



# POLICY BRIEF

## APPLICATION OF CO-CREATION METHOD IN PRIORITIZING ADAPTATION RESEARCH NEEDS IN ACCELERATING LOCALLY-LED SMALLHOLDER AGRICULTURE INTERVENTIONS IN NIGERIA

David Awolala, Elijah Adefisan, Julis Adanlawo, Olajumoke Salako, Richard Balogun, Boluwaji Dada, Mashoko Grey, Jesse DeMaria Kinney, George Wamukoya

## KEY MESSAGES

- User-tailored climate information services provide localized, actionable, and timely climate-related precautionary advisories for smallholder farmers on optimal decisions supporting agricultural risk management based on their unique environmental, geographical, and economic contexts
- Investing in research of local context Climate Smart Agriculture practices specific to different microclimates across the diverse agro-ecological zones can increase farmers' productivity, food security, and agricultural sustainability, transforming into resilience and a long-term economic stability
- Integration of advanced soil-fertility management and efficient irrigation practices can optimize yield and minimizes environmental impacts
- Promotion of co-creation principles will foster collaboration between farmers' groups, researchers, and extension workers to identify interventions and designing innovations that meet local needs in managing climate risks for crops and livestock
- Integrating gender-responsive needs in designing adaptation options will encourage development of women-and youth-friendly lightweight technologies and locally-fabricated tools to optimize agricultural productivity and improve farmers' welfare

# 1.0 INTRODUCTION

## 1.1 Background

Science has studied the relationship between extreme events and climate change. Human activities are profoundly altering the global climate, hence the IPCC Sixth Assessment Report (IPCC-AR6) states with high confidence that human-caused climate change is already affecting many weather and climate extremes in every region across the world with widespread adverse impacts and related losses and damages to nature and people (IPCC, 2023; Awolala, et al, 2022). Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts and tropical cyclones, and specifically their attribution to human influence has been strengthened to provide answers to the extent of how human-induced climate change affected extreme weather events likelihood, intensity and impacts (Otto, 2023; IPCC-AR6). However, huge geographical differences exist which present knowledge gaps especially in the Global South countries in providing information about where the largest damages and socio-economic losses are occurring.

Smallholder farmers are on the frontline of climate change and therefore, adapting to a changing climate is critical. Despite producing a third of the world's food while bearing the brunt of climate change impacts, smallholder farmers receive just 1.7% of global climate finance. The needs for climate adaptation are nowhere more pressing than in the agriculture sector because production of agriculture rely directly on weather and associated biological processes but also the smallholder farmers who are directly involved are also some of the most economically vulnerable in the world. It is estimated that 80% of the poor global population live in rural areas, relying on agricultural production and related activities for their livelihoods (FAO, IFAD, UNICEF, WFP and WHO, 2019). As a result, many agriculture-dependent populations lack the economic resources, and associated access to markets and services, needed to cope with and manage the risks posed by climate change.

Nigeria is a fast growing lower-middle-income country with an economy worth of $362.81 billion in 2023 representing 0.34% of the world economy which makes the country a great regional economic, political significance, and opportunities in Africa (World Bank, 2024). The growing population of over 200 million people amplifies its climate change vulnerability and climate-led systemic disruptions with the potential to greatly impact the African continent. The economy is largely dependent on the primary agricultural producing sector contributing 23.69% of the national Gross Domestic Product (GDP) with a performance increase of 0.18% in 2024. The sector is responsible for 38% of total national employments characterized by limited mechanization. Smallholder farmers are contributing significantly to the country's agricultural sector by producing most of the food consumed domestically, accounting for about 90% of the national agricultural outputs making them the backbone of Nigeria's food supply despite farming on smallholding scattered farmlands.

Despite its important contributions, the sector is facing human insecurity, climate change, and escalating price inflation. Consequently, food inflation reached the unprecedented level of 35.41% in 2024. These challenges could have far-reaching resultant impacts on other sectors and significantly aggravate food insecurity issues. The Nigerian agriculture and food security sector is among the most climate-sensitive sectors. The vulnerability of roots and tuber crops, and pastoral

livestock systems to extreme weather events is very high due to climatic impacts such as droughts, flooding, heatwaves, and abnormal rainfall patterns which makes the matter of smallholder agriculture adaptation an urgent priority (Awolala, et al, 2021).

The most recent Climate Change Vulnerability Index classifies Nigeria as a region of high risk, one of the most vulnerable countries in the world. The frequency and intensity of severe weather events especially the rise in sea levels resulting into coastal inundation and flooding in low-lying regions are expected to increase. Temperature increase has been recurrent over the past three decades with projected increase across all agro-ecological zones. The declining rainfall and rising heat experiences in the North-East and North-West regions have further compounded the aridity, drought, desertification, and biodiversity losses while heavy flooding have led to loss of agricultural investments and infrastructure in the Southwest, and South-East, and South-South regions of Nigeria. **Figure 1** shows the climate change vulnerability index map of Nigeria.

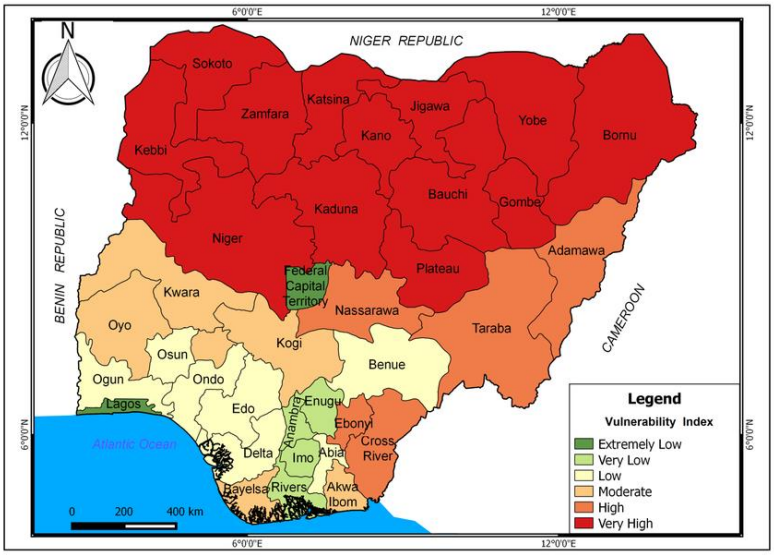

Figure 1. Climate Change Vulnerability Index Map of Nigeria

This policy note highlights key findings about the prioritization of adaptation research for accelerating smallholder agriculture and provides important policy recommendations for action-oriented adaptation research in Nigeria

## 1.2 Projected Extreme Climate Events and Adaptation Policy Frameworks

Recent projections suggested that the impacts of climate change and extreme weather events on smallholder agriculture will be more rapid, impactful, and might be irreversible in some cases not just on people but the species and ecosystems. Rainfed agriculture is facing highest vulnerability due to shifting weather patterns, unpredictable and erratic rainfall patterns such as late onset and/or early cessation of rainfall, increased frequency and/or severity of droughts, and heavy rainfall events which has affected planting and harvesting schedules, crop failures, reduced yields, and food insecurity. Livestock are experiencing heat stress, feed shortages, and the spread of parasites and diseases. In crop plants, heat stress has resulted in yields and quality reduction with expansion of pests and diseases.

Rising temperatures manifest in unequal increase in daily maximum, minimum and mean surface temperatures, negatively impacting crop growth and development due to dehydration and water deficits disrupting growth cycles and increases water stress. Projected annual precipitation shows a tendency to increase in the future with an extension of the very likely ranges of around 150 mm in 2080. Heavy precipitation events are projected to increase in the next decades, as a warmer atmosphere can hold more evaporated water to rain down, increasing the risk of flash floods with potential to destroy farmlands, disrupts natural ecosystems of aquatic animals and fishing activities. Despite these risks, many regions lack the capacity to adequately respond to these risks, therefore policy attention should shift towards enhancing smallholder adaptation to accelerate the pace of progress for a climate resilient agriculture.

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), Nigeria has demonstrated its commitment to addressing climate change and contributing to global efforts to reduce its impacts. A number of policies have been implemented with the objective to enhance productivity and sustain food security by deploying appropriate technologies and good agricultural practices for a rapid value chain improvements. Some of these policies which include the **2023 Nigeria Climate Adaptation Country Compact (NCACC)** guides decision-making and investment in climate adaptation, emphasizing climate-smart agriculture and digital tools for farmers to enhance resilience through scalable practices and accessible advisory services. **The 2022-2027 National Agricultural Technology and Innovation Policy (NATIP)** was designed to promote digital and climate-smart agriculture by enhancing stakeholder capacity in precision and e-agriculture. The policy supports technologies such as remote sensing, artificial intelligence, food blockchain, and e-extension services to increase productivity, reduce greenhouse gas emissions, and equip youths with right technologies for sustainable agriculture, thereby optimizing food systems.

The **2021 Updated Nationally Determined Contribution (NDC)** emphasizes climate-smart agriculture, sustainable land management, and improved irrigation to enhance resilience by promoting low-emission farming practices to boost productivity while reducing environmental impact. The 2021 National Climate Change Policy for Nigeria (NCCP) promotes climate-resilient agriculture, sustainable land use, and early warning systems to enhance adaptation. It supports ecosystem-based approaches and capacity building to mitigate climate risks. The **2020 Climate Change and Gender Action Plan (CCGAP)** highlights the need for gender-responsive adaptation strategies to empower women in climate-resilient agriculture through equal access to resources, technology, and decision-making for sustainable livelihoods. The **2019 REDD+ Strategy** focuses on reducing deforestation and promoting sustainable forest management to enhance climate resilience by supporting ecosystem restoration, biodiversity conservation, and community-based adaptation efforts. The **2018 National Drought Plan** focuses on early warning systems, sustainable water management, and climate-resilient farming to mitigate drought impacts by promoting adaptive strategies to enhance food security and ecosystem sustainability.

Despite significant efforts in translating these policies into action through several agricultural practices and technologies developed to support adaptation among smallholder farmers, partial adoption and dis-adoption are frequently experienced. The cost effectiveness analysis on adaptation practices in Nigerian agriculture shows that effectiveness depends significantly on the possibility of implementing adaptation by exploiting low-cost opportunities which show a positive benefit-cost ratio in all the climate regimes. Understanding the factors driving this phenomenon is

critical to develop more effective climate adaptation interventions. The identified key constraints hindering the adoption and sustained adoption of climate adaptation practices and technologies in the context of smallholder agricultural systems are adoption related costs, low and uncertain benefits of adaptation practices and technologies, and inadequate household resources.

## 2.0 CO-CREATION PROCESS IN DESIGNING ADAPTATION INTERVENTIONS

### 2.1 What is Co-Creation?

Climate adaptation interventions designed at the local level have greater impact to the local communities since the impacts of extreme events are most felt at the local level where the vulnerability and adaptive capacities are context-specific to local circumstances. It becomes imperative to use a multi-stakeholder co-design process to assess smallholder agriculture adaptation priorities for acceleration and scaling up under a changing climate. The co-creative approach to knowledge production to bridge the knowledge-to-practice gap. The co-creation process is an active involvement of stakeholders in the creation of an innovation and product development, where end-users are involved in the design process so that products align with user needs and expectations (Ertz, 2024). The **co-creation approach** is an important shift from the traditional model of development where a product or service is developed and delivered to users, to a more participatory and interactive process, where ideas and feedback from all stakeholders are continuously integrated (Frow et al, 2015). This process often leads to shared ownership, deeper engagement, and stronger relationships between creators and users.

Co-creation or co-production is a collaborative approach where diverse stakeholders, including researchers and non-academic actors, work together to generate knowledge, design solutions, and implement interventions, focusing on user needs and maximizing impact. The users are part of the problems identification at the beginning whereby a locally-led approach involves collation of naturally adaptive strategies of the users alongside the problems. There have been a few of co-creation activities in Nigeria with the relevant stakeholders. One of such is the one organized by the African Science for Weather Information and Forecasting Techniques (African SWIFT – https://africanswift.org/2019/03/26/swift-stakeholder-workshop-on-climate-and-weather-information-services-taking-place-in-nigeria/). It involved all the sectors (agriculture, water resources, communication, health, ecosystems etc) and the agriculturists were of commercial farmers and hence did not cater for the smallholders. A few individual or group/town hall interviews were also carried out and documented in the past Awolala *et al.*, 2022 and Awolala *et al.*, 2023) but have not been able to address the "locally-led co-creation of smallholder agriculture practices in the country in the face of a changing climate". Learning how to co-produce was put together and archived at https://walker.reading.ac.uk/academy/courses/learning-to-co-produce/ (some members of this team were involved). The steps were followed to organized a well-coordinated locally-led co-creation activities for the smallholder agriculture.

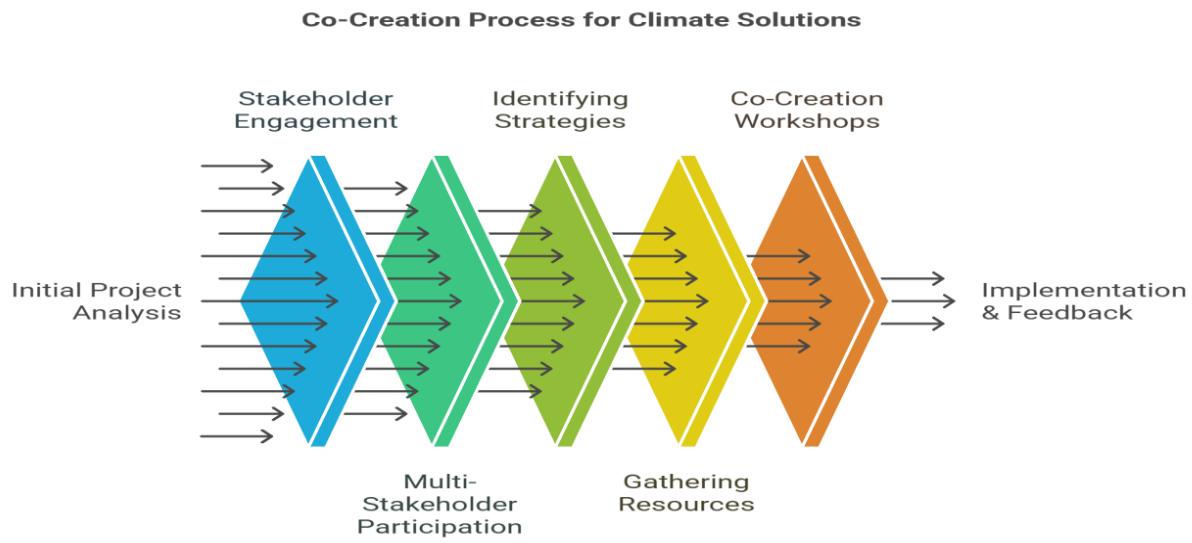


Figure 1: The Co-creation Methodology for Prioritising Adaptation Interventions in Nigeria

## 2.2 Steps in Conducting the Co-Creation

The co-creation process involves active participation of local stakeholders in delivering and designing the services they needed using gender equality and social inclusion strategy to ensure a balanced representation of ideas and the technique in assessing stakeholder feedback.

**Co-Creation Process Flowchart**

Initial Review & Scoping

- Analyze past adaptation projects & lessons learned.
- Identify key themes & gaps.

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Stakeholder Engagement & Inclusion

- Apply gender equality & social inclusion (GESI) strategy.
- Ensure balanced participation of local stakeholders.

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Multi-Stakeholder Participation in Agriculture

- Gather input from farmers, policymakers, researchers, and NGOs.
- Prioritize action-research needs.

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Identifying Scalable Adaptation Strategies

- Focus on locally led solutions for smallholder farmers.
- Consider regional agroecological differences.

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Gathering Research & Resources

- Collect references, case studies, and climate resilience data.
- Use insights to shape workshops and discussions.

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Workshops & Co-Creation Sessions

- Collaborate on designing climate adaptation solutions.
- Assess stakeholder feedback using structured techniques.

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Implementation & Continuous Feedback

- Test, refine, and scale co-created solutions.
- Maintain stakeholder involvement for iterative improvements.

A total of five co-creation workshops were conducted which comprises two national and three sub-national level workshops. The sub-national workshops were strategically distributed across key regions representing diverse geographical, agroecological, and socio-economic contexts for smallholder agriculture in Nigeria. Different methods of engagement were used during the sub-national workshops to ensure inclusive, collaborative, and interactive participation. Expert presentations, breakout groups, plenary sessions, and post-workshop iterations. local perspectives and priorities were used. The sub-national workshops were organized by regions with States grouped. The co-creation approach enable the workshops become more impactful, leveraging the collective expertise and perspectives of participants in generating innovative, actionable solutions that meets their challenges.

## 2.3 Stakeholder Mapping at the Sub-National Levels

The identification and engagement of key multi-stakeholders across various sub-sectors of Nigeria's agriculture were carried out using a stakeholder matrix. This matrix helped to assess stakeholders' levels of influence and interest, and to determine the appropriate degree of involvement for each group. Stakeholders were categorized into four main groups: Government Representatives (extension workers, desk officers on climate change from Ministries of Agriculture and Environment; subject matter specialists; Farmers Representatives (crop/irrigation, livestock, water resources and fisheries farmer groups); Academic/Research Institutions (universities and crop and livestock research institutes; Non-Governmental Organizations (gender empowerment initiatives, adaptation intervention vendors). The Figure 2 illustrates the flow of workshops and intended deliverables produced.

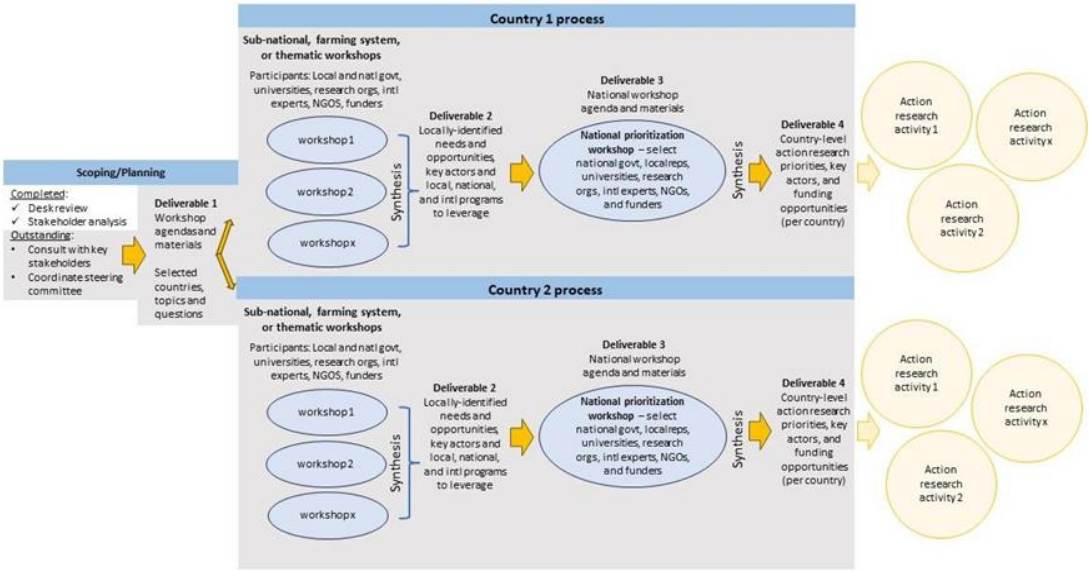


Figure 2: Flow of activities in the sub-national workshops in Nigeria

## 3.0 HIGHLIGHTS FROM THE CO-CREATION PROCESS IN IDENTIFYING ACTION RESEARCH PRIORITIES FOR SMALLHOLDER FARMERS

The co-creation approach is essential in identifying challenges, current practices, knowledge and practice gaps, action research, and research prioritization because it fosters inclusive, participatory, and context-specific solutions tailored to smallholder farmers' needs. Through co-creation, diverse stakeholders—smallholder farmers, researchers, policymakers, extension workers, and non-governmental organizations—collaborate to diagnose pressing agricultural adaptation issues, ensuring that solutions reflect ground realities. This process enhances the relevance of interventions, bridges knowledge-to-practice gaps, and aligns adaptation research with local experiences. By prioritizing action research through participatory engagement, co-creation supports the development of scalable, evidence-based, and farmer-driven solutions that address climate vulnerabilities while fostering ownership and long-term sustainability in agricultural adaptation strategies.

### 3.1 Locally-led Smallholder Adaptations

Locally-led adaptation efforts at the subnational level are designed, implemented, and managed by communities, non-governmental organizations, and local governments. The interventions are tailored to specific climate risks and vulnerabilities while responses highlighted long-standing local practices which reveal vary levels of effectiveness. Some practices were identified as best fit with potential for scaling up while others struggle to withstand the intensifying impacts of climate change. The best practices are provided by sub-sectors.

#### 3.1.1 Crop and Agroforestry

Farmers use these approaches combine traditional wisdom with modern advancements to cope with climate variability, soil degradation, and changing agricultural conditions with the key practices:

- **Creation of water channels to reduce flooding:** Physical structures such as embankments, drainage canals, mini reservoirs or mini earth dams, gutters and downspouts, are used to redirect water and help to drain vulnerable areas.
- **Combination of organic and inorganic fertilizers:** Integrated nutrient management strategies that combine organic and inorganic fertilizers with other agronomic practices, help optimize yields while preserving soil health and environmental integrity. This also effectively inhibited weed growth and nutrient removal.
- **Mulching at the planting stage:** Mulching that reduces soil deterioration by limiting runoff and soil loss increase soil water availability by reducing evaporation, managing soil temperature, or reducing crop irrigation requirements.
- **Early harvest and immediate sun drying**: Sun drying approach were consistently used in an effort to help improve postharvest management of agricultural produce at the smallholder farmer level.

### 3.1.2 Livestock and Fisheries

Local adaptation efforts for livestock and Fisheries help smallholder farmers and pastoralists cope with challenges like climate change, drought, diseases, declining grazing lands and other limited resources. These practices to some extent improve animal health, productivity, and sustainability as presented:

- **Using alternative feed sources like maggot production:** Feather meal, chicken offal meal, and maggot meal are potential alternative animal protein sources because of their availability, high protein contents, and low price.
- **Use of water hyacinth to feed pigs:** Water hyacinth can be used fresh, ensiled, dried, whole, chopped or ground. Fresh forage Water hyacinth is usually chopped and fed directly to animals.
- **Use of cassava root as alternative energy source:** In this process, cassava waste is transformed into briquettes, the combustion of which produces heat. This energy source is then captured to produce electricity. Many states are already practicing it.

### 3.1.3 Water resources and Irrigation

Smallholder farmers in Nigeria rely on irrigation to supplement rainfall, especially during dry seasons or in regions with unpredictable rainfall patterns. Given the high cost of large-scale irrigation infrastructure, farmers use low-cost techniques to maximize water efficiency and crop yields. These irrigation practices vary based on water availability, soil type, crop selection, and financial resources. These methods aim to optimize water use while minimizing labor, cost, and environmental impact. Below are some common irrigation practices used by smallholder farmers in Nigeria:

- **purchase/harvest of water for irrigation:** Using water more efficiently by reducing water losses, improving irrigation practices and recycling or storing water.
- **use of wetlands:** Wetlands can help mitigate the effects of climate change. Wetlands are fertile and have been used for food and fodder production as an adaptation strategy.
- **Use of perforated bottles for drip irrigation system:** Small holder farmers adopted the use of water plastic bottles with specific perforation size and height from the ground level in order to boost production in agriculture.

## 3.2 Emerging Gaps in Scaling Up Agriculture Adaptation

The emerging adaptation gaps identified during the co-creation workshops across different agro-ecological zones in Nigeria are reflections on the major drivers constraining effective uptake of interventions by smallholder farmers. These gaps are disparities between status of implementation of adaptation interventions and actual needs of users in effectively addressing impacts of climate change as categorized into knowledge gap, resource limitation, financing and planning, and other compelling issues.

### 3.2.1 Knowledge and Data for Planning

- **Localized climate data:** Inadequate granular data on climate impacts and attribution evidence is a huge barrier to developing location-specific adaptations, resulting in mis-match in the design
- **Limited evidence of adaptation impacts:** Very few studies have been conducted on the economic and livelihood impacts of adaptation strategies, hence no evidence on the returns to investments, hence hindering uptake
- **Low integration of indigenous knowledge:** There is no functioning framework of incorporating useful indigenous knowledge systems into research and design of adaptation interventions
- **Uncertainty in climate modelling:** Inherent errors in climate modelling and poor studies on extreme weather events and their consequences on crops, livestock, and water resources are major challenge to generate proven evidence to support development of innovations

### 3.2.2 Institutional Coherence

- **Research-policy gap:** Disconnection between academic research and policies implemented by governments or other decision-making bodies is leading to exclusion of valuable research findings in informing policy-making or practice
- **Fragmentation in Policy Implementation:** Weak coordination among the concerned stakeholders, especially government, local institutions, non-government actors, and academic/research institutions resulting in poor enforcement of present climate policies.
- **Poor stakeholder inclusion:** Representation of smallholder farmers, women, youths, and marginalized communities who are mostly affected are not adequately involved in the adaptation planning, decision-making, or implementation processes
- **Insufficient Technical Capacity: Limited training and capacity building** in climate science, engineering, societal impacts, or planning **by** governments, communities, extension workers, and local institutions. This is hampering how to effectively plan, design, and implement context-specific adaptation strategies that recognize local environmental, economic, and social conditions

### 3.2.3 Funding and Investment

- **Low investment in adaptation research and scaling up processes**: Insufficient financial and institutional commitment to expanding solutions that help communities and ecosystems adjust to the impacts of climate change
- **Low private sector engagement:** The mobilization of financial resources by private businesses and entities is scanty and weaker to support adaptation such as climate-smart agriculture compared with mitigation
- **Limited funding to scale up innovation:** Barriers to securing necessary investment to pilot, implement, and scale up innovative adaptation technologies from the research and development stage to wider deployment and on-the-ground implementation. There is no subsidy, tax breaks, and microcredits as incentives for farmers to adopt climate-smart practices.

### 3.2.4 Uptake of Technologies

- **Low adoption rates:** Prioritizing short-term needs over long-term adaptation due to exclusion of local knowledge practices in favour of external solutions that may not be suitable for local context, high costs of implementing adaptation measures without immediate returns on investment, unclear land rights as a major disincentive to invest in long-term adaptation, and lack of access to context-specific climate-smart information
- **Weak extension systems:** Ineffective delivery networks that help deliver knowledge on technologies and innovations to smallholder farmers enabling them to adopt climate adaptation technologies and practices.

- **Digital divide:** Unequal access to digital technologies and information for early warning systems, market information, weather forecasts, and financial services exacerbates vulnerability, limiting the ability of smallholder farmers and marginalized groups to take effective action in response to climate risks.

### 3.3 Emerging Research Priorities for Investment Considerations

Adaptation priorities focus on addressing the most urgent and essential needs to enhance the resilience and sustainability of Nigeria's agricultural sector in the face of climate change. These priorities will guide policy and investment decisions, ensuring the effective allocation of resources for climate resilience. Diverse stakeholders provided insights during co-creation workshop sessions and identified critical gaps and vulnerabilities across the major agricultural sub-sectors. **Table 1** presents the research priorities in the crop and agroforestry sub-sector, **Table 2** presents the research priorities in the livestock and fisheries sub-sector, **Table 3** shows the research priorities in the water resources and irrigation sub-sector, and **Table 4** presents the cross-cutting priority across all sub-sectors in Nigeria. By directly responding to these needs, adaptation interventions will drive feasible, high-impact solutions.

Table 1: Research priorities in the crop and agroforestry sub-sector

| Research Priority | Policy Concerns | Expected Change |
|---|---|---|
| **Building capacity of local artisans on equipment fabrication** | Limited capacity of local artisans to fabricate lightweight agricultural equipment in support of local adaptation | Reduced dependence on expensive imports, creation of local employment opportunities, and affordable, context-specific tools |
| | | Strengthened technical skills in equipment design and maintenance to enhance sustainability and self-sufficiency |
| **Enhancement of Farmers' Knowledge on Agroforestry Techniques** | Inability to combine scientific knowledge with local practices by smallholder farmers on agroforestry practices to improve land productivity, enhance soil health, and increase resilience | Integrated trees and shrubs with crops and livestock for income streams diversification and reduction of environmental degradation |
| | | Training programmes on species selection, sustainable land management, and the economic benefits of agroforestry |
| **Promotion of Locally Adaptable Seeds** | Exclusion of using locally adaptable seeds in cultivation, suitable for specific to different regions | More resilient seeds to local climatic conditions, pests, and diseases to reduce losses and input costs |
| | | Community-based seed systems and farmer-led breeding programs to enhance seed availability and adoption |

Table 2: Research priorities in the livestock and fisheries sub-sector

| Research Priority | Policy Concerns | Expected Change |
|---|---|---|
| | Inconsideration for local livestock breeds through | Knowledge programs established on genetic |

| | | |
|---|---|---|
| **Knowledge Development on Upgrading Indigenous and Local Livestock Breeds** | selective breeding and crossbreeding to enhance productivity, disease resistance, and adaptability to changing climate | improvement techniques and breed selection |
| | | Farmers' capacity strengthened in breeding management for sustainable livestock production and increased profitability |
| **Adoption of Resilient Livestock Management Practices** | Inadequate uptake of climate-smart livestock practices such as multi-species pastures, rotational grazing, and forage conservation to optimize resource use and ecosystem health | Soil fertility improved to prevent overgrazing and ensure year-round feed availability while mitigating environmental degradation |
| **Development of High-Quality Alternative Feeds for Livestock** | Inefficient development of alternative feed sources which include agro-industrial by-products, insect-based protein, and drought-resistant fodder to reduce reliance on conventional feeds and lower production costs. | Improved livestock nutrition with high-quality feed options to boost growth rates against climate-induced feed shortages |
| | | Research and farmer training and knowledge sharing on feeds formulation for successful adoption |
| **Improvement in Rangeland Management Practices** | Unsustainable rangeland management strategies including controlled grazing, reseeding degraded lands, and integrating trees into pasture systems | Community-led rangeland monitoring and policy support strengthened for long-term livestock productivity and land degradation prevention |
| **Introduction of Heat-Resistant Bird Varieties and Quick-Maturing Fish Species** | Inefficient production of poultry breeds that could thrive in high temperatures and fish species with shorter production cycles | Resilient breeds with potential to reduce losses from heat stress and prolonged production periods developed and supported by extension services and farmers training. |
| **Enhancement of Water Harvesting Techniques for Fish Farming** | Inefficient development of water harvesting methods such as pond rainwater collection, underground storage, and drip irrigation system for fish farming especially during dry seasons. | Stable water levels and fish survival rates enhanced to improve overall aquaculture productivity. |
| | | Smallholders farmers trained on cost-effective water conservation methods to support sustainable fish farming operations |

Table 3: Research priorities in the water resources and irrigation sub-sector

| Research Priority | Policy Concerns | Expected Change |
|---|---|---|
| **Development of Management Systems to Support Evolving Agricultural Needs** | Inefficient water management systems to address increasing demand for water in agriculture under changing climatic conditions. | Efficient water use strategies, including improved irrigation scheduling, water recycling, and watershed management optimized agricultural productivity. |

| | | |
|---|---|---|
| | | Institutional capacity and governance strengthened in water resource management for long-term sustainability |
| **Capacity enhancement for Smallholder Farmers on Water Harvesting Technologies** | Poor capacity to develop cost-effective water harvesting techniques, such as rainwater collection, underground storage, and the use of locally available materials to improve water availability | Practical training on the maintenance of water harvesting systems to ensure durability and effectiveness. |
| | | Community-led initiatives further enhance adoption and knowledge sharing. |
| **Expansion of Small-Scale Irrigation Facilities** | Poor outcomes from small-scale irrigation systems, such as drip and sprinkler irrigation, due to water use inefficiency, especially in drought-prone areas. | Reduced water wastage will improve crop yields, and facilitate all year-round farming. |
| | | Government and private-sector invested in affordable irrigation technologies to facilitate wider adoption. |
| **Promotion of Innovative Water Harvesting Technologies** | Neglect of investments in small earth dams, rooftop rainwater collection systems, and underground reservoirs undermine the potential or reliable water sources for dry-season farming. | Integrating water saving technologies with community-based water management strategies enhanced long-term impact. |

Table 4: Cross-cutting priority across all sub-sectors

| Research Priority | Policy Concerns | Expected Change |
|---|---|---|
| **Improvement of access to context-specific and cost-effective climate information services** | Existing climate information services and early warnings are too generalised, fragmented and rely on one-way communication exacerbates food insecurity, income loss, and environmental degradation | Granular, context-specific and consistent climate information services and early warnings with feedback loop for smallholder farmers in decision-making and enhancing their capacity for adaptation uptakes |

# 4. CONCLUSION AND RECOMMENDATIONS

## 4.1 Conclusion

The co-creation process ensures a participatory, inclusive, and demand-driven process in which diverse stakeholders jointly connect scientific knowledge and practical on-the-ground smallholder farming practices. Local community level participation helps in identifying successful practices, local practices require scaling or improvement and barriers to uptake through a systematic approach. The multi-stakeholder co-creation approach provided platform for developing convergent research agenda that are aligns with local adaptation needs but compliant with the feasibility, and viability of diverse agro-ecological conditions. Finally, the process reshapes policy direction for investments in adaptation research, foster ownership and long-term impacts for resilient agrifood system.

## 4.2 Recommendations

1. Strengthening collaboration and institutional linkages between research, policy, and practice is essential for fostering inclusive and responsive knowledge sharing partnerships through co-implementation of innovative practices and feedback to ensure that research findings are grounded in robust scientific evidence.
2. Long-term research agendas on climate-resilient crops, livestock, fisheries, water resources, and irrigation technologies should be developed to meet local needs to achieve a climate-resilient agrifood system transformation.
3. Developing low-cost, energy-efficient irrigation facilities will improve agricultural productivity by optimizing water usage, reduce energy costs, and strengthen uptake of climate smart agricultural practices through simple technologies, local resources, and empowering agricultural engineering institutions in fabricating affordable tools for improve water resource management and sustainable agricultural practices.
4. Continuous research, investment, and support for the development and adoption of early-maturing, drought-resilient, and high-yielding seed varieties, and other sustainable practices of pest management, storage, and harvesting technologies can assist smallholder farmers to shifting environmental conditions, and reduce environmental impact.
5. Generating high-quality localized data and research evidence on weather information and agro-advisory will assist smallholder farmers to improve in their decision-making, reduce crop losses, minimize vulnerability to sudden climate events and support climate-smart agricultural practices that improve productivity.
6. Reducing post-harvest losses, improving fodder, and pasture production will ensure food and feed availability to build resilience livestock systems. Restoring lost rangelands through afforestation will help provide environmental benefits when combined with sustainable livestock practices to support farmers and pastoralists in adapting but also contribute to broader environmental goals of carbon sinking and land restoration.

## Further Reading


[1] African Development Bank (2017). Climate Change and Agriculture in Africa.

[2] Awolala, D. O., Mutemi, J. N., Adefisan, E. A., Antwi-Agyei, P., and Taylor, A. (2022). Profiling User Needs for Weather and Climate Information in Fostering Drought Risk Preparedness in Central-Southern Nigeria: Multi-Criteria Decision-making Analysis. *Front. Clim. 4:787605.* doi: 10.3389/fclim.2022.787605

[3] Awolala, D. O., Ajibefun, I. A, Ogunjobi, K., & Miao, R (2021). Integrated Assessment of Human Vulnerability to Extreme Climate Hazards: Emerging Outcomes for Adaptation Finance Allocation in Southwest Nigeria. *Climate and Development,* DOI:10.1080/17565529.2021.1898925

[4] Bosello, F., Campagnolo, L., Cervigni, R. et al (2018). Climate Change and Adaptation: The Case of Nigerian Agriculture. Environ Resource Econ 69, 787–810 (2018). https://doi.org/10.1007/s10640-016-0105-4

[5] Central Emergency Response Fund (2022) Nigeria Raid Response Flood. In: CERF Allocation Report on the use of funds and Achieved Results. Available at: https://cerf.un.org/sites/default/files/resources/22-RR-NGA-56022_Nigeria_CERF_Report_0.pdf

[6] Climate Analytics and Ifo Institute (2021). Climate Risk Profile: Nigeria. Published and implemented by ifo Institute for Economic Research and Climate Analytics gGmbH

[7 Climate Risk Index (2025). "Who Suffered Most from Extreme Climate Events". Published by the Germanwatch Global Climate Risk Index funded by the International Climate Initiative (IKI) on behalf of the German Federal Foreign Office (FFO).

https://www.germanwatch.org/sites/default/files/2025-02/Climate%20Risk%20Index%202025.pdf
[8] Ertz, M (2024). Co-Creation. Encyclopedia **2024**, 4, 137–147. https://doi.org/10.3390/encyclopedia4010012
[9] FAO (2013). Climate-Smart Agriculture Sourcebook.
[10] FAO (2020). Economic and Policy Analysis of Climate Change – Supporting climate adaptation in smallholder agriculture: Summarizing Lessons Learnt. Agrifood Economics - Economic and Social Development. www.fao.org/in-action/epic|epic@fao.org
[11] Frow, P., S. Nenonen,, A. Payne and K, Storbacka (2015). Managing Co-creation Design: A Strategic Approach to Innovation. British Journal of Management. DOI: 10.1111/1467-8551.12087
[12] Global Sentinel (2023). Treating climate change as a national security threat. https://globalsentinelng.com/treating-climate-change-as-a-national-human-security-threat/
[13] Greatrex, H., et al. (2015). Can climate-index insurance improve resilience to drought? Evidence from a randomized controlled trial in Kenya.
[14] Hansen, J., et al. (2011). A methodology for assessing agricultural weather information dissemination systems.
[15] Harmonisé, C (2024): Regional Report on Food Security and Nutrition in West Africa and the Sahel 2024 (accessed at https://www.fsinplatform.org/regional-report-food-security-and-nutrition-west-africa-and-sahel-2024 on 20th January, 2025).
[16] https://www.worldbank.org/ext/en/home
[17] Lawal, O and O. Adesope (2021). Geospatial Analysis of Maize Yield Vulnerability to Climate Change in Nigeria. GeoJournal. 10.1007/s10708-019-10099-x.
[18] Madu, I.A., Nwankwo, C.F. Spatial pattern of climate change and farmer–herder conflict vulnerabilities in Nigeria. *GeoJournal* **86**, 2691–2707 (2021). https://doi.org/10.1007/s10708-020-10223-2
[19] Madu, Ignatius (2016). Rurality and climate change vulnerability in Nigeria: Assessment towards evidence based even rural development policy
[20] Molden, D., et al. (2010). Improving agricultural water productivity at different scales.
[21] Morton J (2007). The impact of climate change on smallholder and subsistence agriculture. Proc Natl Acad Sci.104:19680–5.
[22] Niang I, Ruppel OC, Abdrabo MA, Essel A, Lennard C, Padgham J, Urquhart P. Africa. In: Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL, editors. Climate change 2014: impacts, adaptation, and vulnerability. Part B: regional aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge; 2014. p. 1199–265.
[23] Otto, F (2023). Atribution of Extreme Events to Climate Change. Annual Review of Environment and Resources 48, 813-28. Available at https://doi.org/10.1146/annurev-environ-112621-083538.
[24] PIK, GIZ, and KfW (2020) "Climate Risk Profiles: Supplemental Information". Online available: https://agrica.de/wp-content/uploads/2020/12/nClimate-risk-profiles-Supplemental-Information_EN.pdf
[25] Scoones, I and J. Thompson (2011). The politics of agricultural research in Africa.
[26] Shiru, M.S., Shahid, S., Dewan, A. *et al.* Projection of meteorological droughts in Nigeria during growing seasons under climate change scenarios. *Sci Rep* **10**, 10107 (2020). https://doi.org/10.1038/s41598-020-67146-8

[27] Vanlauwe, B. et al (2015). Integrated soil fertility management in sub-Saharan Africa.