2013. 2: 12.
20. Cervigni R, Valentini R, Santini M. Toward climate resilient development in Nigeria. World Bank. 2013.
 21. UN. Department of Economics and Social Affairs, Population Division. *World Population Prospects: summary of Results*. 2022.
 22. UN. Department of Economic and Social Affairs, Population Division. *World Population Prospects*. 2017.
 23. Ajator C, Anabaraonye B, Ewa B. The Health Benefits in the Use of Solar Energy for Sustainable Development in Nigeria. *EC Emergency Medicine and Critical Care*. 2020. 4: 01-06.
 24. CPI. *Landscape of Climate Finance in Nigeria*. Climate Policy Initiative. 2022.
 25. FAO. *The future of food and agriculture- Alternative pathways to 2050*. 2018. 228.
 26. FAO. *Climate -Smart Agriculture in Adamawa state of Nigeria*. Food and Agriculture Organization of the United Nations. 2019.
 27. UNFCCC. *Nigeria's Adaptation Communication to the United Nations Framework Convention on Climate Change*. 2021.