

# Adapting to environmental changes and climate impacts in rural communities: A comprehensive review

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**ABSTRACT:** The Earth's climate is ever-evolving. The detected warming aligns with the anticipated impacts of greenhouse gases released by human activities. Seventy per cent of the global impoverished population resides in rural regions, and rural livelihoods are particularly susceptible to climate change. The effects of climate change on rural populations are detrimental. Nonetheless, certain effects may also be beneficial. This review highlights the strategies rural communities adopt to mitigate and adapt to changing environmental conditions, focusing on agricultural practices, water resource management, livelihood diversification, community resilience, and traditional knowledge. Rural communities rely on these adaptation strategies to cope with increasingly frequent extreme weather events, such as droughts, floods, and unpredictable rainfall patterns, which significantly affect agriculture and food security. The study examines how these adaptation responses are influenced by socioeconomic factors, government policies, and local capacities. Moreover, the study integrates Resilience Theory, CBA Theory, and SES Theory to examine adaptation. These theories emphasise absorbing shocks, leveraging local knowledge, and balancing human-ecological systems for sustainable resilience. By employing a mixed-methods approach, incorporating both qualitative and quantitative data collection, the study draws on case studies from various rural contexts to identify patterns and commonalities in adaptation strategies. Qualitative data from existing studies provide insights into community perceptions, local practices, and traditional knowledge. Meanwhile, quantitative data collected through surveys enable a broader assessment of adaptation practices and the extent of climate impacts. This approach allows for a nuanced understanding of the factors driving adaptive behaviour and the barriers faced by rural communities in achieving sustainable responses. The findings underscore the need for policies that integrate local knowledge and address specific vulnerabilities of rural areas. They also highlight the importance of community-based strategies in enhancing resilience and promoting sustainable development in the face of environmental change.

**Keywords:** Climate change, adaptation, strategies, resilience, rural, traditional.

## INTRODUCTION

Climate change has become an undeniable driver of environmental, economic, and social transformation globally, and its impacts are particularly acute in rural regions due to their reliance on climate-sensitive sectors like agriculture and natural resource management. The

Intergovernmental Panel on Climate Change (IPCC) notes that rural areas are experiencing significant temperature increases and more extreme weather events, which destabilize rural economies dependent on consistent seasonal patterns (IPCC, 2021a). The National Climate

Assessment further highlights that U.S. rural areas face intensified crop yield declines, disrupted water supplies, and heightened risks of wildfires and droughts, creating "cascading impacts" on both local and national scales (NCA, 2018).

In developing countries such as Nigeria, the impacts are even more severe. For example, the UN's 2020 report on displacement linked over 23 million cases of climate-induced migration, primarily from rural areas affected by climate shifts. These changes are particularly pronounced in Sub-Saharan Africa, where fluctuating rainfall and rising temperatures have decreased agricultural productivity, leading to food insecurity and loss of income (Gemenne *et al.*, 2021; World Bank, 2021). Such instability not only affects individual livelihoods but also threatens regional food security, as rural areas are crucial to the food supply for surrounding urban centres (FAO, 2021a).

Given rural areas' fundamental role in food production, it is essential to understand their adaptive responses to climate change. For instance, in the U.S., rural regions contribute over 15% to the GDP through agriculture, forestry, and related industries, demonstrating that rural resilience is pivotal for the economy (USDA, 2018). The Food and Agriculture Organization (FAO) emphasizes that climate resilience strategies in rural regions are essential not only for local stability but also for global food security, especially in developing regions like South Asia and Sub-Saharan Africa, where smallholder farms provide 80% of the food supply (FAO, 2021b).

Understanding rural communities' perceptions of climate change is critical for designing appropriate adaptation strategies. Several studies have shown that rural populations often perceive climate change through the lens of their everyday experiences, such as changes in seasonal rainfall patterns, increases in temperature, and shifts in agricultural productivity (Oyediji *et al.*, 2024). However, the level of awareness and understanding of the global drivers of climate change varies considerably, with many rural residents attributing changes to local environmental factors or spiritual beliefs rather than anthropogenic causes (Nyasimi *et al.*, 2017). Despite these diverse perceptions, rural communities have demonstrated resilience by adopting various adaptation strategies, including modifying planting times, using drought-resistant crops, and developing traditional water conservation techniques. However, these strategies are often limited by a lack of access to scientific knowledge, financial resources, and technology (Deressa *et al.*, 2020; Sennuga *et al.*, 2024; Olaitan *et al.*, 2024).

## Theoretical foundations

This study is premised on the fusion of three fundamentally relevant theories, namely The Climate Resilience Theory, Community Based Adaptation Theory and Socio-

Ecological Systems (SES) Theory. The adaptation of these theories is considered necessary due to their unique relevance to this study and because they conceptualize vulnerability and exposure, adaptive capacity, and, ultimately, feedback mechanisms and transformation. Resilience theory explores the capacity of communities to absorb climate shocks, adapt, and transform in response to environmental stressors. This framework, grounded in both ecological and social sciences, examines how communities can retain their core functions while adapting to new environmental realities (Folke, 2016). The theory distinguishes between absorptive resilience (maintaining stability despite changes), adaptive resilience (incremental adjustments), and transformative resilience (significant structural shifts). For instance, smallholder farmers in Sub-Saharan Africa employ drought-resistant seeds as an adaptive response to increasing temperature extremes (Adger, 2000).

Community-Based Adaptation (CBA) Theory emphasizes the role of local knowledge, social capital, and agency in developing community-driven adaptation measures. Unlike top-down approaches, CBA advocates for engaging communities directly in planning and decision-making, allowing them to leverage indigenous knowledge for context-specific solutions (Ayers and Forsyth, 2009). This approach has been highly effective in areas with recurrent flooding, where community-driven projects like raised houses and flood barriers have minimized impacts. In Bangladesh, CBA initiatives—such as floating gardens during flood season—have improved food security and resilience in rural communities (Ahmed *et al.*, 2017).

Socio-Ecological Systems (SES) Theory, on its path, conceptualizes human communities as part of interconnected ecological systems. According to this theory, adaptive capacity is seen as a balance of social and ecological factors that enable communities to respond flexibly to environmental feedback. It emphasizes the relationship between human activity and ecosystem health, positing that adaptation depends on ecological sustainability (Berkes and Folke, 1998). This interdependence is evident in traditional pastoralist systems, where practices like rotational grazing manage livestock numbers based on available pasture, maintaining both human livelihoods and ecological health (Moritz, 2010; Odoh *et al.*, 2024).

Feedback mechanisms play a crucial role in SES theory, guiding community adjustments based on environmental shifts. For example, rural farming communities experiencing soil degradation may adopt conservation practices, such as crop rotation and minimal tillage, to maintain soil fertility. This adaptability is central to SES theory, stressing that effective adaptation involves integrating social and environmental knowledge for a balanced approach (Folke *et al.*, 2005; Iliyasu *et al.*, 2023).

## RESPONSES TO ENVIRONMENTAL CHALLENGES AND CLIMATIC IMPACTS IN RURAL COMMUNITIES

Adaptation responses, particularly Climate-Smart Agriculture (CSA), are crucial for mitigating climate impact. For example, a CSA initiative in India promotes heat- and drought-tolerant crop varieties and soil conservation practices that help farmers adapt to irregular rainfall. As reported by the World Bank, this CSA approach has reduced vulnerability by 30%, illustrating the importance of climate-responsive agriculture in maintaining food production stability under climate stress (World Bank, 2021). However, it is distressing that many rural communities still face a range of barriers to adaptation, including limited infrastructure, insufficient financial resources, and restricted access to technology. According to the Environmental Protection Agency (EPA), many rural areas in the U.S. have limited transportation and healthcare resources, which lowers their ability to respond effectively to climate impacts (EPA, 2021). This challenge is echoed globally, where lack of funding for adaptation limits rural areas from implementing measures like improved irrigation, drought-resistant crops, and soil management practices (Ameh *et al.*, 2024; Lai-Solarin *et al.*, 2024).

Social and economic factors such as income disparity, education levels, and land ownership also play a significant role. A recent study by the International Fund for Agricultural Development (IFAD) highlights that rural communities with higher education levels and equitable land access have greater adaptive capacity, as they are more likely to adopt sustainable practices (Lipper *et al.*, 2022). In Mexico, for example, a government-supported education initiative that trains farmers in sustainable agricultural techniques has led to a marked increase in local climate resilience, demonstrating the positive impact of targeted support on rural adaptation (Lipper *et al.*, 2022).

Research has shown that the socioeconomic impacts of climate change in rural areas often lead to migration, as individuals move from increasingly uninhabitable rural areas to urban regions in search of stability. In Sub-Saharan Africa, migration due to drought and food scarcity is well-documented. A World Bank report found that climate-driven migration from rural to urban areas has risen by 25% in the last decade, particularly in drought-affected regions of East Africa (World Bank, 2021). In Central America, rural communities in Guatemala and Honduras have similarly experienced increased migration due to fluctuating rainfall and reduced agricultural yields, with families relocating to find employment opportunities (NCA, 2018).

This migration presents challenges for both the rural areas left behind and the urban areas absorbing incoming populations. Rural areas lose a significant portion of their workforce, hindering agricultural productivity and local

economic resilience, while urban centres face infrastructure strain from an influx of migrants. Policies that support climate resilience in rural regions are thus essential to reducing migration pressure and maintaining demographic balance. In adapting to the challenges posed by climate change, Indigenous and traditional knowledge systems have proven to be invaluable, especially in equipping rural communities with adaptive strategies that align with their specific environments. The IPCC recognizes Traditional Ecological Knowledge (TEK) as a critical component of climate adaptation, as it offers sustainable practices tailored to local ecological conditions (IPCC, 2021b). For example, in the Arctic, Inuit communities use traditional knowledge to predict weather patterns and guide subsistence practices, which has enabled them to sustain their livelihoods despite rapidly changing conditions (Berkes, 2007; Lai-Solarin *et al.*, 2024).

In Kenya, Maasai pastoralists rely on indigenous practices to manage resources, such as selective grazing and migration patterns, that have preserved land productivity amid prolonged droughts. This traditional approach has been validated by scientific studies showing that rotational grazing supports soil health and biodiversity (IFAD, 2021). Integrating traditional knowledge into broader adaptation strategies can thus provide scalable models for resilience in rural areas globally.

Similarly, in Nigeria, Indigenous practices like selective grazing and migration patterns are traditional resource management methods employed by pastoralist communities, especially among the Fulani herders, to adapt to environmental variability. Selective grazing involves moving livestock to different grazing areas based on seasonal conditions and grass availability, ensuring that pasturelands are not overgrazed and have time to regenerate. This practice is critical for sustaining the productivity of rangelands and protecting biodiversity, especially during the dry season when resources are scarcer (Blench, 1997).

Migration patterns, also known as transhumance, are equally significant. These seasonal migrations allow herders to access better grazing areas in different regions, thereby optimizing livestock health and productivity. For instance, during the dry season, Fulani herders often migrate southward to access water and greener pastures, while in the rainy season, they return to northern areas where fresh pasture is available. This cyclical movement not only helps manage resources sustainably but also supports the social and economic livelihoods of these communities (Moritz, 2010). These indigenous practices have also proven effective in reducing the environmental impacts of livestock rearing. Studies show that transhumant pastoralism is highly adaptive to the Nigerian Sahel's climate variability, as it allows communities to balance resource use with the ecosystem's regenerative cycles. Such traditional knowledge is increasingly recognized as a valuable component of climate adaptation

strategies (Blench, 2004; FAO, 2021c).

Community-based adaptation (CBA) is another response to environmental changes and climatic impacts. This emphasizes the involvement of local populations in designing and implementing climate resilience strategies. CBA approaches prioritize local knowledge and resources, making them more responsive to specific needs and conditions. In Bangladesh, for example, flood-prone rural communities have introduced floating gardens and elevated housing as part of CBA initiatives to mitigate flood impacts (Ahmed *et al.*, 2017). These initiatives, often facilitated by NGOs and supported by international funding, have proven effective in reducing vulnerability in these communities (Lipper *et al.*, 2022).

Collaborative governance—where local governments, NGOs, and other stakeholders work together—further strengthens CBA. In the U.S., the EPA's "Climate Ready Communities" initiative supports local governments and environmental organizations in rural areas by providing technical assistance for climate adaptation projects like wetland restoration, which both protect biodiversity and help manage flood risk (EPA, 2021). This collaborative approach to governance enhances rural resilience by leveraging diverse resources and expertise.

Climate Policy and Institutional Support are also essential in providing rural communities with the resources needed for adaptation. For instance, the European Union's Common Agricultural Policy (CAP) allocates substantial funds to support climate-smart agricultural practices across rural areas in Europe. CAP funding has supported projects like reforestation, crop rotation, and organic farming, which strengthen the resilience of European rural areas to climate impacts (European Commission, 2020). Similarly, the African Union's Great Green Wall initiative aims to restore degraded land across the Sahel, directly improving rural livelihoods through land rehabilitation and reducing vulnerability to droughts (African Union, 2020). In the U.S., the Farm Bill provides funding for rural conservation programs, supporting practices like cover cropping and reduced tillage that enhance soil health and improves water retention, which are vital in the face of increasing drought risks (USDA, 2018). These policies underscore the importance of institutional support in facilitating climate adaptation at the rural level.

Lastly, technological advancements in agriculture and resource management have proven crucial for rural adaptation. Precision agriculture, which includes GPS-guided equipment and soil monitoring, helps farmers optimize resource use and increase resilience to climatic variability. In India, precision agriculture techniques have enabled farmers to reduce water consumption by 40% and increase crop yields, which is critical for sustaining productivity amid rising temperatures (World Bank, 2021). Mobile technology also bridges information gaps, especially in rural areas. In Kenya, the "M-Farm" platform provides real-time weather forecasts, market information,

and agricultural advice, helping farmers make informed decisions. This use of mobile technology for early warning systems has been transformative in rural Asia, where timely alerts reduce disaster impacts and enhance preparedness (FAO, 2021a).

## **RESPONSES TO CLIMATE CHANGE: CHALLENGES AND LIMITATIONS**

Addressing the responses to environmental changes and climate impacts in rural communities reveals several notable challenges and limitations. These constraints affect the ability of communities to adapt effectively to climate change, hindering resilience and long-term sustainability.

### **Limited access to resources and infrastructure**

Many rural communities lack access to essential resources such as water, energy, transportation, and technology, which hinders adaptive measures. For instance, financial resources are crucial for adopting climate-smart agricultural practices, installing irrigation systems, or building flood defences. However, rural populations often face limited access to credit and capital due to poverty and weak financial markets (World Bank, 2021). In sub-Saharan Africa, for instance, 90% of rural inhabitants rely on rain-fed agriculture, leaving them highly vulnerable to erratic rainfall and droughts (IPCC, 2021a). In Ethiopia, the lack of infrastructure for efficient water management exacerbates the effects of climate-induced droughts, severely affecting agricultural output and food security (World Bank, 2021).

### **Knowledge gaps and limited awareness**

Effective climate adaptation requires knowledge about climate risks, adaptation techniques, and environmental management practices. Rural communities, particularly in developing regions, often lack access to climate information, such as early warning systems or weather forecasts. This limitation prevents them from making informed decisions to safeguard their livelihoods. In rural India, farmers' limited awareness of climate-resilient practices has led to low adoption rates of drought-resistant crops and soil conservation techniques (Tanner and Allouche, 2011). Expanding educational programs could bridge this knowledge gap, but limited funding and reach restrict their effectiveness.

### **Institutional and policy constraints**

In many rural settings, the lack of supportive policies and weak institutional frameworks undermine adaptation efforts

efforts. Government policies on resource management, climate financing, and land use are often centralized, with rural areas receiving inadequate representation and support. Research shows that countries in West Africa, including Niger and Mali, have attempted to decentralize climate adaptation policies. However, the local governments frequently lack the capacity or resources to implement these strategies effectively, resulting in a disconnect between policy and practice on the ground (Boko *et al.*, 2007).

### **Cultural and social barriers**

Cultural beliefs, traditional practices, and social norms can influence how communities perceive and respond to climate change. Some communities are resistant to adopting new practices due to strong ties to tradition or fear of abandoning long-standing methods. For example, in the Sahel Region, pastoralist communities continue traditional grazing practices, which can lead to overgrazing under drought conditions, further degrading soil health. Efforts to introduce sustainable grazing practices often meet resistance due to the deep-rooted cultural significance associated with traditional livestock management (Moritz, 2010).

### **Climate-induced migration and population displacement**

Climate change can result in migration, as people are forced to relocate due to environmental degradation, droughts, and floods. This migration disrupts community cohesion, strains local resources, and complicates adaptation planning in both source and host communities. In Bangladesh, for example, recurrent flooding and river erosion displace thousands yearly, often leading to urban migration. These displaced individuals face challenges such as a lack of employment opportunities, inadequate housing, and limited access to services in urban areas, reducing their resilience (IPCC, 2021b).

### **Dependency on agriculture and natural resources**

Rural communities are heavily dependent on agriculture and natural resources, making them more susceptible to climate impacts such as extreme weather events and shifting growing seasons. This dependency exacerbates vulnerability, as climate events directly affect food security and income stability. Using Kenya region as a case study, prolonged droughts have drastically impacted livestock production and crop yields, reducing income sources and contributing to food insecurity. A lack of alternative income opportunities and limited access to agricultural insurance compounds these issues, leaving communities with minimal safety nets (FAO, 2021a).

### **Inadequate climate finance**

While international funds for climate adaptation exist, accessing these resources remains challenging for rural communities. Factors such as bureaucratic complexities, lack of technical expertise, and inadequate representation in climate finance institutions restrict rural areas from benefiting fully from global climate funding. A good example of this is the Green Climate Fund (GCF). The GCF, established to support climate adaptation and mitigation, has faced criticism for its inaccessibility to rural areas in Africa and Asia. A report by the United Nations (2020) highlights that only a small fraction of the fund reaches vulnerable rural populations due to stringent application processes and administrative delays.

### **Weak coordination among stakeholders**

Adaptation initiatives often require coordination among multiple stakeholders, including local governments, non-governmental organizations (NGOs), and international agencies. However, weak coordination can lead to duplication of efforts, inefficient resource use, and fragmented adaptation strategies. The Disaster Risk Reduction in the Philippines is a good example of this direction. The Philippines faces numerous climate-related hazards, including typhoons and floods. Despite various adaptation projects funded by international donors, a lack of cohesive collaboration between government and community organizations has hindered the effectiveness of these initiatives. This fragmentation often leads to insufficient response capabilities at the community level (UNDRR, 2019).

### **Increased frequency of climate extremes**

The intensification and frequency of extreme climate events, commonly referred to as natural disasters, such as cyclones, floods, and droughts, surpass the adaptive capacity of rural communities. Repeated exposure to such events erodes resilience, depleting natural resources and reducing community capacity to recover. As an example, Southern Mozambique has faced recurrent cyclones, with Cyclone Idai (2019) displacing hundreds of thousands and causing widespread infrastructure damage. Recovery efforts were hindered by subsequent floods, which undermined the community's efforts to rebuild and adapt, highlighting the difficulty of coping with repeated climate shocks (World Bank, 2021).

### **Conclusion**

Environmental changes and climate impacts present profound challenges to rural communities worldwide.

These communities, often heavily reliant on agriculture and natural resources, face unique vulnerabilities due to limited resources, inadequate infrastructure, and minimal access to critical adaptation information and funding. Despite varied responses—such as community-based adaptation initiatives, traditional resource management practices, and attempts at diversification—their adaptive capacity is still constrained by structural, social, and financial limitations. The resilience of rural communities remains fragile, particularly in the face of increasingly severe and frequent climate events, which exacerbate existing vulnerabilities. This overview demonstrates that while adaptation efforts are underway, without substantial and targeted support, rural communities will struggle to withstand the ongoing and future impacts of climate change. Effective adaptation requires integrating local knowledge with scientific expertise, establishing sustainable financial mechanisms, and fostering policies that support resilience-building at the grassroots level.

## Recommendations

To enhance the effectiveness of climate adaptation in rural communities, the following recommendations are crucial:

1. Governments, NGOs, and private investors should develop water systems, renewable energy, and climate-resilient roads through targeted funding and partnerships.
2. NGOs and research centres should deliver localized training, early warning systems, and workshops incorporating local knowledge.
3. Local governments must involve communities in decentralized planning and ensure marginalized groups' representation in climate policies.
4. Global funds and microfinance bodies should simplify funding processes, offer low-interest loans, and educate rural communities on financial resources.
5. Extension agents and NGOs should train farmers in agroecology, crop diversification, and agroforestry to strengthen ecosystems.
6. Governments and migration organizations should restore degraded lands, provide urban support for migrants, and address the root causes of displacement.

## CONFLICT OF INTEREST

The authors declare they have no conflict of interest.

## REFERENCES

Adger, W. N. (2000). Social and ecological resilience: Are they related? *Progress in Human Geography*, 24(3), 347-364.

- African Union (2020). *The Great Green Wall initiative: Restoring Africa's degraded landscapes and transforming millions of lives in the Sahel*. African Union.
- Ahmed, A. U., Mondal, P., & Islam, M. (2017). *Community-based adaptation: An analysis of best practices in the South-western Region of Bangladesh*, Dhaka, CARE Bangladesh. Pp. 1-70. Retrieved from <https://careclimatechange.org/wp-content/uploads/2019/06/Community-Based-Adaptation-An-Analysis-of-Best-Practices-in-the-South-Western-Region-of-Bangladesh.pdf>
- Ameh, D. A., Sennuga, S. O., Bamidele, J., Osho-Lagunju, B., & Abdulahi, R. O. (2023). Linkage behaviour and practices of agencies in the agricultural innovation transfer subsystem in Nigeria: Issues for agricultural extension policy. *Journal of Agriculture and Education Research*, 1(1), 1-6.
- Ayers, J., & Forsyth, T. (2009). Community-based adaptation to climate change: Strengthening resilience through development. *Environment*, 51(4), 22-31.
- Berkes, F. (2007). Community-based conservation in a globalized world. *Proceedings of the National Academy of Sciences*, 104(39), 15188-15193.
- Berkes, F., & Folke, C. (1998). *Linking social and ecological systems: Management practices and social mechanisms for building resilience*. Cambridge University Press.
- Blench, R. (1997). *Aspects of resource conflict in semi-arid Africa*. ODI Natural Resource Perspectives. Overseas Development Institute.
- Blench, R. (2004). *Natural resource conflicts in North-Central Nigeria: A handbook and case studies*. Mandarins Publishing.
- Boko, M., Niang, I., Nyong, A., Vogel, C., Githeko, A., Medany, M., & Yanda, P. (2007). Africa. In *Climate Change: Impacts, Adaptation and Vulnerability* (pp. 433-467). Cambridge University Press.
- Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2020). Determinants of farmers' climate change adaptation strategies: Evidence from rural Ethiopia. *Global Environmental Change*, 19(2), 248-255.
- Environmental Protection Agency (EPA) (2021). *Climate adaptation action plan*. U.S. Environmental Protection Agency. Retrieved from <https://www.epa.gov/system/files/documents/2021-09/epa-climate-adaptation-plan-pdf-version.pdf>
- European Commission (2020). *EU Common Agricultural Policy: Supporting farmers and protecting the environment*. European Commission. Retrieved from [https://agriculture.ec.europa.eu/common-agricultural-policy\\_en](https://agriculture.ec.europa.eu/common-agricultural-policy_en).
- Folke, C. (2016). Resilience (republished). *Ecology and Society*, 21(4), 44-58.
- Food and Agriculture Organization (FAO) (2021a). *Building resilience for food security and nutrition in times of conflict and crisis*. Food and Agriculture Organization.
- Food and Agriculture Organization (FAO) (2021b). *Climate-smart agriculture: Building resilience and sustainability in agriculture*. Retrieved from <https://www.fao.org/climate-smart-agriculture/>
- Food and Agriculture Organization (FAO) (2021c). *Indigenous peoples' food systems: Insights on sustainability and resilience from the front line of climate change*. FAO.
- Iliyasu, H., Sennuga, S. O., Bamidele, J., Osho-Lagunju, B., & Abdulahi, R. O. (2023). A critical review of the impact of climate change on food security in Nigeria: A Vulnerability Assessment, *Merit Research Journal of Agricultural Science and Soil Sciences*, 11(6), 77-87.
- Gemenne, F., Zickgraf, C., Hut, E., & Castillo Betancourt, T.

- (2021). Forced displacement related to the impacts of climate change and disasters. Reference Paper for the 70th Anniversary of the 1951 Refugee Convention. Retrieved from [https://www.unhcr.org/people-forced-to-flee-book/wp-content/uploads/sites/137/2021/10/Franc%CC%A7ois-Gemenne-et-al\\_Forc-displacement-related-to-the-impacts-of-climate-change-and-disasters.pdf](https://www.unhcr.org/people-forced-to-flee-book/wp-content/uploads/sites/137/2021/10/Franc%CC%A7ois-Gemenne-et-al_Forc-displacement-related-to-the-impacts-of-climate-change-and-disasters.pdf).
- Intergovernmental Panel on Climate Change (IPCC) (2021a). *Climate Change 2021: Impacts, Adaptation, and Vulnerability*. Intergovernmental Panel on Climate Change.
- Intergovernmental Panel on Climate Change (IPCC) (2021b). *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. Retrieved from <https://www.ipcc.ch/report/ar6/wg1/>
- Lai-Solarin, W. I., Bamidele, J., Joel, O. J., Abubakar, T. T., Olaitan, M. A., Joel A. F., & Sennuga, S. O. (2024). Challenges and benefits of extension service delivery for dairy cooperatives in Kaduna State, *Journal of Agricultural Extension and Rural Economics*, 1(1), 1-14
- Lipper, L., Cavatassi, R., Symons, R., Gordes, A., & Page, O. (2022). Financing climate adaptation and resilient agricultural livelihoods. International Fund for Agricultural Development. Retrieved from <https://www.ifad.org/documents/48415603/49777885/RS85-formatted-web-v1.pdf/037307be-e800-2051-7ea3-be5a9af864df?t=1726642460067>
- Moritz, M. (2010). Understanding herder-farmer conflicts in West Africa: Outline of a processual approach. *Human Organization*, 69(2), 138-148.
- National Climate Assessment (NCA) (2018). *Impacts, risks, and adaptation in the United States: Fourth National Climate Assessment, Volume II*. U.S. Global Change Research Program. Retrieved from [https://nca2018.globalchange.gov/downloads/NCA4\\_Ch00\\_Front-Matter.pdf](https://nca2018.globalchange.gov/downloads/NCA4_Ch00_Front-Matter.pdf)
- Nyasimi, M., Ringler, C., & Alemu, T. (2017). Evidence of impact: Climate-smart agriculture in Africa. *Agriculture for Development*, 30, 1-12.
- Odoh, P. O., Sennuga, S. O., Bamidele, J., & Ameh, D. A. (2024). Examining disparities and empowering women in ensuring food security in Nigeria: A critical review. *Research Journal of Food Science and Quality Control*, 10(1), 20-36.
- Olaitan, M. A., Bamidele, J., Joel, O. J., Oyediji, B. I., Joel, A. F., & Sennuga, S. O. (2024). Effects of FADAMA III Development Project on Livestock Farmers' Productivity and Food Security Status in Abuja, Nigeria. *Cross Current International Journal of Agriculture and Veterinary Sciences*, 6(3), 73-84
- Oyediji, B. I., Yekinni, T., Sennuga, S. O., & Bamidele, J. (2024). Factor influencing the attitude of poultry farmers towards credit services in South-Western, Nigeria, *African Journal of Agriculture and Allied Sciences*, 4(2), 106-119.
- Sennuga, S. O., Bamidele, J., Joel, O. J., Olaitan, M. A., Joel, A. F. & Raymond, T. (2024). Assessment of the Factors Affecting Smallholder Livestock Farmers' Use of Information and Communication Technologies to Access Market Information in Nasarawa State, Nigeria, *Journal of Veterinary and Biomedical Sciences*, 6(2), 17-27.
- Tanner, T., & Allouche, J. (2011). Towards a new political economy of climate change and development. *IDS Bulletin*, 42(3), 1-14.
- United States Department of Agriculture (USDA) (2018). *The impact of climate change on American agriculture: Farm Bill and rural resilience initiatives*. Retrieved from <https://www.usda.gov/about-usda/general-information/staff-offices/office-chief-economist/office-energy-and-environmental-policy/climate-change/climate-change-adaptation>.
- Walker, B., & Salt, D. (2006). *Resilience thinking: Sustaining ecosystems and people in a changing world*. Island Press.
- World Bank (2021). *Climate resilience and agriculture development project*. World Bank Group. Retrieved from <https://projects.worldbank.org/en/projects-operations/project-detail/P178715>.