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**Website:** <https://info@ajol.org>.

**Email:** [agricultural.extension.nigeria@gmail.com](mailto:agricultural.extension.nigeria@gmail.com) ; [editorinchief@aessonigeria.org](mailto:editorinchief@aessonigeria.org)

### Emerging Role of Extension Services in Strengthening the Capacity of Farmers' Resilience to Climate Change in Nigeria

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**Mustapha, Shettima Bulama<sup>1\*</sup>, Timothy Enan<sup>2</sup>. and Shehu Halima<sup>3</sup>.**

Department of Agricultural Extension Services, University of Maiduguri, Nigeria<sup>1,2,3</sup>

Correspondence and Presenting author:

\*[sbmustapha@unimaid.edu.ng](mailto:sbmustapha@unimaid.edu.ng); +2347060573884

<sup>2</sup>[enantimothy@gmail.com](mailto:enantimothy@gmail.com); +2348132451120

<sup>3</sup>[halimashehuyusuf@gmail.com](mailto:halimashehuyusuf@gmail.com); +2348039873808

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#### Abstract

*The paper described the climate-resilient technologies and practices as well as the benefits associated with the adoption of such technologies and practices. The paper explored the role of extension services on how farmers' resilience can be strengthened to ensure food security in the changing climate in Nigeria. The paper also identified the approaches/strategies to extension services in strengthening the resilience capacity of farmers to climate change. Then, the implications for extension services for strengthening farmers' resilience to climate change were drawn and presented herein. The paper concluded that, there is a need for agricultural extension service providers to extend their mandates and broaden their scope by connecting and working with multiple actors and groups within and beyond the agriculture sector for collective action in strengthening climate change resilience in the agriculture sector.*

**Keywords:** Climate change, extension services, farmers resilience,

#### Introduction

Climate change is projected to have a substantial and widespread impact on crop and livestock production, food security and livelihoods globally and developing countries including Nigeria and are highly susceptible to further negative consequences (World Bank, 2022). Extreme climate change events such as droughts, heavy rainfall, flooding, water scarcity, severe fires, rising sea levels, melting polar ice, catastrophic storms and declining biodiversity are expected to accelerate in many regions across the globe, impacting food production and supply (Saran 2022). Average and seasonal maximum temperatures are projected to continue rising, imposing a threat to crops, wildlife and freshwater supplies. Heat stress further increases the vulnerability of livestock to disease, reduces fertility, and reduces milk production (Jones et al., 2021).

The Nigeria economy, food security and the livelihoods of its rural communities are extremely vulnerable to the impacts of climate change, with an increasingly hot and dry climate and major fluctuation in rainfall across years. Increasing temperature and rainfall variability have

severe impacts on agriculture, which is the main source of income and livelihoods for more than 70% of the Nigerian population (Azariah, 2020). Smallholder farmers and rural producers are among the populations most vulnerable to climatic shocks and weather-related disasters, and their vulnerability is compounded by market fluctuations, poor governance, conflict, and pests & diseases (Mohammed et.al 2022).

Agwu et al. (2023) defined agricultural extension as a system that facilitates access of farmers or their organizations to new knowledge, information and technologies and promotes interaction with research, education, agri-business, and other relevant institutions to assist them in developing their own technical, organizational and management skills and practices. Extension services in rural areas are challenging even under normal circumstances. Extension services today is viewed from a broad systems perspective, which focuses on the roles and capacities needed at individual, organizational and system levels to address current challenges. In addition to the traditional role of promoting agricultural innovation and technology adoption, these services now must deal with myriad issues, including human nutrition, risk and disasters, climate change adaptation and rebuilding after emergencies. These issues present additional challenges not only to the extension workers but especially to the farmers themselves. The paper hypothesized that the capacity of extension services to provide preventive measures or coping mechanisms to address these issues is a critical component of resilience. If these challenges can be overcome, extension services may be able to aid in enhancing the resilience of farmers in several ways. One way is by acting as a coordinating body for multiple support organizations as well as by providing more relevant services.

A strong extension system is well positioned to coordinate multiple groups at various stages of a shock, because of its linkages at local, sub-national and national levels. Due to its potential access to timely information, the system can identify relevant actors with whom to work to ensure that intervention strategies are harmonized, relevant, effective, and timely. In this way, short-term emergency responses can be harmonized with long-term resilience-building strategies. From the service angle, another possible way extension services could enhance farmers' resilience is by providing information and knowledge regarding weather and climate change, market prices, regulatory structures, quality standards and consumer demands so that farmers can make informed decisions.

Agricultural extension provides an opportunity for strengthening the resilience of rural and farming households by increasing their access to tangible and intangible resources, such as inputs and knowledge. These services could promote resilient agricultural systems by relaying farm-level challenges and potential solutions to policymakers promptly to enable them to make better-informed policy decisions. To address climate change and achieve food security, systemic changes are needed in the global food and agricultural system. Ensuring that smallholder farmers can become resilient to climate change, while also increasing productivity.

Studies suggested that agricultural investments through successive generations of climate-resilient projects may increase agricultural productivity and mitigate climate change (IPCC, 2021; Saran et.al., 2022). There seems to be a need to fill the gaps in evidence on agricultural interventions which may be used to promote climate-resilient approaches to smallholder farmers in Nigeria. Against this background, this paper synthesized the evidence on the interventions used to promote climate-resilient approaches to enhance the resilience of farmers under changing climatic conditions. This paper explored the role of agricultural extension in building the resilience capacity of farmers to climate change. It indicates where to move the policy and implications for extension with regards to the role of extension services in building resilience at the farm level. A key element required for sustainable and transformational development in agriculture is ensuring that investments are informed by robust evidence about past and future climate risks. Resilience can be enhanced by implementing short and long-term climate mitigation and adaptation strategies, as well as ensuring transparent and inclusive participation of multiple actors and stakeholders in decision-making and management processes.

This paper aimed to explore the role of agricultural extension in strengthening the climate resilience capacity of farmers. The paper is organized as follows: following this introduction, the paper defined concepts in this context and highlighted the climate hazards, resilient technologies/practices, their description, and benefits. Secondly, the paper described the extension approaches in building the resilience capacity of farmers to climate change with the interventions that promote resilience for the farmers. Thirdly, it explored the potential roles of extension services in specific areas and discussed the strategies for building the resilience of smallholder farmers to climate change. Then, fourthly, the policy considerations to strengthen extension services for improved resilience as well as the implications for agricultural extension to strengthen climate resilience in rural communities were discussed. Finally, the conclusion was drawn based on the context herein.

## **Definition of Concepts**

### ***Climate***

Climate is the average weather in each area over a longer period (IPCC, 2021). A description of a climate includes information on, e.g. the average temperature in different seasons, rainfall, and sunshine. Also, a description of the (chance of) extremes is often included. Changes in climate are difficult to detect without very long-term records. The average weather pattern in a place over several decades is called climate. "Climate" refers to the average weather in terms of the mean and its variability over a certain timespan and a certain area World Metrological Organization (WMO, 2023). The climate varies from place to place, depending on latitude, distance to the sea, vegetation, presence or absence of mountains or other geographical factors. The climate varies also in time, from season to season, year to year, decade to decade. Different regions have different regional climates.

### ***Climate change***

Climate change is any systematic change in the long-term statistics of climate variables such as temperature, precipitation, pressure, or wind sustained over several decades or longer. Climate change can be due to natural external forces (changes in solar emission or changes in the earth's orbit, natural internal processes of the climate system) or it can be human-induced. Statistically significant variations of the mean state of the climate or of its variability, typically persisting for decades or longer, are referred to as "climate change". IPCC (2021) defined 'climate change' as 'any change in climate over time, whether due to natural variability or as a result of human activity'. Climate variability refers to variations in the mean state of climate on temporal and spatial scales beyond that of individual weather events; examples of climate variability include extended drought and floods (WMO, 2023).

### ***Resilience***

As with climate change, the concept of climate resilience is a contemporary one. There has been a lot of debate among academics, scientists, humanitarians, and development agencies in a single definition. This has caused a multiple definition to arise, reflecting different perspectives. For example, the IPCC (2021) defined "resilience as the ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration or improvement of its essential basic structures and functions". Kim et al. (2022) defined the concept from a human development perspective stating that climate resilience is the capacity of socio-ecological systems to be able to absorb stressors, whilst maintaining function in the face of the external stressors imposed upon it by climate change impacts. Although a universally agreed definition of the concept of resilience does not exist, scholars working on climate resilience in rural communities and the literature they refer to generally agree that it is the capacity to cope with and recover from disturbances (Azariah, 2020; Kamruzzaman et al., 2021). Therefore, the ability of institutions and individuals to avoid potential damage and to take advantage of opportunities will be a critical factor in building resilience to climate change. In addition, building resilience to climate change requires simultaneously building resilience in human systems and in the interlinked ecosystems on which they depend. In its most general definition, resilience is the ability of a system to react or cope with change. More specifically, the concept refers to the ability of a system to respond to shocks (temporary) or more persistent adverse trends (stressors) (Nwafor et al., 2021). A system is resilient when it is less vulnerable to shocks across time and can recover from them United Nation Development Programme (UNDP, 2023).

Resilience in this paper refers to the capacity of a group of people-usually at the community level-to monitor, anticipate, respond to and manage both known risks and future uncertainties. It is the ability of a community or society, through incremental and transformational change, to absorb shocks, adapt to stresses and bounce back better from both. The shocks and stresses that communities face can be extremely diverse. They include natural hazards (such as floods, droughts, or hurricanes), as well as political, economic or

social shocks (such as a financial crash, political upheaval or outbreak of a disease epidemic).

### ***Resilient Agriculture***

Resilience is becoming an increasingly important topic to consider in agriculture, because of the necessity to adapt to unpredictable conditions climate change is causing. Resilient Agriculture (RA) or Climate Resilient Agriculture (CRA) is an approach that includes sustainably using existing natural resources through crop and livestock production systems to achieve long-term higher productivity and farm incomes under climate variability. This practice reduces hunger and poverty in the face of climate change for the forthcoming generations. CRA means the incorporation of adaptation, mitigation and other practices in agriculture which increases the capacity of the system to respond to various climates related disturbances by resisting damage and quickly recovering Food and Agriculture Organization (FAO, 2021). Such disturbances can include events such as drought, flooding, heat/cold waves, erratic rainfall pattern, long dry spells, insect or pest population explosions and other perceived threats caused by changing climate. In short it is the ability of the system to bounce back. CRA includes an in-built property in the system for the recognition of a threat that needs to be responded to and the degree of effectiveness of the response. The goal of climate-resilient agriculture (CRA) is to increase long-term farm incomes and productivity by sustainably exploiting the natural resources already available through crop and livestock production systems. CRA will essentially involve judicious and improved management of natural resources viz., land, water, soil and genetic resources through adoption of best bet practices. CRA practices can alter the current situation and sustain agricultural production from the local to the global level, especially in a sustainable manner. Improved access and utilisation of technology, increased use of resource conservation technologies, an increased adaptation of crops and livestock to climatic stress are the outcomes from climate-resilient practices.

The resilience of agricultural systems is vital in order to thrive in a changing climate (Leper et al., 2020). Agricultural resilience is a facet of overall agricultural sustainability. Currently, the focus within agricultural sustainability is to develop technology or methods of farming that do not harm the environment are easy to implement, effective for farmers and that increase food productivity as well as enhance the surrounding environment and ecosystems (Pretty et al., 2020). Resilient agriculture should enhance productivity of the land as well as promote environmental health in the face of climate change-related challenges that impact soil and water quality as well as general agriculture due to weather uncertainty United States Department of Agriculture (USDA, 2022). It is thought that localizing food systems can increase resilience as well as make food production more sustainable, as growing practices of smaller, local farms are consistently more ecologically sound than those used on large, conventional farms (Jones et al., 2021).

### **Climate Resilient Agriculture Technologies and Practices**

Climate Resilient Agriculture (CRA) technologies and practices provide an opportunity to meet the challenges of climate change as well as economic growth and development of the agricultural sector. One of the goals of the CRA is adaptation and/or mitigation of the effects of climate change. Hundreds of technologies and approaches around the world are covered by CRA (FAO, 2021; Grosjean et al., 2021). The use of stress-tolerant varieties (flood, salinity, drought, and heat tolerance) and water collection technologies are good examples. Although such treatments can be easily done by the farmers themselves, however, considerable technical support is needed to improve their shelf life and efficiency. These practices are mainly related to the management of climate risk, but also have a significant positive impact on farm incomes and the sustainable development of fish production.

### **Climate Hazards, Resilient Technologies/Practices, their Description and Benefits**

A key element required for sustainable and transformational development in agriculture is ensuring that investments are informed by robust evidence about past and future climate risks. Climate resilience is a fundamental concept of climate risk management. In this context, resilience refers to the ability of an agricultural system to anticipate and prepare for, as well as adapt to, absorb, and recover from the impacts of changes in climate and extreme weather. Resilience can be enhanced by implementing short and long-term climate mitigation and adaptation strategies as well as ensuring transparent and inclusive participation of multiple actors and stakeholders in decision-making and management processes. Climate hazards, resilient technologies/practices, their description, and benefits are presented in Table 1.

**Table 1: Climate hazards, resilient technologies/practices, their description, and benefits**

Hazards	Practices	Description and Adaptation/Mitigation Benefits
<i>Extreme Heat</i>	Heat tolerant crops (e.g. quinoa, pearl millet, sorghum) or crop varieties Short cycle crop varieties	<ul style="list-style-type: none"> <li>■ Promote crops and/or crop varieties with a higher heat tolerance and/or optimal heat range.</li> <li>■ Enhance yields in areas where temperature is expected to exceed heat thresholds that are harmful to existing cropping systems.</li> <li>■ Reduce the effect of heat stress at key phenological phases (germination and flowering) and improve final yields.</li> <li>■ Reduce plants' exposure to heat by shortening the growing cycle.</li> <li>■ Reduce the total water requirements during the growing season.</li> </ul>
<i>Strong Winds</i>	Windbreakers	<ul style="list-style-type: none"> <li>■ Rows of trees can protect crops by breaking strong winds, reducing soil erosion, increasing crop yields and protecting livestock from heat and cold conditions</li> </ul>
<i>Drought</i>	Agroforestry  Agronomic practices (e.g. weeding, harrowing, grafting, mulching)	<ul style="list-style-type: none"> <li>■ Root systems stabilize the ground and reduce soil erosion.</li> <li>■ Improves soil health by increasing soil organic matter, nutrient availability and microbial activity.</li> <li>■ Weeding and defoliation reduce soil water losses from plant transpiration.</li> <li>■ Cover crops reduce soil erosion by increasing soil organic matter, water, air, and nutrient availability.</li> <li>■ Harrowing (breaking the soil into small fragments) can prevent the loss of land moisture by evaporation.</li> </ul>
<i>Flooding and Water Logging</i>	Raised bed system	<ul style="list-style-type: none"> <li>■ Removes excess water during plant growth by better draining the water retained in the soil.</li> <li>■ Promotes optimal growth of root systems through soil aeration.</li> <li>■ Improves soil structure by limiting the compaction from human feet</li> </ul>
<i>Land Degradation and Greenhouse Gas Emissions</i>	Agronomic (e.g. sub-soiling)  Crop rotation, crop association and fallow  Mulching	<ul style="list-style-type: none"> <li>■ Sub-soiling can break possible hard pans and improve soil aeration.</li> <li>■ Introduction of root crops (e.g. horseradish) for deep root penetration and soil structure improvement</li> <li>■ Increase soil fertility as each crop has different nutrient requirements and plant-soil dynamics.</li> <li>■ Increase crop yields with the diverse nutrient availability.</li> <li>■ Increases soil moisture by reducing losses from direct evaporation.</li> <li>■ Reduces weed growth by keeping light from reaching the soil surface.</li> <li>■ Moderates soil temperatures by keeping the soil warmer during cold nights and cooler in hot days.</li> <li>■ Reduces irrigation requirements by reducing losses from direct evaporation</li> </ul>

Source; Alvar-Beltrán et al. (2021)

## **Strengthening the Capacity of Farmers' Resilience to Climate Change**

The agricultural sector in Nigeria is facing multiple stressors and sources of change. In addition, climate change will make the country hotter and shift precipitation patterns, although scientists do not know exactly how much. Decision-makers in Nigeria are therefore facing not just uncertainty, but deep uncertainty-meaning, they cannot predict what is going to happen with any confidence or reliability. In this context, Nigerian decision-makers must figure out how to maintain and develop the country's ability to feed itself. The concept of resilience offers a framework for how to do this.

Farmers who have the largest role to play in achieving food and nutrition security are largely "climate dependent" but have the weakest capacity to adapt to this increasingly volatile world (Kim et al., 2023). Their resilience needs to be strengthened, through targeted policies, investments and institutions (Cattaneo et al., 2020). Enhancing resilience, at every scale and from environmental, economic and social perspectives, is a crucial goal of climate-resilient agriculture interventions. To strengthen the resilience of farmers, it is relevant to facilitate their access and use of productive assets, such as land, water and production inputs. Strengthening of land and water rights may encourage farmers to invest, build assets and diversify. Enhancing access to water, through on-farm water harvesting, the enhancement of soil's capacity to hold moisture, on-farm water retention, and more systematic access to groundwater or supplementary irrigation can have a positive impact on household's resilience (FAO, 2021). Further investment in technological innovations is needed. This may include research, development and dissemination of drought-tolerant seed varieties and bio-fortified crops, replacement of inefficient subsidies, provision of social safety nets and risk management tools that support household livelihood strategies and preparedness, prevention, response, and recovery activities in response to shocks and climate change-related occurrences (Frankenberger et al., 2019). But strengthening resilience also entails strategies such as improving the sustainability of forest management. This not only increases the forest's resilience, but also contributes to improving water management, protecting the soil from erosion, and conserving agro-biodiversity (FAO, 2021). Climate Resilient Agriculture involves sustainable agricultural practices that enhance productivity, mitigate risks, and reduce greenhouse gas emissions. By adopting climate-resilient agriculture, farmers can ensure food security in the face of extreme weather events and climate change.

## **Extension Approaches to Building Resilience Capacity of Farmers to Climate Change**

According to IPCC (2021), building farm resilience is a prerequisite for farms that are operating in increasingly consistent and unpredictable climate shocks. In general, resilience refers to "the ability of a system to absorb disturbance and reorganize while changing so as to still retain essentially the same function, structure, identity and feedback". At the farm level, resilience refers to the ability of farms to adapt to climatic, social, and market shocks (IPCC, 2021). This ability of farms to adapt can be improved through internal and external



interventions and tapping into farmer characteristics which facilitate self-organization and innovative problem-solving. In general, Hossain et al., (2022) identified three strategies for building resilience. These strategies are reducing exposure, reducing sensitivity and increasing adaptive capacity (Kangogo et al., 2020):

**(a)** Reducing exposure implies reducing the likelihood of a particular risk occurring, as well as the severity. This strategy makes a distinction between climatic and non-climatic shocks. For some non-climatic shocks, it may be possible to reduce the likelihood of their occurrence and severity at the farm level, while this is difficult for climatic shocks.

**(b)** Reducing sensitivity of the farm to shocks implies identification of the likely risk and developing response mechanisms to reduce the impacts. For instance, sensitivity to drought can be reduced by developing and using drought-tolerant varieties. This strategy requires that the likely risks are measurable and identifiable in advance; however, this is not always possible at the farm level.

**(c)** Increasing adaptive capacity implies enhancing the capacity of farmers to respond promptly and effectively to the effects of climate change, for instance, using novel management practices and innovative technologies (Khatri-Chhetri et al., 2020). Farmer adaptive capacity is associated with increasing the options to manage climate change and with improving decision-making under uncertainty.

In the context of farming, farmer adaptive capacity is, therefore, a prerequisite for building farm resilience to climate change. Farmer adaptive capacity is a function of the ability to access, organize, or reorganize resources, and of linkages to organizations that influence the access to the necessary resources (Kangogo *et al.*, 2020). While farmer adaptive capacity as a means of building and/or strengthening farm resilience is important, it so far received little attention in climate change adaptation research.

### **Interventions Promoting Resilience for Farmers**

The intervention in this paper, aims to support the adoption of Climate Resilient Agriculture (CRA) approaches by smallholder farmers (Lopez-Avila *et al.*, 2022; Saran et al., 2022) including:

- Knowledge dissemination approaches such as social networking and peer learning (e.g., local champions), information and communication technologies (e.g., telephone, SMS, radio, television), group and individual training and demonstration (e.g., extension, demonstration plots, field days and schools).
- Financial approaches include credit and subsidies (e.g., cash transfers, vouchers, matching grants), insurance against loss and advice on risk management.
- Institutional arrangements include collectivization (e.g., farmer cooperatives and federations), contract farming, land titling, and community infrastructure (e.g., dams for irrigation).
- Interventions to promote participation in natural resource management committees and gender-responsive planning and budgeting.

- Behaviors and social change communication influence shifts in gender norms and values in agriculture and natural resources management.

These interventions may be based on different underlying principles and approaches. At one end of the spectrum, they may follow a top-down approach; for example, a transfer of technology extension approach is used to disseminate knowledge about improved agricultural practices. At the other end of the spectrum could be the suite of interventions built on local synergies and following participatory (bottom-up) and community-led development approaches. Such collaborative ventures may include not just agricultural producers and users of natural resources, but everyone responsible for land/soil, water and biodiversity management, including those involved in natural resources governance at local and higher levels, including policymakers.

### **Strategies for Building Resilience Capacity of Farmers to Climate Change**

To build the resilience of smallholder farmers in Nigeria, it is important to adopt a holistic approach in managing both climatic and non-climatic stressors including access to ready markets. These include the following strategies as reported by Cattaneo *et al.* (2020) and WFP (2019):

**(i)** There must be a conscious effort to address inequalities that make it particularly difficult for female farmers to manage climate risks. To do this, one needs to support and empower government agencies to identify and address gender barriers to adaptation. It is also critical that one works with the traditional authorities that are critical in addressing the traditional practices and norms that give rise to gender inequalities.

**(ii)** Using improved crop varieties, such as those that can withstand drought, is a key adaptation strategy in Nigeria. However, these crop varieties are not always available and, even if they are, the cost can be prohibitive for many. Provision of subsidies for such improved varieties of crops is another viable strategy that could yield significant benefits. Solutions targeting farmers themselves are more likely to be successful if they are combined with appropriate support from the authorities. Agricultural extension services are critical in building resilience to climate change because extension agents act as bridge between farmers and research, ensuring the smooth flow of information and innovations to farmers.

**(iii)** Smallholder farmers need access to innovative funding mechanisms to finance adaptation practices. Forming strong and empowered co-operatives is critical as this can be used as collateral for accessing funds.

**(iv)** Farmer-to-farmer exchange and sharing of relevant agricultural information should also be more pro-actively encouraged and supported by the relevant governmental agencies and ministries, led by the Federal and State Ministries of Agriculture and Food Security.

**(v)** There is need to find new ways of blending scientific knowledge with local indigenous knowledge at the community level in addressing climate change effects on food production.

**(vi)** Climate information is critical in guiding the adaptation needs of farmers – so getting it to them in a format they understand in time to make farming decisions is key.

As climate change will continue to work against efforts of farmers to achieve food security, all hands should be on deck in building the capacity of farmers whose agriculture-based livelihoods are threatened.

### **Key Stakeholders of Extension Services**

Extension service delivery is carried out in partnership with various stakeholders at different levels (i.e., those who have a direct interest or who might be affected by the issue at hand or intervention). Within an institutional framework for agricultural extension, these includes:

- The farmers;
- The public sector such as the Ministries/Departments of Agriculture;
- The private sector e.g. farmer associations, agro-marketing and processing firms;
- Non-profit organizations e.g. Women Farmer's Advancement Network (WOFAN), Leventis Foundation, Sasakawa Global 2000, Women in Agriculture (WIA) and Practicing Farmers Association of Nigeria (PFAN);
- International organizations/Donor agencies e.g. the World Bank, International Fund for Agricultural Development (IFAD), United States Agency for International Development (USAID) and Food and Agriculture Organization (FAO) of the United Nations;
- International research centres such as International Institute of Tropical Agriculture (IITA), International Fertilizer Development Centre (IFDC), International Livestock Research Institute (ILRI), and International Crops Research Institute for Semi-Arid Tropics (ICRISAT), International Fund for Agricultural Development (IFAD), the Food and Agriculture Organization (FAO) of the United Nations and the United Nations Development Programme.

Jointly and individually, these key stakeholders deliver farmer technical information and supporting services aimed at improving rural livelihoods (Devis et al., 2020; FAO, 2021). The major stakeholders in extension advisory services are the public sector (state ADP, National Agricultural Research System), private sector, NGOs, and international donor agencies. The ADPs in collaboration with the LGAs in some states are responsible for grass-roots extension delivery nationwide.

### **Potential Roles of Extension Services in Specific Areas**

Extension services focus is being made on potential roles that the services can play in specific areas as reported by Davis *et al.* (2020) as follows:

**Seeds and inputs provision:** These are often a part of humanitarian responses in post-disaster and post-conflict situations. If they have acquired such knowledge through prior presence on the ground, extension/advisory agents can play a role in informing providers of what inputs are appropriate in the affected areas and which ones could be locally sourced. Extensionists can also help farmers learn how to use new varieties. As an intermediary institution, with knowledge of markets and natural resource management regimes, extension services can in theory help to ensure that agricultural rehabilitation programs are relevant and sustainable. These services may often be the only agencies operating in rural areas that are able to assist after a disaster. For example, UNDP, FAO, WFP's Starter Pack Projects

distributed packages of high-yielding seeds and fertilizer to farmers to help them overcome the North-eastern Nigeria's post-insurgency conditions. The project relied on extension agents to register farmers and distribute the packs via distribution centres (FAO, 2021).

**Climate change:** a core challenge for extension services in the future is shifting from providing “packages” of technological and management advice to supporting farmers with the skills and information they need to make informed decisions. Climate change increases not only year-to-year, but even day-to-day variability. Farmers thus need high-frequency access to weather information as well as training on how to interpret the data and adapt their farming practices as necessary (Frankenberger et al., 2020). Some will also need access to new technologies and management options in areas where climate change or other shocks or stresses render their existing farming systems unviable.

**Information-sharing tools:** Information sharing tools such as information and communication technologies (ICTs) are another area at the nexus of these services and resilience. Farmers' exposure to risk and uncertainty is often aggravated by lack of information about weather, inputs, farm management practices or market prices; this lack of information can hurt crop production and income. Hence, a farmer who receives quality, up-to-date information and has the ability to use it may be able to lessen the effects of these risks. Mobile-based information services can influence the behaviour pattern of farmers, which can in turn facilitate the dissemination of information and the adoption of improved techniques, leading to better yields (World Bank, 2020). Information about weather and prices could potentially help farmers reduce their production and market risks.

**Weather Insurance:** While information sharing and the use of tools such as ICTs can potentially reduce risks, mechanisms such as weather insurance can compensate for risks that have occurred. Extension services can possibly play a brokering and facilitation role in new insurance options. For mitigating risk, extension services can link up different stakeholders, including smallholders, researchers, insurance providers, input dealers and other market players, International Fund for Agricultural Development (IFAD, 2019).

### **Outcomes: The Behavioural Changes Needed**

To sustainably achieve the desired impacts of climate resilient agriculture, the proposed intervention must influence behavioural change. This section describes the behavioural changes needed for achieving the desired impacts of climate resilient agriculture interventions among six key stakeholder groups: (i) producers; (ii) policy makers and institutions; (iii) extension workers; (iv) consumers; (v) civil society; and (vi) the private sector as reported by Devis et al. (2020) and Frankenberger *et al.* (2020) as follows:

**(i). Producers:** Climate resilient interventions and projects aim to induce the following observable behavioural changes in producers:

**(a).** Producers adopt appropriate climate resilient agriculture technologies and inputs such as seed, fertilizer, pesticides and risk management tools. This outcome demonstrates that

producers have taken up the outputs of a specific climate resilient intervention into their daily practice.

**(b).** Producers demonstrate improved knowledge on the costs, benefits and trade-offs of adopting climate resilient agriculture technologies. To ensure a sustainable adoption of these climate resilient agriculture technologies/practices, knowledge and capacity of producers must be developed. This supports the resilience as well as the productivity of farming systems.

**(c).** Producers engage with extension services, which are crucial, if the desired impacts are to be achieved, because such engagement has the potential to empower them to make decisions.

**(d).** Producers adopt income improvement strategies including income diversification and access to improved financial instruments and services.

**(e).** Producers integrate into new markets and engage with value chains. Access to markets is essential for smallholder producers to generate income, strengthen food security and contribute to sustainable livelihoods.

**(ii). Policy Makers and Institutions:** Climate resilient agriculture interventions and projects aim to induce the following behavioural changes in policy makers and institutions:

**(a).** Policy makers monitor and oversee climate-resilient agriculture compliance. The institutional commitment and support of policy makers is crucial to ensure the sustainable adoption and application of climate-resilient agriculture not only at the farm level but also at the landscape and national levels.

**(b).** Institutions cooperate in developing and disseminating information. Climate Resilient Agriculture (CRA) demands a landscape approach, and its implementation requires cooperation across different sectors. Decision-makers from various ministries and research institutes with different thematic focuses must work together to gather and provide timely and relevant information. This behavioural change in policy makers and institutions aims to facilitate the future availability of data and information on climate-resilient agriculture within a landscape approach.

**(c).** Policy makers utilize a diversity of instruments, information, and stakeholder inputs for creating incentives and building capacity of producers to implement CRA in an inter-sectorial manner and across various stakeholders including technical, research and extension staff, as well as nongovernmental stakeholders and international partners.

**(d).** Policy makers establish an institutional framework for CRA implementation. Policy makers establish the legal and regulatory frameworks to promote and mainstream climate resilient agriculture. This behavioural change conveys the commitment and frame for implementing climate resilient agriculture. Within this framework, policies and regulations that aim at promoting climate-resilient agriculture are drafted.

**(e).** Government agencies implement, enforce, and monitor & evaluate CRA policies. Thus, it is crucial that policy makers monitor and oversee climate resilient agriculture compliance across various sectors and institutions.

(f). Government should also commit to regional and global agreements and mechanisms to support climate change adaptation and mitigation. This outcome supports the goal of mitigating GHGs caused by agriculture.

(iii). **Extension Workers:** Extension workers should also engage in multilateral knowledge sharing and strive to be up to date with the latest knowledge on climate resilient agriculture from a variety of sources including the farmers themselves. Extension services are one of the key channels through which information on new technologies and practices will be disseminated and are therefore an important supporting service for CRA implementation.

(iv). **Consumers:** Consumers support climate resilient agriculture practices in consumption decisions. Value is captured and determined by consumers when they buy the product, which then benefits other segments in the value chain. Hence consumers, in particular those in developed countries, have a large degree of power. Consumers' behaviour should reflect raised awareness regarding reduction, reuse, and recycling of food that is still fit for human or animal consumption or other purposes (for example, compost or biogas) (FAO, 2021). Their behaviour should also be reflected in an increased demand for goods that stem from integrated, sustainable value chains that build on CSA practices. Their demand will support farmers (and value chains) to promote sustainable production (Davis et al., 2020).

(v). **Civil Society:** Civil Society supports CRA-related activities and the sector goals of improved productivity, enhanced sustainability and resilience, and reduced GHG emissions. Civil society plays a crucial role in mainstreaming CRA activities to achieve the desired impact. Civil society institutions readily foster bottom-up engagement and have considerable potential to exercise influence in decision-making processes, for instance, by becoming vocal about local concerns and demand measures or services (FAO, 2021). Civil society's engagement can take place on a local to international level and has considerable potential to support the achievement of the desired impacts (Frankenberger et al. 2020).

(vi). **Private Sector:** The private sector engages in CRA-related activities and supports an environment that furthers the sector goals of improved productivity, enhanced sustainability and resilience and reduced GHG emissions. The key private sector agents may include farmers themselves, producer cooperatives, national and international agribusinesses, commercial consultancies, and banks and credit & savings institutions. Private sector actors provide research, development, education and extension. Whereas the private sector agents often aim for profits and public perception, favourable behavioural change would include an enhanced interest in supporting CRA-related activities. These may come about by policy or regulatory incentives or by the design of a brand surrounding CRA. As markets and market engagement of smallholders become ever more important, it is relevant to provide outputs that change the private sector's behaviour to support CRA.

### **Policy Considerations to Strengthen Extension Services for Improved Resilience**

The several potential policy considerations for building the resilience of farmers through extension include:

- **Build individual, organizational and system capacity to deal with climate risk and change:** Too often, capacity has been focused at the individual level, not

considering the need for organizational and system-level capacity. There is a critical need for assessing capacity requirements at all levels to develop a comprehensive strategy for capacity-development investments.

- **Considering long-term sustainability:** Extension services are often pulled in different directions by political pressure and donor preferences. Building capacity for resilience-oriented systems requires shifting from the project approach to building sustainable institutions that anticipate shocks and contextualize interventions to meet the specific needs of communities affected. What is needed is long-term political commitment to extension services.
- **Using ICTs to communicate information to reduce and prevent climate risk and change:** ICTs are not a silver bullet and are not very useful without institutions and reputable information sources. However, they have the potential to quickly and cheaply share information that can strengthen farmer resilience to climate change.
- **Using proven intervention plans and programs such as weather insurance:** Extensionists must play an honest brokering role to link farmers to such options to compensate for shocks that have occurred. This process will require building the institutional capacity of extension services to anticipate shocks and adapt existing programs that enable farmers to respond to and bounce back from a climate change shock.
- **Develop policies that define the role of extension in assisting farmers to become more resilient:** Governments should devise holistic policy frameworks for enhancing farmer resilience that entail various complementary services, investments and safety nets. Developing such a policy framework will require continued learning from communities that face frequent shocks, including how they deal with them and what adjustments are needed to reduce their impact. This framework can place communities on a dynamic long-term development path.

### **Implications for Agricultural Extension Services**

The key concept of climate-resilient agriculture is to provide location-specific climate-resilient technologies/practices. Multiple stakeholders i.e. governments, civil societies, science and private sectors have to be involved in formulating and disseminating location-specific climate-resilient technologies/practices in agriculture. The implications for extension can be through the following:

- The focus of extension has to shift from transferring skills, technologies and knowledge related to the production of crops, livestock and forestry products to develop climate resilient technologies/practices with farmers, catalysing and facilitating the innovation processes.
- Participatory methods and approaches such as participatory technology development, enables rural innovation and innovation platforms to develop and disseminate the climate resilient technologies/practices and encourage innovation through multiple stakeholder engagement to ensure climate resilient agriculture.

- There is a strong need for climate-resilient agriculture researchers to tap local knowledge and to have a clear understanding of farmers' needs and problems in order to develop a close linkage with extension personnel.
- Successful climate resilient agriculture implementation involves effective and efficient extension providers and systems, which will require major organization and institutional reforms in the country as well as capacity building at organization and individual levels.
- Implementation of climate resilient agriculture requires critical investment in relation to both on-farm capital and wider agricultural outreach programmes. All the agricultural extension service providers need to give priority to implement climate resilient agriculture technologies/practices and also provide fund to develop those technologies/practices.
- The capacities of policy makers, extension agents, agricultural entrepreneurs and farmers need to be enhanced through different climate-resilient agriculture training modules to strengthen organizational and institutional capacities, such as coordination mechanisms.
- Public-private partnerships can be encouraged to promote climate-resilient agriculture. The government has to recognize and promote such partnerships through incentives and create an enabling environment where farmers can do business with the private sector.
- Development of an information hub related to climate-resilient agricultural technologies, practices, etc. is essential. Success stories, case studies and initiatives of different stakeholders in various places can be shared so that it can be accessed by farmers and other stakeholders across the globe.

The implementation of climate-resilient agriculture would involve changes in the behaviour, strategies and agricultural practices of farmers nationwide. Farmers need support to understand the impacts of climate change and to adopt climate-resilient agriculture practices.

### **Conclusion and Recommendations**

In conclusion, this paper has demonstrated the vital role of agricultural extension services in enhancing the resilience of farmers to climate change in Nigeria. By disseminating climate-resilient technologies and practices, extension services contribute significantly to safeguarding agricultural productivity and food security. The analysis emphasized the importance of a coordinated and inclusive approach, involving multiple stakeholders to ensure that farmers are well-equipped to adapt to the challenges posed by climate change. This collaborative effort is crucial for building a resilient agricultural sector capable of sustaining livelihoods in the face of ongoing climatic shifts.

1. Broaden the Scope of Extension Services: Extension services should integrate climate change adaptation strategies into their existing programs. This includes providing farmers with information on climate-resilient crops and farming.



2. Enhance Capacity Building: Extension services must focus on continuous capacity building for both extension workers and farmers. This includes regular training programs, workshops, and seminars on the latest climate-resilient technologies and practices.
3. Leverage Technology: Utilize digital tools and platforms to disseminate information and provide real-time support to farmers. Mobile applications, online forums, and social media can be effective in reaching a larger audience and ensuring timely communication.
4. Promote Community-Based Approaches: Encourage community involvement in planning and implementing resilience-building activities. This participatory approach ensures that local knowledge and needs are taken into account, making the strategies more relevant and effective.
5. Foster Multi-Stakeholder Collaboration: Strengthen partnerships between government agencies, research institutions, NGOs, and the private sector. Collaborative efforts can lead to more comprehensive and sustainable solutions for climate resilience in agriculture.

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