FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 9 No. 6, June, 2025, pp 266 – 273
DOI: https://doi.org/10.33003/fjs-2025-0906-3630

CLIMATE CHANGE, POLICIES AND ADAPTATION FOR A RESILIENT FUTURE IN AGRICULTURE

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ABSTRACT

Biodiversity on planet Earth once existed in harmonious balance. However, agricultural technological advancements have significantly transformed farming practices. Though, these changes have increased efficiency, they have also triggered human activities to contribute to climate change impacts on the global community. These impacts pose significant threats to our planet and food security. Consequently, it is imperative to establish policies and adaptation strategies to address climate change challenges and ensure sustainable climate and food security. This article logically reviews relevant literature, focusing on critical issues and the implications of climate change. The objectives are to propose strategic policies that protect biodiversity, promote technological innovation, and robust adaptation plans to foster a resilient future. The negative impacts of climate change necessitate comprehensive and well-considered responses from nations, because proactive approaches to these challenges have been insufficient, especially in developing nations compared to their developed counterparts. This article therefore logical argues that the world, especially the developing nations urgently need to create effective policies, develop robust adaptation plans, implement practical measures to regulate human activities and excesses at national and local levels and mitigate their adverse effects. More so, they should develop strategic frameworks for managing both biodegradable and non-biodegradable waste. Additionally, Sub-Sahara Africa, where Nigeria belongs to must strategically establish ideological structures that identify the underlying causes of ongoing climate change and assess climate risks. These initiatives should not only provide solutions for a healthier ecosystem and generate revenue to build a resilient future that enhances livelihoods.

Keywords: Adaptation, Mitigation, Policies, Resilient, Strategy

INTRODUCTION

Biodiversity on planet Earth once existed in harmonious balance, but agricultural technological advancements have significantly transformed farming practices. Climate change is a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates. These changes have a broad range of observed effects that are synonymous with the term (National Aeronautics and Space Administration [NASA], 2024). Since the end of the last ice age Climate Change History [CCH] has it that, social activities have disrupted the earth (CCH, 2020), humans have developed tools and machines; and have modified and re-modified the land for multi-purposes for self-benefit and long-term adaptation (Afolabi *et al.,* 2019). As the populations continue to grow the demand for food increases also new technologies rapidly spread across the agricultural sector and continents thus, more and more of the planet's resources are continually being compelled to serving the emanating inhabitants to enable them acclimatize and move on with their innumerable activities.

On one hand, the primary causes of climate change are human activities and excesses that release greenhouse gases at national and local levels into the atmosphere. These activities include burning fossil fuels for energy, which emits carbon dioxide and other pollutants; deforestation, which reduces the Earth's capacity to absorb carbon dioxide; and various agricultural practices that release methane and nitrous oxide. Additionally, these activities enhance the greenhouse effect, leading to rising global temperatures, shifting weather patterns, and creating environmental challenges that impact on the global community. On the other hand, natural processes that contribute to climate change include a diversity of phenomena such as volcanic eruptions, variations in solar radiation, and changes in ocean currents. These processes could result in considerable changes to the Earth's climate system over time, ultimately affecting our food security. As the climate shifts, we may witness altered weather patterns, intensified natural disasters, and disruptions in agricultural production, all of which can jeopardize our ability to reliably nutritious food. For instance, volcanic eruptions can release large amounts of ash and gases into the atmosphere, which can momentarily cool the planet by blocking sunlight, thus preventing sustainable climate and food security. Additionally, fluctuations in solar radiation, caused by natural cycles in the sun's output, can affect global temperatures. Furthermore, shifts in ocean currents can impact heat distribution across the globe, influencing weather patterns and contributing to climate variability. In addition, floods are climatic hazards that have become more frequent and cause severe damage to crop plants due to climate change. The objectives are to propose strategic policies that protect biodiversity, promote technological innovation, and robust adaptation strategies and plans to foster a resilient future.

MATERIALS AND METHODS

The article logically reviews the literature on exploratory and normative approaches to climate change, policies, and adaptation strategies for creating a resilient future in agriculture. It uses secondary data from case studies, technical reports, and articles, employing a qualitative method to uncover insights. For the impact evaluations of rapid and extensive changes to global ecosystems and their effects on human health, the study relies on regional reports and various types of literature for counterfactual analysis (Alvar-beltran *et. al.,* 2021; Clarke *et al.,* 2022; ILO, 2019; IPCC, 2022; OECD, 2024; WHO, 2023). This approach helps identify key issues and explore the implications of climate change,

facilitating the implementation of local, national, and global adaptation strategies.

Impacts of Climate Change on Ecosystems, Weather Patterns, and Human Communities

According IPCC (2022), reports there will be rapid and extensive changes to global ecosystems with unknown and unpredicted climate change impacts on human and ecosystem health. Impacts generally refers to effects on ecosystems and species, lives, livelihoods, health and well-being, economic, social, and cultural assets, services, and infrastructure. Yet, impacts can be adverse or beneficial. The impacts of climate change become increasingly visible and making our earth degenerate. More so, most countries are at risk from the impact of human systems climate change, both now and in the future. There are some direct consequences of climate change which include sea-level rise, extreme weather events, including drought and flooding, increases in temperature leading to wildfires, and high rainfall variability (Clarke *et al.,* 2022). Additionally, the consequences of realized risks on natural and anthropogenic, where risks result from the interactions of climate-related hazards, exposure, biodegradable and non-biodegradable waste and vulnerability due to technological advancement (Organisation for Economic Co-operation and Development [OECD], 2024; Alvar-beltran *et. al.,* 2021).

The technological advances and the challenges posed to our ecosystems in the 21st century is the greatest curse that turn our planet earth into what is known as '*Technological Planet'.* In this technological planet, as a matter of fact, technology developments have given the rise to the internet, therefore, shifts attention to how innovation can be used to aid any process, and check influence effects either positively or negatively. Besides, scientific discovery brought about this digital age, and the technological development in turn impact adaptation which brought about the natural losses herein. Although, the application of advance technologies and scientific knowledge to the environment practically keep us ten years ahead of time, to improve human life or the change and manipulation of the human environment (OECD, 2024; ILO, 2019).

Heat stress is one of the primary causes of weather-related fatalities and can worsen pre-existing conditions such as cardiovascular disease, diabetes, asthma, and mental health issues, and facilitate the transmission of certain infectious diseases. Heatstroke has a high fatality rate: for example, the heatwave that hit Europe in the summer of 2003 resulted in approximately 80,000 deaths (though estimates vary widely), and it is estimated that more than 60,000 heat-related excess deaths occurred in the summer of 2022 in Europe. Extreme heat adversely affects pregnant women by increasing the risk of stillbirth, low birth weight, reduced gestational age, and neo-natal stress. Children, the elderly, and people from lower socio-economic backgrounds are also particularly vulnerable to heat stress. For example, in 2013-2022, heat-related deaths of people older than 65 years increased globally by 85% compared with 1990-2000. Moreover, heatwaves degrade air quality, leading to subsequent impacts on human health, ecosystems, agriculture, and everyday activities (WHO, 2023; OECD, 2024).

Additional direct and indirect health impacts from climate change encompass water-, food-, and vector-borne diseases, fatalities, injuries, shifts in air pollution and allergens, consequences stemming from changes in agricultural production and food insecurity, and implications for conflict. These can be caused by both slow onset events and extreme weather events. For instance, sea-level rise can cause direct fatalities from coastal flooding and pose risks to vital infrastructure such as hospitals, potentially causing knock-on effects and impacting health outcomes even for those who were not initially affected by the event. Meanwhile, droughts reduce water quality and availability and, in extreme cases, can lead to malnutrition. Long-term health impacts caused by particulate matter emissions (PM2.5, PM10) emitted during wildfires include increased respiratory and cardiovascular diseases, neurological and psychological disorders, skin and eye issues, and adverse birth outcomes. Overall, exposure to wildfire smoke alone is responsible for approximately 340,000 premature deaths annually worldwide (WHO, 2023, International Labour Organization [ILO], 2019).

International Agreements and Frameworks on Climate Change

The primary international agreement addressing climate change is the United Nations Framework Convention on Climate Change (UNFCCC), which serves as the foundational framework for global climate action, with key subsequent agreements including the Kyoto Protocol and the Paris Agreement, each building upon the previous one and aiming to progressively strengthen emission reduction commitments and adaptation strategies, though with varying levels of binding targets and participation depending on the agreement; notable aspects include differentiated responsibilities based on countries' development levels, mechanisms for monitoring and reporting, and financial support for developing nations to mitigate and adapt to climate change.

Although there are several existing climate change agreements historically; UNFCCC's (1992) agreement was to stabilize greenhouse gas concentrations in the atmosphere to prevent dangerous anthropogenic interference with the climate system. Develop a structure to establish a general framework for international cooperation, including the principle of "common but differentiated responsibilities" acknowledging the different capabilities of nations. However, this agreement lacks specific emission reduction targets, relying on voluntary commitments from countries. The Kyoto Protocol (1997) agreement was to achieve legally binding emissions reduction targets for developed countries. The concept of emissions trading allows countries to buy and sell emission allowances and establish a commitment period with specific reduction targets for participating countries. However, the Kyoto Protocol was not ratified universally, particularly by major emitters like the United States, and was considered by some to be insufficiently ambitious (Tibni, 2024). The Paris Agreement (2015) was to limit global warming well below 2 degrees Celsius, pursuing efforts to limit it to 1.5 degrees Celsius. The agreement requires all countries to submit Nationally Determined Contributions (NDCs) outlining their emission reduction plans, regular Global Stock takes to assess progress, and a mechanism for providing financial assistance to developing countries. Significantly, it is considered a landmark agreement as it includes commitments from all countries and focuses on adaptation and mitigation strategies. The Paris Agreement has near-universal participation, signifying a strong international commitment to addressing climate change. Also, the NDCs allow countries to set their targets based on their capabilities, promoting ownership and engagement. Besides transparency and accountability, it has set up mechanisms such as the global stock take to provide a platform for reviewing progress and identifying areas for improvement. However, enforcement was a key challenge. Also, mandatory compliance mechanisms and relying on political will to meet commitments were lacking. Based on the current issues

mentioned, the NDCs may not be sufficient to achieve the temperature goals of the Paris Agreement. In addition, due to the funding issues for adaptation and mitigation efforts in developing countries.

Overall, while the international climate change agreements have evolved over time, with the Paris Agreement representing the most comprehensive effort to date, significant challenges remain in achieving substantial emission reductions and adapting to the impacts of climate change, requiring ongoing political commitment and collaboration between nations (United Nations Framework Convention on Climate Change (UNFCCC), 2024)

National and Local Policies to Combat Climate Change

The national policies developed to combat climate change typically emphasize renewable energy sources, including solar and wind power, which are crucial for reducing greenhouse gas emissions. These policies advocate for the installation of solar panels and wind turbines and incentives for individuals and businesses to transition to these cleaner energy sources. Also, to promoting renewables, there is a strong focus on enhancing energy efficiency standards in buildings. This involves implementing rigorous building codes that mandate improvements in insulation, heating, and cooling systems to minimize energy consumption. Carbon pricing mechanisms, such as carbon taxes and cap-and-trade systems, are also integral to these policies. Carbon taxes impose a direct fee on companies based on their carbon emissions, encouraging them to reduce their greenhouse gas output. Cap-and-trade systems spelt out a limit on total emissions and allow companies to trade permits, creating a financial incentive to cut emissions. Furthermore, significant investments are being made in research and development for clean technologies. This includes advancing energy storage solutions, smart grid technology, and innovative carbon capture and storage methods to enhance efficiency and sustainability. In addition, supporting sustainable land use practices is a key focus. The policies promoting reforestation and afforestation would not only help absorb carbon dioxide from the atmosphere but also restore ecosystems and increase biodiversity, contributing to a more resilient environment (The Sustainable Development Goals (SDG) Report, 2023).

Key National Policies

Renewable energy mandates

Setting targets for the percentage of electricity generated from renewable sources like solar and wind power.

Energy efficiency standards

Implementing regulations on appliance and building energy consumption to reduce overall energy demand.

Carbon pricing

By implementing carbon taxes or cap-and-trade systems to incentivize businesses to reduce emissions.

Clean technology investment

By providing financial support for research and development of new clean technologies.

Sustainable land use policies

Promoting responsible land management practices like reforestation and sustainable agriculture.

In contrast, local policies focus on initiatives to improve public transportation, promoting energy-efficient building codes, community-based tree planting programs, and waste reduction strategies. Additionally, these policies advocate the adoption of energy-efficient building codes that mandate environmentally sustainable practices in new construction and renovations. Community-based tree planting programs can be developed to enhance urban green spaces, improve air quality, and foster community engagement. Furthermore, waste reduction strategies can include comprehensive recycling initiatives and educational campaigns to inspire residents to minimize waste and embrace sustainable consumption practices. These focused efforts will contribute to a healthier, more sustainable community overall (SDGs Report, 2023).

Key Local Policies

Public transportation improvement

Investing in public transportation systems like buses, trains, and bike lanes to reduce reliance on cars.

Building codes

Enacting stricter building codes to mandate energy efficiency measures in new construction.

Urban greening

Planting trees in urban areas to improve air quality and mitigate urban heat island effect on the land.

Waste reduction and recycling programmes

Implementing robust waste collection and recycling initiatives to minimize landfill waste.

Community outreach and education

Raising awareness about climate change issues and promoting individual actions to reduce carbon footprint.

Over the past decade, Nigeria has made significant strides in developing several Agricultural Policy Frameworks (APFs) that specifically address the challenges posed by climate change. These frameworks articulate Nigeria's comprehensive and ambitious vision for integrating climate adaptation into all levels of governance and policy-making. In addition to these key policy documents, Nigeria has developed various national frameworks that encompass elements of adaptation and economic development, reflecting a holistic approach to addressing the multifaceted impacts of climate change (Clean Technology Hub, 2021). Through these efforts, Nigeria is positioning itself as a leader in climate resilience, aiming to safeguard its agricultural sector and enhance the livelihoods of its population in the face of climate adversity and wherever possible, reducing and/or removing greenhouse gas effects on the ecosystem (Afolabi *et al.,* 2023).

Table 1: The Key Agricultural Policy Frameworks

S/No	Initiative	Implication
i	The Updated National Adaptation Plan (NAP) Framework	This document provides a strategic roadmap for implementing adaptation measures across various sectors, ensuring resilience against climate impacts.
ii	The National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN)	This plan outlines concrete actions and strategies that local governments and communities can take to adapt to climate change, focusing on building adaptive capacity at grassroots levels.
iii	The Nigeria Climate Change Policy Response and Strategy (NCCPRS)	This policy framework aims to create a harmonized approach to climate change mitigation and adaptation, fostering cooperation between governmental and non-governmental entities.
iv	The Nigeria Climate Change Act (CCA) of 2021	This landmark legislation enshrines climate action into the legal framework of Nigeria, establishing a regulatory environment for climate response initiatives and enhancing accountability in climate governance.
v	The National Climate Change Policy for Nigeria (2021–2030)	This forward-looking policy outlines Nigeria's long-term vision for climate resilience, emphasizing sustainable development practices and the importance of public engagement in climate action.
iv	The National Action Plan on Gender and Climate Change for Nigeria (NAPGCC)	Recognizing the intersection of gender and climate issues, this plan aims to promote gender-responsive approaches to climate action, ensuring that women and marginalized communities are included in decision-making.

(Adapted from Clean Technology Hub, 2021)

India is already grappling with the health consequences of air pollution. The country's emissions are causing poor air quality, ranking low in global air quality assessments. This pollution has substantial economic costs, resulting in a significant loss to India's GDP each year. Practicable actions are taken to mitigate climate change and build resilience in vulnerable communities in India (India School of Public Policy [ISPP], 2023). The actionable steps are implemented to address climate change and strengthen resilience in at-risk communities. The Indian public policies provide a framework for guiding actions and behaviours at the national and local levels to address climate change effectively.

Table 2: Climate Change Framework for Practicable Solution

S/N	Indicators	Solutions
i	Emission reduction targets	Public policies set targets emission reduction for industries, transportation, and energy sectors, by establishing the adoption of cleaner technologies and practices.
ii	Renewable energy promotion	Governments promote renewable energy sources, such as solar, wind, and hydropower, by providing incentives, subsidies, and favourable regulations for renewable energy projects.
iii	Energy efficiency standards	Public policies enforce energy efficiency standards for buildings, appliances, and industrial processes, therefore, reducing energy consumption and greenhouse gas emissions.
iv	Carbon pricing mechanisms	Create financial incentives for businesses to reduce carbon emissions and invest in low-carbon technologies.
v	Afforestation and reforestation	Public policies support afforestation and reforestation initiatives to increase the carbon sink capacity of forests and mitigate climate change impacts.
iv	Climate adaptation plans	Public policies can facilitate the development of climate adaptation plans to help communities prepare for and respond to the impacts of climate change, such as extreme weather events and sea-level rise.
vii	International cooperation	Governments engage in international agreements and partnerships to address climate change on a global scale and share best practices and knowledge.

(*Adapted from Indian School of Public Policies (ISPP), 2023*)

Socio-economic Implications of Climate Change and the Need for Equitable Policies

The implications of climate change on socio-economic cannot be overstressed, disproportionately impacting vulnerable populations, particularly in developing countries, making it crucial to implement equitable policies that address the needs of those most affected and ensure a just transition to a low-carbon future globally (World Bank, 2023). Scholars in Scholars Death (2024); Pienknagura (2024); World Bank (2023), and Nascimento (2021), collectively assert that realizing a low-carbon future demands a comprehensive array of policies. This includes implementing carbon pricing mechanisms, such as carbon taxes, making substantial investments in renewable energy, establishing energy efficiency standards, and creating supportive regulations for low-carbon technologies. Additionally, it is crucial to prioritize a just transition that safeguard vulnerable populations and ensures equitable access to clean energy, particularly in developing countries.

In OECD economies, GDP growth is projected to be modest compared to the robust levels experienced before the pandemic, with an anticipated rate of 1.9% for 2025 and 2026. This reflects a cautious recovery as economies navigate the lingering effects of the pandemic. In non-OECD economies, overall economic growth is projected to maintain a consistent pace similar to current levels, highlighting resilience in these regions. Emerging Asia is poised to remain a pivotal driver of global growth, significantly contributing to the overall economic expansion with its dynamic markets and increasing consumer demand. The forecast underscores the divergent recovery paths of developed and developing economies as they adapt to changing global conditions (OECD, 2024).

On a global scale, GDP growth is expected to increase slightly, rising to 3.3% in 2025 and stabilizing at this rate through 2026 (OECD, 2024). At the national level, poverty rates have declined in most Sub-Saharan African countries, except Mozambique, Cote d´Ivoire and Guinea. However, Sub-Saharan still has the highest proportion of people living

below the poverty line of all world regions (World Bank, 2015). Around one in four people in Sub-Saharan Africa is undernourished, amounting to a quarter of the world's malnourished people (FAO, IFAD and WFP, 2014). Additionally, agricultural production in Sub-Saharan Africa is particularly vulnerable to the effects of climate change, with rainfed agriculture accounting for approximately 96 % of overall crop production (World Bank, 2015).

In the present day, climate change has various impacts, including increased poverty, food insecurity, extreme weather events, displacement and migration, health risks, and economic losses in critical sectors like agriculture. It also places strain on infrastructure. These challenges highlight the urgent need for equitable policies that prioritise both adaptation and mitigation strategies tailored to the specific needs of different regions and communities.

Importance of equitable policies

Vulnerability disparities

The impacts of climate change are not evenly distributed, with marginalized communities, low-income populations, and those living in vulnerable ecosystems experiencing the most severe consequences.

Historical responsibility

Developed countries have historically contributed significantly to greenhouse gas emissions, making it crucial for them to take greater responsibility in addressing climate change and supporting adaptation efforts in developing countries.

Social justice

Equitable policies ensure that climate change mitigation and adaptation measures consider the needs of all communities and do not exacerbate existing inequalities.

Climate Adaptation Strategies

Climate change challenges to adaptation began in the early 1800s when ice ages and other natural changes were first suspected. The natural greenhouse effect was first identified, and other gases collected in the atmosphere affected the insulated Earth, which created more curiosity than concern (CCH, 2020).

Scholars Khalid *et al.* (2025); Clarke *et al.* (2022); Foster *et al.* (2017); FAO (2017), and Global Environment Facility [GEF], (2015), believe climate change will affect the physical and biological characteristics of the continents (GEF, 2015), modifying their ecosystem structure and functioning. The process of direct human activities has also disrupted the natural order of the environment by depopulating and eliminating species and adding harmful chemicals to the air, water, and soil activities that are changing the climate and the structure and function of ecosystems, as well as the biological communities they contain' (GEF, 2015). Climate change adaptation options combine policies, institutions, investments, crop and water management practices and capacity development (Khalid *et al.*, 2025; FAO, 2017).

Several historical case studies have identified climate and adaptation strategies to increase agricultural yields. Adaptation at the local level is usually fast-paced and iterative. Communities adopt several traditional methods specific to their environment to enhance their adaptive capacities and build resilience against climate change. These adaptation practices have continued for decades, notwithstanding, at a small scale. However, there has been a surge in the number and frequency of adaptation practices and initiatives in some agroecological zones due to the increasing impacts of climate change (FAO, 2017).

Research on Community-Based Advisor (CBA) projects and Agroecology partnerships in Nigeria indicates that, despite their limited understanding of national and regional policies, local communities effectively organize participatory adaptation strategies to bolster resilience among smallholder farmers. The findings suggest that these actions can be connected to the objectives outlined in key climate adaptation policy frameworks. The adaptation practices and initiatives observed in these identified communities are primarily shaped by various agroecological zones, indigenous knowledge systems, and socio-cultural values as challenges. Preliminary insights from in-depth studies on these projects reveal that rural communities are motivated by economic, social, and behavioural factors. These findings are drawn from four summarized case studies.

Case I

Climate Smart Backyard Gardening Production for Women CBAs

Changes in weather conditions give rise to variations in temperature, precipitation, wind patterns, cloud cover, and other atmospheric factors, which can impact ecosystems, human activities, and overall environmental conditions with potential effects such as flooding, droughts, storms, heat waves, and changes in plant and animal life depending on the severity and duration of the weather shift in Nigeria. In Northern Nigeria, a training programme on climate-smart backyard gardening production was held for women and individuals with physical disabilities associated with Alliance Green Revolution in Africa [AGRA], NAERLS-CBAs in the Sabon Gari, Giwa, Kudan, Kubau, and Kauru Local Government Areas of Kaduna State. The capacity-building training was to improve the smallholder farmers' skills by introducing them to various vegetable cultivation methods. These approaches are climate-smart, addressing the challenges caused by limited land and water resources in rural and urban areas that encounter difficulties in backyard gardening due to these constraints.

Case II

Capacity Building of Smallholder Sorghum Farmers for Climate Resilience Technologies Promoted by Institute of Agricultural Research in partnership with NAERLS in Kaduna State

The agroecology project partnership in Nigeria is a milestone in building gender-based smallholder sorghum farmers' capacity for climate resilience. This initiative promises to foster sustainable agricultural practices that can significantly impact local livelihoods and the environment. The agroecology project in Nigeria is to encourage smallholder farmers in sorghum planting as ecosystem-friendly innovative measures. Also, to mitigate the devastating impact of climate change and build resilient crops. Strategically, the agroecology partnership project focuses on disseminating climate-resilient sorghum varieties for poverty reduction and nutrition improvement in some villages across selected Local Government Areas in Kaduna State, Nigeria. To improve farmer's output through continuous deployment of improved technologies. Improve sorghum farmers' management skills through participatory capacity building. Additionally, this is to enhance farmers' nutritional status.

Case III

Climate Smart Agriculture Technologies Promoted by AGRA NAERLS in Adopted Villages

Agriculture technologies promoted by AGRA NAERLS in the NAERLS-adopted villages in Nigeria. The major adaptation strategies employed include Maize-Cowpea Relay Cropping, Maize-Soybean Strip Cropping, Zero tillage Maize production, Climate-smart vegetable production, Composting, Screen House vegetable production, Drought tolerant crop varieties, Solar powered irrigation pumping machines, Weather forecasting and prediction and Climate information services.

Case IV

Climate-smart agriculture action plan for Jordan

Jordan's varied agro-climatic conditions necessitate customized strategies to tackle a range of challenges, including changing rainfall patterns, drought spells, frequency of hot days/heat waves, pests and diseases, erosion risk, land degradation, enhanced salination, input supply chain, harvest, storage, packaging, value addition, transportation, retail, consumption, and waste management (Alvar-beltran *et. al.,* 2021). Different agricultural practices were designed for the agroecological zones to mitigate the impacts and increase adaptation to climate change on crop production.

While national adaptation strategies involve high-level planning and policymaking, Nigeria has developed several Adaptation Policy Frameworks (APFs) for climate change over the past decade. These frameworks underscore Nigeria's ambitious plans, actions, goals, and strategies for integrating adaptation across all levels of governance. Some of the key policy documents include the updated National Adaptation Plan (NAP) framework, the National Adaptation Strategy and Plan of Action on Climate Change for Nigeria (NASPA-CCN), the Nigeria Climate Change Policy Response and Strategy (NCCPRS), the Nigeria Climate Change Act (CCA) of 2021, the National Climate Change Policy for Nigeria (2021–2030), the National Action Plan on Gender and Climate Change for Nigeria (NAPGCC), along with other national policy frameworks that incorporate elements of adaptation and economic development plans (Okeke *et al.,* 2023).

A report by Okeke *et al.* (2023), indicates that Nigeria experienced its worst flooding in 2022 since the major floods in 2012. The devastating floods resulted in over 800 fatalities, displaced approximately 1.5 million people, injured 2,407 individuals, and affected a total of 2,504,095 people in the affected areas. According to the Ministry of Humanitarian Affairs, Disaster Management, and Social Development, around 332,237 hectares of farmland were damaged, and more than 200,000 houses with properties were either partially spoilt or destroyed.

An analysis of policy frameworks shows that the Nigerian government has made significant strides in enhancing adaptation actions across thirteen priority sectors, including agriculture, freshwater and coastal resources, fisheries, forests, biodiversity, health, housing, energy, transportation, industry, disaster management, livelihoods, and education. Also, there are key documents such as Nigeria's Adaptation Communication to the United Nations Framework Convention on Climate Change (UNFCCC) (ADCOM), NASPA-CCN, the NAP framework, and NCCPRS that outline structured strategies and action plans for these sectors. The planning process involves various stakeholders, including federal, state, and local governments, the private sector, civil society organizations, households, and international entities (Okeke *et al.,* 2023). Additionally, effective climate adaptation strategies employed by the Nigerian government include capacity building and community-based adaptation, Nigerian Meteorological Agency (NiMet) early warning systems, agriculture and coastal protection, finance, policy and governance and Gender Responsiveness with a strong focus on local knowledge and participation across the agricultural sector.

Effective Climate Adaptation Strategies

Capacity building and community-based adaptation

The Federal Government of Nigeria (FGN), through the Ministry of Agriculture and Rural Development, leads initiatives by supporting institutions and agencies that collaborate with States and Local Governments to enhance community capacity skills, and awareness on the use of weather information. The FGN and many local and international Civil Society Organizations (CSOs) such as AGRA/NAERLS use a "Training the Trainers" approach with extension workers.

Nigerian Meteorological Agency (NiMet) early warning systems

The Federal Government of Nigeria (FGN) has improved its climate change adaptability through the World Bank-supported Nigeria Erosion and Watershed Management Project. This initiative has installed automated flood warning systems and monitoring devices in over ten states to help mitigate flood-related disasters.

Agriculture and coastal protection

Nigeria's Climate-Smart Agriculture integrates sustainable productivity and resilience, focusing mainly on seed improvement and hybridization, water Management, community-based initiatives for sustainable land use, coastal erosion control, mangrove structures restoration and protection.

Finance, policy and governance

Nigeria recognizes the need for equitable financing to address climate change, currently losing about 5% of its GDP per capita due to its impacts, a figure projected to increase to 30% by 2050. The Federal Ministry of Environment states that Nigeria will require approximately USD 142 billion (EUR 133 billion) in the next decade to implement its Nationally Determined Contributions (NDC). The government issues Green Bonds to fund climate initiatives. Also, implementing the National Adaptation Plan (NAP) through inter-ministerial coordination and developing policies for sustainable climate-smart agriculture.

Gender Responsiveness

To promote gender mainstream, the Nigerian government has signed several UN treaties, including the Convention on the Elimination of All Forms of Discrimination Against Women. It has also developed the National Gender Policy and the National Action Plan on Gender and Climate Change (NAPGCC) to address inequalities affecting women and youths.

CONCLUSION

Climate change has a profound impact on biodiversity, agricultural productivity, economies, rural livelihoods, and food access. These consequences are increasingly apparent and disproportionately affect marginalized communities, low-income populations, and those residing in vulnerable

ecosystems. To effectively tackle climate change, the following recommendations were made:
Firstly, implement equitable policies that recognize the varying vulnerabilities of different populations, ensuring a just transition to a low-carbon future and prioritizing the needs of those most affected, particularly in developing countries. Also, develop policies aimed at enhancing the resilience of individuals, economies, and ecosystems while striving for net-zero greenhouse gas emissions by 2050. Furthermore, establish robust adaptation strategies to alleviate the adverse effects of climate change on communities and ecosystems, ensuring that these strategies are communicated clearly and implemented practically for a sustainable future. In addition, provide funding to developing countries for renewable energy initiatives and resilient infrastructure while also facilitating the transition to low-carbon economies and strengthening community-based decision-making in climate policy. By implementing these measures, it is possible to mitigate the negative impacts of climate change and build sustainable adaptation for a resilient future in agriculture.

REFERENCES

Afolabi, E. A. (2019). New media for effective communication in extension: communication channels in extension services. *Paper presented at the In-house Seminar Series. National Agricultural Extension Review,* (3). ISSN2672-4847

Afolabi, E. A., Atala, T. K., Akpoko, J. G., & Oladimeji, Y. U. (2023). Implications of digital divide in digitalization of farming activities in the NAERLS Adopted Villages. *FARA Research Report,* 7(9),70-79. https://doi.org/10.59101/frr072309

Adom, P. K. (2024). The socioeconomic impact of climate change in developing countries over the next decades: A literature survey. *Heliyon*, 10(15), e35134. https://doi.org/10.1016/j.heliyon.2024.e35134

Adom, P. K. (2024). The socioeconomic impact of climate change in developing countries in the next decades: A Review. *CGD Working Paper 681*. Washington, DC: Center for Global Development. https://www.cgdev.org/publication/socioeconomic-impact-climate-change-developing-countries-next-decades-review

Alvar-Beltrán, J., Elbaroudi, I., Gialletti, A., Heureux, A., Neretin, L., & Soldan, R. (2021). Climate resilient practices: typology and guiding material for climate risk screening. Rome, FAO. https://openknowledge.fao.org/items/defb13cd-37b2-4486-8225-e61a734cb34f

Bolan, S., Padhye, L. P., Jasemizad, T., Govarthanan, M., Karmegam, N., Wijesekara, H., Amarasiri, D., Hou, D., Zhou, P., Biswal, B. K., Balasubramanian, R., Wang, H., Siddique, K. H., Rinklebe, J., Kirkham, M., & Bolan, N. (2024). Impacts of climate change on the fate of contaminants through extreme weather events. *Science of The Total Environment,* 909, 168388. https://doi.org/10.1016/j.scitotenv.2023.168388

Clean Technology Hub. (2021). National climate change policy for Nigeria. National Environment, Department of Climate Change. https://cleantechnologyhub.com/wp-content/uploads/2023/06/ECA-Policy-Guide-12.pdf

Death, C. (2024). Narrating transitions to low carbon futures: the role of long-term strategies (LTS) in fossil fuel producing emerging economies. *New Political Economy,* 29(4), 628–645. https://doi.org/10.1080/13563467.2024.2317704

FAO. (2017). Climate Smart Agriculture Sourcebook. https://www.fao.org/climate-smart-agriculture-sourcebook/concept/module- a1introducingcsa/chapter-a1-3/en/.

Foster, G., Royer, D., & Lunt. D. (2017). Future climate forcing potentially without precedent in the last 420 million years. *Nat Commun*, 8(14845). https://rdcu.be/eqXZt https://www.nature.com/articles/ncomms14845

Framework Convention on Climate Change. (nd). Evaluating the socio-economic and environmental impacts of climate change in Northern East of Nigeria. https://unfccc.int/sites/default/files/resource/Proposal_ASABE%20SHEHU%20YAR%27ADUA%20FOUNDATION%20%28ASYARFS%29_0.pdf

Indian School of Public Policy (ISPP). (2023). Can public policies help in combating climate change. https://www.ispp.org.in/can-public-policies-help-in-combating-climate-changes/

Khalid, J. M., Ibrahim, R.W., & Molyneux, N. (2025). Part 1: Climate-smart agriculture practices compendium – Climate-smart farmer field school curriculum. Amman, FAO. https://doi.org/10.4060/cd3483en

Levy, B. S., & Patz, J. A. (2015). Climate Change, Human Rights, and Social Justice. *Annals of Global Health,* 81(3), 310-322. https://doi.org/10.1016/j.aogh.2015.08.008

Maizland, L., & Fong, C. (2025). Global climate agreements: Successes and failures. https://www.cfr.org/backgrounder/paris-global-climate-change-agreements

Nascimento, L. (2021). Twenty years of climate policy: G20 coverage and gaps, climate policy, (22), 158174. https://newclimate.org/resources/publications/twenty-years-of-climate-policy-g20-coverage-and-gaps

National Aeronautics and Space Administration (NASA). (2024). What Is Climate Change? https://science.nasa.gov/climate-change/what-is-climate-change/

OECD (2024). *OECD, Economic Outlook*, (2), 116. OECD Publishing, Paris. https://doi.org/10.1787/d8814e8b-en.

Okeke, C., U., Butu, H., M., & Okereke, C. (2023). Climate action strategies, practices and initiatives: Challenges and opportunities for Locally-Led adaptation in Nigeria. *Short Analysis*.APRI: Berlin, Germany. www.afripoli.org

Pienknagura, S. (2024). Trade in low carbon technologies: The role of climate and trade policies," *IMF working paper. No. WP/2024/075*. Pp 1-26. https://ideas.repec.org/d/imfffus.html

Tibni, H. (2024). Assessing the effectiveness of the 10 United Nations global and multilateral climate treaties. International Environmental Agreements (IEAs). *European Journal of Development Studies,* 4(4), 41–55. https://www.ej-develop.org/index.php/ejdevelop/article/view/366

United Nations. (1992). United Nations framework convention on climate change. https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf

World Bank. (2021). Climate-smart agriculture action plan for Jordan., 2nd (ed). Ministry of Agriculture and Ministry of Environment of the Hashemite Kingdom of Jordan and Partnership for Market Readiness (PMR). World Bank, Washington, DC. https://documents1.worldbank.org/curated/en/099105005092240188/pdf/P16068202548b20c10b2940571353a64afa.pdf

World Bank. (2023). Reality check: Lessons from 25 policies advancing a low-carbon future. The World Bank. https://doi.org/10.1596/978-1-4648-1996-4