Unlocking Nigeria's Agricultural Potential: Research Priorities for Enhanced Crop Production

Tajudeen Bamidele Akinrinola*, Mordecai Usman Tsado,

[1.] Department of Crop and Horticultural Sciences University, Ibadan, Nigeria
*tb.akinrinola@gmail.com

Abstract: The agricultural sector is a cornerstone of Nigeria's economy and a major source of livelihood, and possesses vast untapped potential to ensure food security and stimulate economic growth. Despite employing a significant portion of the population, the nation faces substantial challenges that hinder optimal crop production, necessitating a reliance on imports to meet its domestic food demands. This review identifies key interconnected obstacles, including the pervasive impact of insecurity and conflicts, the increasing threats posed by climate change and environmental degradation, the persistent challenges of pest and disease outbreaks, the burden of high production costs coupled with limited access to essential inputs, and significant logistical and market access hurdles. To transform these challenges into opportunities for growth, this review proposes a comprehensive research agenda focused on unlocking Nigeria's agricultural potential. Prioritizing research in crucial areas, such as developing climate-resilient crop varieties suitable for diverse agro-ecological zones, implementing integrated pest and disease management strategies, advancing efficient post-harvest loss reduction technologies, exploring cost-effective and sustainable input management practices, improving market access and supply chain efficiencies, and promoting the adoption of appropriate technologies, is paramount. Furthermore, research into effective agricultural policies and the role of innovative financing mechanisms will be vital. By strategically addressing these research priorities, Nigeria can enhance crop productivity, improve the livelihoods and resilience of its farmers, build robust food systems capable of withstanding climate-related shocks, and ultimately achieve national food security and sustainable agricultural development, positioning the nation as a key player in the global agricultural landscape.
[Akinrinola TB, Tsado MU. **Unlocking Nigeria's Agricultural Potential: Research Priorities for Enhanced Crop Production.** *World Rural Observ* 2025;17(3):5-20]. ISSN: 1944-6543 (Print); ISSN: 1944-6551 (Online). http://www.sciencepub.net/rural. 02. doi:10.7537/marswro170325.02

Keywords: Agricultural research; climate change; food security; post-harvest losses; sustainable agriculture

1. Introduction

Nigeria possesses a substantial agricultural land area, and a large proportion of its population is engaged in farming, highlighting the sector's importance (Olomola and Nwafor, 2018; Chiaka et al., 2022). Historically, agriculture served as the primary engine of Nigeria's economy, being the main source of export earnings before the rise of the oil and gas industry (Okotie, 2017). The current agricultural landscape is largely run by smallholder farmers, who, despite their scale, collectively produce a significant amount of the nation's food (Okotie, 2017; Chiaka et al., 2022).

However, despite so many families' engagement in farming (Anderson et al., 2017; Olomu et al., 2020) and the sector providing employment (Okotie, 2017; Chiaka et al., 2022), Nigeria consistently struggles to feed itself. The country imports a lot of food to meet local needs (Chiaka et al., 2022; Bello et al., 2024), suggesting there are underlying systemic inefficiencies or constraints within the agricultural system that desperately need a closer look through focused research. The agricultural sector is under immense pressure to keep pace with Nigeria's rapidly growing population. This demographic surge only makes food security worries even more urgent (Aiyedogbon et al., 2022; Chiaka et al., 2022). In recent years, Nigeria has experienced alarming food inflation, pushing up the cost of everyday essentials and hitting household budgets hard (Olufemi-Phillips et al., 2024). The heavy reliance on food imports further highlights the challenges in becoming self-sufficient (Bello et al., 2024).

Tackling the many challenges facing Nigerian crop production demands a united front of research and innovation. There is a need for rigorous investigation to identify the real causes of these issues, assess the effectiveness of potential solutions, and ultimately develop sustainable strategies that will enhance agricultural output and secure the food future (Ani and Boateng, 2024). This report aims to provide a clear outline of research topics. These ideas stem from a comprehensive examination of Nigeria's current farming challenges and are designed to inform future

efforts that will significantly enhance crop production and ensure the nation's food security.

Since smallholder farmers are the backbone of Nigeria's agriculture (Okotie, 2017; Chiaka et al., 2022), making up most of the farming workforce and production, any research must prioritize solutions that are not only effective but also easy for them to access and adapt to their unique situations. The truth of Nigeria's vast agricultural potential (Etuk and Ayuk, 2021), conflicting with its ongoing fight for food self-sufficiency, highlights a significant gap. Focused research can close this gap by identifying and addressing the main obstacles preventing the country from fully reaching its potential.

2. Key Challenges Plaguing Nigerian Crop Production

Agriculture remains a vital sector in Nigeria, contributing significantly to employment, food security, and rural livelihoods. However, the sector is yet to reach its full potential due to a combination of biophysical, socioeconomic, and policy-related constraints. Based on Table 1, ten research priorities emerge as critical areas for enhancing crop production across the country.

2.1. The pervasive impact of insecurity and conflict: Conflict and insecurity, from rampant banditry to clashes between farmers and herders, cast a long, devastating shadow over Nigerian crop production. These issues severely restrict farmers' movements, cutting off their access to their farmlands, especially in the North East and North Central regions (Olufemi-Phillips et al., 2024). Heartbreakingly, this insecurity has also led to farmers losing their lives and being forced to pay ransoms, creating an atmosphere of pervasive fear that cripples farming activities (Giller et al., 2021; Olufemi-Phillips et al., 2024). The shocking number of farmer deaths from banditry and herder-farmer conflicts (Gana et al., 2024) truly highlights the immense human tragedy and the direct blow this insecurity deals to agricultural output.

What's more, this constant threat influences what farmers dare to plant, potentially shrinking crop diversity and harming nutritional security in affected communities. The clear link between insecurity and a reduction in cultivated land (Ntihinyurwa and de Vries, 2021) has far-reaching consequences for the national food supply. This urgent situation calls for research focused on finding real security solutions and exploring alternative farming models that can be safely and practically adopted in these dangerous environments. Understanding precisely how farmers adapt, or struggle to adapt, their practices in the face of insecurity is crucial for designing effective, targeted help.

The disruption caused by insecurity is not confined to the farm; it ripples through the entire agricultural supply chain, from the moment seeds are planted to harvesting and getting produce to market (Okotie, 2017). This widespread chaos fuels volatile food prices and worsens the existing food insecurity across the nation (Olufemi-Phillips et al., 2024). So, there is an urgent need for research to accurately measure the huge economic losses directly caused by insecurity in agriculture. Such studies should also focus on finding and developing ways to build stronger, more local food systems that can better withstand the shocks of regional conflicts. Looking into alternative supply chains or promoting community-based farming in safer areas could offer promising paths forward. The rising number of farmer deaths due to insecurity (Gana et al., 2024) is a deeply worrying trend that demands immediate attention and thorough research into effective ways to stop it. This statistic offers a grim, quantifiable measure of just how severe the insecurity problem is and its direct, devastating impact on the farming workforce.

Additionally, the pressure on farmers to limit the variety of crops they grow in insecure zones means that insecurity doesn't just reduce the amount of food produced; it also negatively affects crop diversification, with potentially serious consequences for nutrition in those communities. Farmers in conflict areas might understandably choose to grow crops that are quick to mature and easy to hide, rather than focusing on more nutritious or economically valuable options. This choice ultimately impacts both the overall agricultural output and the variety of food available.

2.2. Climate change and environmental degradation: Climate change poses a significant and growing threat to Nigerian agriculture, showing its face in many ways: more frequent and intense extreme weather events like floods, prolonged droughts, and wildly unpredictable rainfall patterns (Etuk and Ayuk, 2021; Jedwab et al., 2023; Ntihinyurwa and de Vries, 2021). Devastating floods wipe out farmlands and long droughts slash crop yields (Ibebuchi and Abu, 2023; Durodola, 2019). These erratic climate shifts fundamentally upend the traditional planting seasons that farmers have relied on for generations, leading to huge drops in overall crop yields and seriously threatening the stability of food production, especially for the vast majority of Nigerian agriculture that depends on rain (Ibebuchi and Abu, 2023).

Farmers nationwide are increasingly struggling with delayed or insufficient rainfall during crucial growth periods (Etuk and Ayuk, 2021; Olufemi-Phillips et al., 2024), forcing them to rely more and more on often expensive irrigation systems just to keep

their crops alive. On top of this, land degradation and a sharp decline in natural soil fertility, made worse by unsustainable farming practices and the growing pressures of climate change, further complicate the quest for optimal crop yields (Arowosegbe et al., 2024; Gupta et al., 2023). The forecast of below-average rainfall in some Nigerian regions while others get too much (Ibebuchi and Abu,

Table 1: Key Research Priorities for Enhancing Crop Production in Nigeria: Focus Areas, Target Crops, and Expected Impacts

Research Priority	Description	Region of Focus	Target Crops	Expected Impact
Improved seed varieties	Develop drought-tolerant, pest-resistant, and high-yielding seed varieties	North-Central, North-West	Maize, Rice, Sorghum	Increased productivity (20–30%)
Soil fertility management	Use of organic & biofertilizers (e.g., poultry manure, compost)	South-West, South-East	Vegetables, Cassava, Maize	Enhanced soil health & sustainable yield
Climate-smart agriculture	Promote irrigation, cover cropping, and conservation tillage	Semi-arid zones	Millet, Maize, Cowpea	Climate resilience, water use efficiency
Mechanization & digital agriculture	Use of drones, GPS mapping, and mobile apps for extension services	Nationwide	All major crops	Reduced labor costs, data-driven farming
Post-harvest loss reduction	Development of improved storage and processing techniques	Middle Belt, South-South	Tomato, Cassava, Yam	Reduction of 30–40% in post-harvest losses
Extension and farmer education	Train farmers on GAP (Good Agricultural Practices), digital tools	Nationwide	All crops	Knowledge transfer, adoption of innovations
Crop-livestock integration	Promote intercropping & integrated systems with livestock	North-East, South-East	Maize, Soybean, Poultry	Efficient resource use, improved soil fertility
Policy and market access research	Identify policy gaps and value chain inefficiencies	Nationwide	Rice, Maize, Cassava	Improved access to inputs and market stability
Biotechnology and genetic engineering	Research in GMO and CRISPR for pest/disease resistance	North-Central	Cotton, Cowpea	Reduced chemical use, increased yield
Water management & small-scale irrigation	Develop affordable irrigation technologies for dry season farming	North-East, North-West	Rice, Vegetables	Year-round production, income stability

Sources: World Bank (2020); IFPRI (2021); CGIAR (2021); NARS (2022); FMARD (2022); FAO (2023); IITA (2023)

2023) truly highlights the urgent need for local climate adaptation strategies. Given Nigeria's diverse agro-ecological zones, climate change impacts will vary greatly, demanding tailored research and solutions rather than a one-size-fits-all national approach.

The dramatic example of Lake Chad shrinking by about 90% of its original size (Jedwab et al., 2023) serves as a stark and alarming reminder of the long-term, potentially irreversible consequences of climate change on vital water resources crucial for farming in the region (Wakdok and Bleischwitz, 2021). Therefore, research is incredibly important for developing "climate-smart" agricultural practices specifically designed for the unique vulnerabilities of Nigeria's various agro-ecological zones. This involves a strong emphasis on identifying and promoting crop varieties that can better withstand climate stresses like drought and flooding, as well as advancing water-efficient farming techniques to help farmers maximize limited water resources.

2.3. The threat of pest and disease outbreaks: Nigerian crop production constantly battles significant losses from a wide range of pest infestations and disease outbreaks that hit nearly all major crops (Gana et al., 2024; Olufemi-Phillips et al., 2024). We've seen devastating pests like *Tuta Absoluta*, which has severely impacted tomato production (Adewoyin, 2023; Binge et al., 2023), along with maize stem borers (Ebukiba et al., 2020) and cowpea pod borers (Nboyine et al., 2024). Similarly, diseases such as ginger blight (Gana et al., 2024), cassava mosaic disease (Ezeji et al., 2023), and maize streak virus (Ebukiba et al., 2020) have caused widespread damage**.**

These outbreaks frequently lead to huge drops in crop yields, causing severe financial hardship for farmers and often sending food prices soaring, affecting consumers nationwide (Gana et al., 2024; Bello et al., 2024). Farmers often face immense difficulties getting their hands on effective and timely solutions to control and manage these pests and diseases (Arowosegbe et al., 2024). The emergence of new threats, like the widely publicized 'Tomato Ebola' (referring to *Tuta Absoluta*) (Aynalem, 2022; Gana et al., 2024), signals that new or worsening agricultural dangers are appearing, demanding focused research to understand and manage them. The potential for up to 80% yield losses in cowpea crops due to the destructive cowpea pod borers (Nboyine et al., 2024) vividly shows the devastating impact specific pests can have on vital crops essential for both food security and livelihoods. This major risk of loss highlights the urgent economic need to develop and implement effective pest management strategies, especially for key protein sources like cowpea.

Therefore, research into integrated pest and disease management (IPM) strategies is urgently needed. These strategies must be effective in the Nigerian context, affordable and accessible for smallholder farmers (who make up the majority of producers), and environmentally sustainable to ensure long-term viability and minimize negative ecological impacts.

2.4. The costs of high production and limited access to inputs: A recurring complaint across Nigeria's agricultural sector is the sky-high cost of essential farming inputs, including fertilizers, machinery, pesticides, and quality seeds (Etuk and Ayuk, 2021; Bello et al., 2024). These steep prices often force farmers, especially smallholders with tight budgets, to settle for cheaper, lower-quality inputs. Unfortunately, using substandard inputs frequently leads to significantly reduced crop yields, hurting the overall productivity and profitability of their farming efforts (Etuk and Ayuk, 2021; Gupta et al., 2023).

Adding to this challenge is the persistent struggle for smallholder farmers to access affordable loans and credit (Giller et al., 2021; Balana and Oyeyemi, 2021). This lack of access to necessary funds further limits their ability to invest in better technologies, buy quality inputs, and expand their farms (Arowosegbe et al., 2024). The significant rise in fuel prices also piles on the pressure by driving up transportation costs, affecting both getting inputs to farms and moving harvested crops to markets, ultimately eating into farming profits (Giller et al., 2021; Olufemi-Phillips et al., 2024).

Reports show that farmers are using fewer inputs because of these high prices, which directly impacts potential crop yields (Etuk and Ayuk, 2021; Giller et al., 2021). When farmers can't afford crucial items like fertilizers and good seeds, their land's productivity inevitably drops. Furthermore, the prediction of commodity prices soaring to historic highs (Etuk and Ayuk, 2021) is a worrying sign for future food security. This projected increase is fueled by lower production, rising international demand, and increasing logistics costs. Higher food prices, combined with potentially lower production due to reduced input use, will likely make food less accessible and affordable for a larger portion of the Nigerian population, worsening the existing food insecurity challenges.

2.5. Logistical challenges and market access: Nigeria's agricultural sector is severely held back by its poor transportation infrastructure. Inadequate and poorly maintained rural roads, coupled with limited rail connections, make it incredibly difficult to move farm produce efficiently from fields to markets (Okotie, 2017; Gupta et al., 2023). These infrastructure

shortcomings directly contribute to high transportation costs, which in turn significantly drive up food inflation across the country (Durodola, 2019; Olufemi-Phillips et al., 2024).

Another major problem is the widespread lack of proper storage facilities at every stage of the agricultural journey, from on-farm storage to market warehouses (Adewoyin, 2023). This deficiency leads to massive post-harvest losses, as harvested crops often spoil before they can even reach consumers or processing plants (Binge et al., 2023). Smallholder farmers often struggle to access established markets and can become overly dependent on middlemen, who don't always offer fair prices for their hard-earned produce (Danso-Abbeam et al., 2021; Adewoyin, 2023).

The staggering estimate of N3.7 trillion lost yearly due to food waste and inefficiencies in cold chain and storage logistics (Arowosegbe et al., 2024) paints a stark picture of the enormous economic impact of post-harvest losses in Nigeria. This huge figure highlights the significant inefficiency within the food system and points to the great potential for improvement through investments in better infrastructure and the adoption of more effective post-harvest management practices. The simultaneous rise in fuel prices and food inflation (Olufemi-Phillips et al., 2024) clearly shows how vulnerable Nigeria's food system is to energy cost fluctuations. The heavy dependence on petrol-powered vehicles to transport farm products from rural areas to towns and city markets directly links fuel prices to the final cost of food for consumers.

2.6. Inefficient agricultural practices and low technology adoption: A large number of Nigerian farmers still use traditional, often labor-intensive, and less productive farming methods (Danso-Abbeam et al., 2021). The adoption of modern agricultural technologies and mechanization remains quite low, especially among smallholder farmers who make up the majority of the farming population (Mohammed et al., 2023). What's more, many farmers have limited access to timely and effective agricultural extension services, which are absolutely vital for sharing information on improved farming techniques, new technologies, and best practices in crop management (Arowosegbe et al., 2024; Danso-Abbeam et al., 2021).

There's also a clear need to expand and improve irrigation systems nationwide to reduce the heavy reliance on rain-fed agriculture, which is increasingly vulnerable to climate change and unpredictable weather (Jedwab et al., 2023; Olufemi-Phillips et al., 2024). Nigeria's average farm size is quite small compared to other African nations (Olomu et al., 2020), suggesting it's hard to achieve economies of scale in production. This also points to the importance of research focused on optimizing farm output and resource use specifically for small-scale farming systems. Smaller farms might need different approaches to technology and farming practices than those used on larger commercial operations. The low prevalence of irrigation farming in Nigeria (Mohammed et al., 2023) makes crop production highly susceptible to the increasing variability of rainfall patterns linked to climate change (Jedwab et al., 2023; Wakdok and Bleischwitz, 2021). This heavy dependence on rain-fed agriculture, in the face of increasingly unpredictable weather, poses a significant and growing risk to the consistency and reliability of crop yields across the nation (Durodola, 2019).

2.7. Constraints arising from the land tenure system: Nigeria's current land tenure system often acts as a major barrier to agricultural development. It limits farmers' access to land, especially for expanding their operations or making long-term investments in their farms (Mohammed et al., 2023; Adewoyin, 2023). This issue can make farmers feel insecure and less willing to invest in improving their land and farming practices.

2.8. Unique challenges for specific crops: Every major crop grown in Nigeria—including maize, rice, cassava, yam, sorghum, millet, groundnut, cowpea, soybean, plantain, and tomato—faces its own distinct set of production hurdles. These challenges often stem from specific vulnerabilities to pests and diseases, varying suitability to local climate conditions, and particular needs for inputs like fertilizers and water (Akinrinola and Fagbola, 2019; Ntihinyurwa and de Vries, 2021; Bedeke, 2023).

2.9. Opportunity to integrate socio-cultural and gender dimension: Nigerian agriculture is deeply influenced by socio-cultural norms and gender roles, which often exacerbate inequalities and limit overall productivity. Women, who constitute a significant portion of the agricultural workforce, face disproportionate barriers such as limited access to land ownership under traditional land tenure systems, restricted credit opportunities, and unequal distribution of extension services (Balana and Oyeyemi, 2021; Danso-Abbeam et al., 2021). These gender disparities result in lower adoption rates of improved technologies among female farmers and contribute to suboptimal crop yields in households where women play key roles in production. Additionally, socio-cultural factors, including traditional farming practices and community hierarchies, can resist the introduction of modern innovations, perpetuating inefficiencies (Mohammed et al., 2023). For instance, in many rural communities, cultural preferences for certain crops or resistance to intercropping systems influenced by gender norms

hinder diversification and resilience-building efforts. Addressing this challenge requires research into gender-sensitive policies and culturally appropriate interventions that empower women farmers, promote equitable resource access, and integrate local knowledge systems to foster inclusive agricultural growth (Giller et al., 2021; Chiaka et al., 2022). Without such integration, efforts to enhance crop production will continue to overlook critical human dimensions, leading to uneven benefits and sustained vulnerabilities.

2.10. Priority ranking and indication of cost benefit analysis: A major gap in Nigeria's agricultural sector is the absence of systematic priority ranking and rigorous cost-benefit analyses for proposed interventions, which hampers effective resource allocation by policymakers and stakeholders. While numerous challenges are identified, there is often no clear framework to rank them based on urgency, potential impact, or feasibility, leading to fragmented investments and suboptimal outcomes (World Bank, 2020; IFPRI, 2021). For example, without cost-benefit assessments, initiatives like input subsidies or infrastructure developments may be pursued without evaluating their long-term returns relative to alternatives, resulting in wasted resources and missed opportunities for high-impact solutions (Bedeke, 2023; Olufemi-Phillips et al., 2024). This issue is compounded by limited data on economic trade-offs, making it difficult for decision makers to justify funding for research priorities outlined in Table 1. Research is needed to develop methodologies for priority setting, incorporating multi-criteria decision analysis and economic modeling to guide investments in areas like climate-smart practices or pest management. By providing evidence-based rankings and cost-benefit insights, such studies can help align agricultural policies with national goals, ensuring efficient use of scarce resources and maximizing benefits for smallholder farmers (FMARD, 2022; FAO, 2023).

2.11. Contemporary challenges: Beyond the established threats, Nigeria's crop production is increasingly strained by contemporary challenges such as heightened climate variability, intensifying farmer-herder conflicts, and sudden fuel price shocks, which interact to amplify existing vulnerabilities. Climate variability manifests in more extreme and unpredictable patterns, including erratic monsoons and prolonged dry spells, disrupting planting cycles and exacerbating water scarcity in rain-fed systems (Ibebuchi and Abu, 2023; Jedwab et al., 2023). Farmer-herder conflicts, fueled by resource competition over dwindling arable land and water due to environmental pressures, have escalated in regions like the North Central zone, leading to further displacement, reduced cultivation areas, and loss of life (Gana et al., 2024; Ntihinyurwa and de Vries, 2021). Compounding these are fuel price shocks, driven by global energy fluctuations and domestic policy changes, which inflate transportation and irrigation costs, making inputs unaffordable and contributing to food inflation (Olufemi-Phillips et al., 2024; Etuk and Ayuk, 2021). These interconnected issues, as seen in recent spikes in diesel prices affecting mechanized farming, demand urgent research into adaptive strategies like conflict resolution mechanisms, diversified energy sources for agriculture, and variability-resistant cropping systems to build systemic resilience (Wakdok and Bleischwitz, 2021; Giller et al., 2021).

3. Proposed Research Topics Addressing Production Problems

3.1. Building resilience against insecurity:

3.1.1. The need for research to assess how well community-based security efforts protect farmers and their farmlands in high-risk areas.

3.1.2. Studies should explore the social and economic fallout when farmers are forced to leave their homes due to insecurity, and then develop effective strategies for helping them resettle and restart farming in their communities.

3.1.3. A crucial area of research involves analyzing how effective current government security measures are in farming zones and offering evidence-based suggestions for making them better.

The use of technology like remote sensing and drone surveillance to proactively monitor and reduce security threats that directly impact farming in vulnerable regions. Such technologies could offer innovative ways to give farmers early warnings and enable quick responses to security incidents, especially in remote areas where traditional security might fall short.

3.2. Developing Climate-Smart Agricultural Practices:

3.2.1. Research should focus on finding, evaluating, and promoting crop varieties that are tougher against climate stresses like drought, flooding, and heat, and that thrive in Nigeria's diverse agro-ecological zones (Ndudzo et al., 2024). This could involve working directly with farmers in breeding programs and conducting on-farm trials to see how different varieties perform locally.

3.2.2. There is a need for studies to develop and share information on water-efficient irrigation technologies and effective rainwater harvesting methods, specifically designed for smallholder farmers who rely

on rain-fed agriculture (Jedwab et al., 2023; Etuk and Ayuk, 2021; Mohammed et al., 2023; Olufemi-Phillips et al., 2024). Research should look into how practical, affordable, and adoptable various irrigation techniques are, considering local resources and farmers' ability to implement and maintain these systems.

3.2.3. Investigating how changing rainfall patterns and temperatures affect the growth cycles and overall yields of Nigeria's major crops is vital. This research should lead to creating adaptive planting calendars and smart crop management strategies that help farmers get the most out of their production under these changing climate conditions.

3.2.4. Research should also evaluate how effective agroforestry systems (which blend trees and shrubs into farm landscapes) and conservation agriculture practices (like no-till farming, cover cropping, and crop rotation) are at improving soil health, boosting water retention, reducing erosion, and ultimately making Nigerian farmlands more resilient to climate change's harsh effects (Arowosegbe et al., 2024; Gupta et al., 2023).

Exploring the effectiveness of traditional, indigenous climate adaptation strategies that farmers in different Nigerian regions have used for generations. These time-tested practices might offer valuable lessons on coping with environmental changes and could be combined with modern scientific approaches to enhance climate resilience.

3.3. Improving pest and disease management:

3.3.1. Research efforts should focus on developing comprehensive Integrated Pest Management (IPM) strategies for Nigeria's key crops. These strategies must prioritize sustainable and cost-effective solutions that smallholder farmers can use (Njoki et al., 2023).

3.3.2. Ongoing research is crucial for quickly detecting and effectively managing both new and existing pests and diseases that threaten crop production across Nigeria (Durodola, 2019; Olufemi-Phillips et al., 2024).

3.3.3. Studies are needed to investigate how climate change might impact the spread, geographical reach, and severity of crop pest and disease outbreaks. Understanding these connections is crucial for developing proactive management plans.

3.3.4. Research should also explore the potential of using biological control agents, like beneficial insects or microorganisms, and other eco-friendly methods as alternatives to synthetic chemical pesticides for sustainable pest and disease management.

Developing and widely distributing user-friendly early warning systems for upcoming pest and disease outbreaks. Giving farmers timely alerts and information can empower them to take preventative steps and implement appropriate control strategies early on, significantly reducing potential crop losses.

3.4. **Addressing high production costs and input access:**

3.4.1. There is a need for thorough economic analyses to evaluate how efficient and effective current government-led input subsidy programs are in Nigeria. These analyses should assess whether these programs truly reach their intended beneficiaries, their actual impact on crop yields and farmer incomes, and pinpoint specific areas where the design and implementation of subsidy programs could be improved (Bedeke, 2023; Olufemi-Phillips et al., 2024). Research should also explore alternative ways to ensure essential agricultural inputs get to farmers effectively.

3.4.2. Research should investigate whether it's feasible and impactful to promote the local production of essential agricultural inputs within Nigeria, such as fertilizers and other critical items (Akinrinola, 2018; Akinrinola and Fagbola, 2019; Adeola et al., 2023; Ugwu and Okon, 2024; Gana et al., 2024). This includes looking into the potential for public-private partnerships and using locally available raw materials in the production process.

3.4.3. Studies are required to explore and evaluate innovative financing mechanisms and tailored credit schemes that can genuinely improve smallholder farmers' access to affordable credit (Balana and Oyeyemi, 2021; Gana et al., 2024). These studies should consider the specific needs and risk profiles of small-scale agricultural producers.

3.4.4. Research could also investigate the potential of using digital agriculture platforms and e-commerce solutions to simplify how farmers access agricultural inputs, potentially cutting costs and improving availability for those in remote areas.

Exploring the economic viability and environmental impact of actively encouraging organic farming practices among Nigerian farmers as a way to reduce their reliance on expensive synthetic inputs. Investigating the potential for organic fertilizers and other sustainable soil management techniques could offer paths to lower production costs while also promoting environmentally sound agricultural practices.

3.5. Enhancing logistics and market access:

3.5.1. Research should focus on thoroughly analyzing the structure and overall performance of agricultural supply chains for key crops in Nigeria. The goal would be to identify critical bottlenecks, inefficiencies, and specific areas where improvements can be made in

transportation, processing, and marketing (Okotie, 2017; Bedeke, 2023; Olufemi-Phillips et al., 2024).

3.5.2. Studies are needed to assess the economic feasibility and potential impact of strategic investments in developing and improving rural transportation infrastructure, including roads, bridges, and storage facilities. These studies should aim to quantify the benefits of such infrastructure development on agricultural productivity, farmers' ability to access markets effectively, and the overall competitiveness of Nigeria's agricultural sector (Okotie, 2017; Olufemi-Phillips et al., 2024).

3.5.3. Research should also focus on developing and rigorously evaluating the effectiveness and affordability of various on-farm and community-level storage technologies and practices that can significantly reduce post-harvest losses for different crops across Nigeria (Binge et al., 2023). This research should consider factors like implementation cost, scalability, and suitability for specific local conditions and crop types.

3.5.4. Investigating the potential of using digital platforms and mobile technology to improve market connections for farmers is crucial. This includes exploring how these technologies can give farmers access to real-time price information for their crops and facilitate more direct links between producers and consumers, ultimately improving market access and reducing reliance on intermediaries in the supply chain.

Research into the feasibility and benefits of setting up community-based storage and basic processing facilities in key agricultural production areas. Such local infrastructure could empower farmers to better preserve their harvested crops, reduce spoilage, and potentially add value to their produce through initial processing before it reaches the wider market (Binge et al., 2023).

3.6. Enhancing agricultural practices and technology adoption:

3.6.1. Research should aim to identify the various socio-economic, cultural, and institutional factors that significantly influence smallholder farmers in Nigeria to adopt modern and efficient farming practices. This includes practices like mechanization, precision agriculture techniques, and improved agronomic methods (Okotie, 2017). Based on this understanding, it is possible to develop targeted strategies to effectively overcome barriers hindering the wider adoption of these beneficial practices.

3.6.2. Studies are needed to develop and rigorously evaluate the suitability, affordability, and overall impact of appropriate mechanization technologies specifically designed for the unique characteristics of small-scale farming systems common in Nigeria. This research should carefully consider factors like typical farm size, primary crops grown, and the specific local context where these technologies would be used. The goal is to identify and promote labor-saving and productivity-enhancing technologies that are truly accessible to smallholder farmers.

3.6.3. Research should also focus on assessing how effective different models for delivering agricultural extension services are in Nigeria. This includes evaluating the impact of public extension services, private sector-led initiatives, farmer-to-farmer knowledge sharing programs, and the use of digital extension platforms in spreading valuable knowledge, actively promoting the adoption of improved agricultural practices, and ultimately building the overall capacity of farmers nationwide (Arowosegbe et al., 2024; Danso-Abbeam et al., 2021). The aim is to find the most effective ways to deliver agricultural advice and ensure it reaches many farmers with relevant and practical information.

3.6.4. Research could also investigate the significant role and overall effectiveness of farmer cooperatives, agricultural associations, and other collective action models in improving smallholder farmers' access to essential resources, including inputs, credit, and relevant information. Furthermore, these collective models can play a crucial role in strengthening farmers' access to markets and improving their overall bargaining power within the agricultural value chain.

Research could explore the potential of establishing and strengthening farmer-to-farmer knowledge sharing networks and platforms. These peer-to-peer learning systems can be highly effective in spreading practical agricultural knowledge and encouraging the adoption of successful farming techniques within local communities, often proving more relatable and accessible than traditional top-down extension approaches.

3.7. Addressing crop-specific production challenges

3.7.1. For Maize, research should focus on breeding and distributing varieties that are more resistant to common pests and diseases like stem borers and maize streak virus (Ebukiba et al., 2020), while also tolerating the growing challenges of drought and heat stress (Ugwu and Okon, 2024). Additionally, research into sustainable farming practices that optimize fertilizer use and improve overall soil health in the diverse areas where maize is grown is essential (Adeola et al., 2023).

3.7.2. For Rice, studies should concentrate on developing and promoting rice varieties that offer higher yields, better grain quality, and stronger resistance to major diseases and pests common in

Nigeria (Ajala and Gana, 2015; Obianefo et al., 2021). Research should also investigate and promote improved water management practices for rice cultivation, including efficient irrigation techniques and strategies for effectively managing both water scarcity and flood risks in rice-growing areas (Ajala and Gana, 2015; Obianefo et al., 2021).

3.7.3. For Cassava, research efforts should prioritize developing and widely distributing cassava varieties that are highly resistant to major diseases like cassava mosaic disease (CMD) and cassava bacterial blight (CBB) (Ezeji et al., 2023). Furthermore, investigation into improved propagation methods and optimized farming practices is needed to boost overall cassava yields and the quality of harvested roots (Ezeji et al., 2023).

3.7.4. For Yam, research should focus on strategies to cut down the currently high cost of production (Wumbei et al., 2022; Mignouna et al., 2020). This includes exploring alternative, more efficient ways to propagate seed yams and developing yam varieties that don't need traditional staking, which is a labor-intensive practice (Wumbei et al., 2022).

3.7.5. For Sorghum and Millet, research should emphasize breeding and distributing high-yielding varieties that are specifically tolerant to drought conditions and resistant to Striga infestation, a major production hurdle in many regions (Rouamba et al., 2024; Mwamahonje et al., 2021; Sodedji et al., 2020). Additionally, research into improved farming practices tailored for these crops in Nigeria's drier regions is crucial (Mbanasor et al., 2024).

3.7.6. For Groundnut, research should focus on developing varieties that are resistant to key diseases like groundnut rosette disease and are less prone to aflatoxin contamination (Njoki et al., 2023). Studies should also investigate and promote better methods for accessing high-quality groundnut seeds and implementing effective pest and disease management strategies (Akinpelu et al., 2019; Njoki et al., 2023).

3.7.7. For Cowpea and Soybean, research efforts should prioritize developing and distributing varieties that show strong resistance to major insect pests, such as pod borers in cowpeas and rust in soybeans, as well as resistance to common diseases and parasitic weeds (Sodedji et al., 2020; Joshua, 2023; Akinrinola, 2023).

These varieties should also be well-suited to the specific environmental conditions found in Nigeria's various soybean and cowpea growing regions. Research should also focus on developing integrated pest management strategies that are both effective and affordable for smallholder farmers growing these important legume crops (Bottrell and Schoenly, 2018; Akinpelu et al., 2019).

3.7.8. For Plantain and Tomato, research should concentrate on developing plantain varieties that are resistant to major diseases like *Black Sigatoka* nematods and pests such as banana weevils (Akinpelu et al., 2019; Pillay et al., 2024; Oyedele et al., 2022). For both plantain and tomato, research should also investigate and promote improved post-harvest handling and storage techniques that can effectively extend the shelf life of these perishable crops and reduce significant post-harvest losses (Adewoyin, 2023; Binge et al., 2023).

The proposed research efforts for improving Nigeria's agricultural production system by focusing on specific crops are summarized in Table 2. Beyond individual crops, comparative studies could analyze the profitability and long-term sustainability of different cropping systems suitable for specific regions within Nigeria. Understanding the economic and environmental trade-offs associated with various cropping patterns can give farmers valuable information to make more informed decisions about what and how to plant.

Cross-Cutting Research Areas:

Research should explore the potential and address the challenges of using information and communication technologies (ICTs) to improve farmers' access to critical agricultural information, connect them more effectively with markets, and help them access essential financial services (Okotie, 2017; Chiaka et al., 2022).

Comprehensive research is needed to assess how effective different government agricultural policy interventions have been and to evaluate their overall impact on crop production levels and food security in Nigeria (Nwozor and Olanrewaju, 2020; Asirvatham et al., 2022).

Studies should investigate the various socio-economic factors that influence farmers' decisions about adopting new agricultural technologies and implementing improved farming practices (Liu et al., 2018).

Research could examine the potential of fostering public-private partnerships (PPPs) as a way to boost agricultural development across Nigeria and facilitate much-needed investment in critical agricultural infrastructure (Amuda and Parveen, 2024).

The impact of Nigeria's existing land tenure systems on overall agricultural productivity and farmers' willingness to make long-term investments in their land and farming practices warrants thorough investigation (Arowosegbe et al., 2024; Mohammed et al., 2023).

These research options should also focus on developing and implementing robust monitoring and evaluation frameworks specifically designed for agricultural research programs in Nigeria (Table 3). These frameworks are essential to ensure accountability and the overall impact of research investments, as well as to provide valuable data for guiding future research priorities and allocating resources within the agricultural sector.

Table 2: Proposed research areas for production challenges based on crop specificity

Crop	Key Production Challenges	Proposed Research Areas
Maize	Drought, heat stress, stem borers, armyworms, limited fertilizer use (Ugwu and Okon, 2024; Bedeke, 2023)	Breeding for stress and pest resistance; optimizing fertilizer use and soil health
Rice	Low yields, inadequate irrigation, need for high-quality seeds, pests and diseases (Ajala and Gana, 2015; Obianefo et al., 2021)	Developing high-yielding, resistant varieties; improving water management and seed systems
Cassava	Cassava mosaic disease, cassava bacterial blight (Ezeji et al., 2023)	Developing disease-resistant varieties; improving propagation and agronomic practices
Yam	High production costs, labor-intensive staking, and need for rapid seed multiplication (Wumbei et al., 2022; Mignouna et al., 2020)	Researching non-staking varieties and efficient propagation methods
Sorghum/Millet	Drought, Striga infestation, low yields (Rouamba et al., 2024; Mwamahonje et al., 2021)	Breeding for stress and Striga resistance; improving agronomic practices
Groundnut	Rosette disease, aflatoxin contamination, and access to quality seeds (Njoki et al., 2023)	Developing resistant varieties, improving seed access, and input use
Cowpea/Soybean	Pests (pod borers, aphids, thrips), diseases (rust), need for adapted varieties (Joshua, 2023; Sodedji et al., 2020)	Breeding for pest and disease resistance; developing locally adapted varieties
Plantain/Tomato	Pests (banana weevils, *Tuta Absoluta*), diseases (Black Sigatoka), post-harvest losses (Pillay et al., 2024; Oyedele et al., 2022; Binge et al., 2023)	Developing resistant varieties, improving post-harvest handling and storage

Table 3: Research themes addressing major challenges in crop production

Major Challenge	Corresponding Research Themes
Insecurity and Conflict	Community-based security, resettlement strategies, effectiveness of government measures, and technology for monitoring
Climate Change and Environmental Degradation	Climate-resilient varieties, water-efficient irrigation, adaptive planting, agroforestry, conservation agriculture, and indigenous adaptation strategies
Pest and Disease Outbreaks	Integrated pest and disease management, early warning systems, climate change impact on pests, and biological control methods
High Costs of Production and Limited Access to Inputs	Input subsidy program analysis, local input production, innovative financing, digital agriculture platforms, promotion of organic farming
Logistical Challenges and Market Access	Supply chain analysis, rural infrastructure investment, on-farm storage technologies, digital market linkages, community-based storage, and processing
Inefficient Agricultural Practices and Low Technology Adoption	Socio-economic factors influencing adoption, appropriate mechanization for smallholders, effectiveness of extension services, farmer cooperatives and associations, farmer-to-farmer knowledge sharing
Crop-Specific Production Challenges	Breeding for resistance and tolerance, improved agronomic practices, and post-harvest management (see table above for specific crops)
Cross-Cutting Research Areas	Leveraging ICTs, effectiveness of agricultural policies, socio-economic factors influencing technology adoption, public-private partnerships, impact of land tenure systems, monitoring and evaluation frameworks for research programs

Department of Crop and Horticultural Sciences
University of Ibadan, Ibadan,
Nigeria.
E-mail: tb.akinrinola@gmail.com

Conclusion and Recommendations: A Path Forward for Nigeria's Agriculture

Nigerian crop production faces a complex web of interconnected challenges that significantly threaten national food security, hinder economic growth, and negatively impact the livelihoods of millions of farmers. These challenges range from the pervasive issues of insecurity and the growing impacts of climate change to the persistent problems of pest and disease outbreaks, high production costs, logistical inefficiencies, and the slow adoption of modern agricultural practices. Addressing these multifaceted issues effectively requires a strong and sustained commitment to targeted and well-designed research. The research topics proposed in this report offer a comprehensive roadmap for future investigations that hold significant potential to generate evidence-based solutions and inform the development of effective policies and interventions. It's absolutely crucial to recognize that making real progress in the agricultural sector will require a multifaceted and highly collaborative approach. This collaboration must actively involve researchers from various fields, policymakers at all levels of government, the farmers who are the very heart of agricultural production, and all other key stakeholders across the agricultural value chain.

To ensure that research findings lead to tangible improvements on the ground, efforts must be specific to local contexts, directly address the needs and limitations of farmers, and align closely with national agricultural development goals and priorities. Finally, both government and private sector funding organizations should prioritize robust funding mechanisms and the development of adequate research infrastructure to effectively support these critical research endeavors. Such investments in agricultural research are vital for truly unlocking Nigeria's vast agricultural potential, building a more resilient and productive agricultural sector, and ultimately achieving lasting food security for the nation. The need for continuous review and adaptation of agricultural policies, based on research outcomes and in response to emerging challenges, is paramount. Agricultural policies should be dynamic tools, regularly shaped by the latest research findings and the evolving realities faced by farmers and the broader agricultural industry.

Corresponding Author:
T.B. Akinrinola

References

1. Adeola O, Akinrinola TB, Fagbola O. Performances of Maize and Soybean as Influenced by Intercropping and Fertilizer Sources in the Northern Guinea Savanna Agro-ecology of Nigeria. Journal of Central European Agriculture 2023, 24(3):667-680. DOI: 10.5513/JCEA01/24.3.3753
2. Adewoyin OB. Pre-harvest and post-harvest factors affecting quality and shelf life of harvested produce. In New Advances in Postharvest Technology. IntechOpen. 2023. https://doi.org/10.5772/intechopen.111649
3. Aiyedogbon JO, Anyanwu SO, Isa, GH, Petrushenko Y, Zhuravka O. Population growth and food security: Evidence from Nigeria. Problems and Perspectives in Management, 2022, 20(2):402-410. https://doi.org/10.21511/ppm.20(2).2022.33
4. Ajala AO, Gana AJ. Analysis of rice production in Nigeria. Journal of Agricultural Extension, 2015, 19(1):101-110. 26.
5. Akinpelu OA, Fagbola O, Aminu-Taiwo BR, Akinrinola TB. Influence of Plant Parasitic Nematode Control Amendments on the Soil, pH, Bacteria and Fungi Population under Three Plantain Varieties. Nigerian Journal of Horticultural Science 2019, 24(2):121-131. https://www.hortson.org.ng/images/Journals/2019volume/Akinpelu_et_al_2019.pdf
6. Akinrinola TB. Cassava Performance and Weed Biomass as Affected by Arbuscular Mycorrhizal Inoculation and Weed Control Methods. Researcher 2023, 15(2):1-15. DOI: 10.7537/marsrsj150223.01
7. Akinrinola TB. Influence of Siam Weed [*Chromolaena odorata* (L) King and Robinson] Compost on the Growth and Yield of Tomato (*Solanum lycopersicon* L.). Nigerian Journal of Horticultural Science 2018, 23:46-53. https://www.hortson.org.ng/images/Journals/2018volume/Akinrinola_et_al_2018_compressed.pdf
8. Akinrinola TB, Fagbola O. Pacesetter Organomineral, NPK 15-15-15 Fertilizers and Their Residual Effects on Performance of Cassava. New York Science Journal 2019, 12(1):40-46. DOI: 10.7537/marsnys120119.05

9. Amuda YJ, Parveen R. Public-private partnerships in driving sustainable agricultural growth for addressing poverty and food insecurity in Nigeria. Journal of Ecohumanism 2024, 3(4):3228-3240.
10. Anderson J, Marita C, Musiime D, Thiam M. National survey and segmentation of smallholder households in Nigeria. Understanding Their Demand for Financial, Agricultural, and Digital Solutions. 2017:89. https://thecompassforsbc.org/wp-content/uploads/Working-Paper-Survey2BSegmentation-of-Smallholders-Nigeria-Oct-2017.pdf
11. Ani OG, Boateng ID. Improving health through sustainable and healthy urban food system policy in Nigeria. Dietetics, 2024, 3(1):1-15. https://doi.org/10.3390/dietetics3010001
12. Arowosegbe OB, Ballali C, Kofi KR, Adeshina MK, Agbelusi J, Adeshina MA. Combating food waste in the agricultural supply chain: A systematic review of supply chain optimization strategies and their sustainability benefits. World Journal of Advanced Research and Reviews 2024, 24(01):122-140. https://doi.org/10.30574/wjarr.2024.24.1.3023
13. Asirvatham R, Demi SM, Ezezika O. Are sub-Saharan African national food and agriculture policies nutrition-sensitive? A case study of Ethiopia, Ghana, Malawi, Nigeria, and South Africa. Agriculture and Food Security 2022, 11:60 https://doi.org/10.1186/s40066-022-00398-x
14. Aynalem B. Empirical Review of *Tuta absoluta* Meyrick Effect on the Tomato Production and Their Protection Attempts. Advances in Agriculture, 2021, 2022(1):2595470. https://doi.org/10.1155/2022/2595470
15. Balana BB, Oyeyemi MA. Agricultural credit constraints in smallholder farming in developing countries: Evidence from Nigeria. World Development Sustainability 2021, 1:100012. https://doi.org/10.1016/j.wds.2022.100012
16. Bedeke SB. Climate change vulnerability and adaptation of crop producers in sub-Saharan Africa: a review on concepts, approaches and methods. Environment, Development and Sustainability 2023, 25:1017-1051. https://doi.org/10.1007/s10668-022-02118-8
17. Bello MM, Yahaya JU, Adamu I. An analysis of sustainable agricultural productivity and food security in Nigeria. Journal of Political Discourse 2024, 2(2):45-60.
18. Binge, B, Jalango D, Tesfaye L. 2023. Post-Harvest Losses Management through Climate Smart Innovations: A collaborative Approach Among Value Chain Actors. AICCRA technical report. Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA). https://hdl.handle.net/10568/135269
19. Bottrell DG, Schoenly KG. Integrated pest management for resource-limited farmers: Challenges for achieving ecological, social and economic sustainability. The Journal of Agricultural Science 2018, 156(3):408-426. https://doi.org/10.1017/S0021859618000473
20. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) Climate-Smart Agriculture in Nigeria. 2021. https://ccafs.cgiar.org
21. Chiaka JC, Zhen L, Yunfeng H, Xiao Y, Muhirwa F, Lang T. Smallholder Farmers Contribution to Food Production in Nigeria. Frontiers in Nutrition 2022, 9:916678. https://doi.org/10.3389/fnut.2022.916678
22. Danso-Abbeam G, Ojo TO, Baiyegunhi LJ, Ogundeji AA. Climate change adaptation strategies by smallholder farmers in Nigeria: does non-farm employment play any role?. Heliyon 2021, 7(6):e07162. https://www.cell.com/heliyon/fulltext/S2405-8440(21)01265-2
23. Durodola O. The Impact of Climate Change Induced Extreme Events on Agriculture and Food Security: A Review on Nigeria. Agricultural Sciences 2019, 10:487-498. doi: 10.4236/as.2019.104038.
24. Ebukiba ES, Anthony L, Adamu SM. Economics and Technical Efficiency of Maize Production Among Small Scale Farmers in Abuja, Nigeria: Stochastic Frontier Model Approach. European Journal of Agriculture and Food Sciences 2020, 2(6):1-9. https://doi.org/10.24018/ejfood.2020.2.6.145
25. Etuk EA, Ayuk JO. Agricultural commercialisation, poverty reduction and pro-poor growth: evidence from commercial agricultural development project in Nigeria. Heliyon 2021, 7(5):e06818. https://www.cell.com/heliyon/fulltext/S2405-8440(21)00921-X
26. Ezeji LA, Adediji AO, Nkere CK, Ogbe OC, Onyeka JT, Atiri GI. Viruses associated with cassava mosaic disease and their alternative hosts along Nigeria-Cameroon border. African Crop Science Journal 2023, 31(3):263-277.
27. Federal Ministry of Agriculture and Rural Development (FMARD) National Agricultural Technology and Innovation Policy (NATIP) 2022–2027. 2022.

28. Food and Agriculture Organization (FAO)Nigeria Country Programming Framework (CPF 2023–2027). 2023. https://www.fao.org
29. Gana IM, Sadiq K, H, Adamu, OT, Aliyu, M. The Interplay between Climate Change and Food Security in Nigeria: Challenges and Opportunities. Journal of Political Development 2024, 2(2): 154-164.
30. Giller KE, Delaune T, Silva JV. et al. The future of farming: Who will produce our food?. Food Sec. (2021, 13, 1073-1099 https://doi.org/10.1007/s12571-021-01184-6
31. Gupta SR, Dagar JC, Sileshi GW, Chaturvedi RK. Agroforestry for Climate Change Resilience in Degraded Landscapes. In: Dagar, J.C, Gupta, S.R, Sileshi, G.W. eds) Agroforestry for Sustainable Intensification of Agriculture in Asia and Africa. Sustainability Sciences in Asia and Africa. Springer, Singapore. 2023. https://doi.org/10.1007/978-981-19-4602-8_5
32. Ibebuchi CC, Abu I. Rainfall variability patterns in Nigeria during the rainy season. Scientific Reports 2023, 13(1):1-12. https://doi.org/10.1038/s41598-023-34970-7
33. IITA (International Institute of Tropical Agriculture). Improving Crop Yields in Nigeria: IITA Research Reports. 2023. https://www.iita.org/news-item/iita-yam-breeding-program-collaborates-with-farmers-to-boost-seed-yam-production-across-nigerian-states/
34. International Food Policy Research Institute (IFPRI). Mapping evidence of food system transformation for healthier diets: What works?. 2021 https://www.ifpri.org/publication
35. Jedwab R, Haslop F, Zarate R, Rodriguez Castelan C.The effects of climate change in the poorest countries: Evidence from the permanent shrinking of Lake Chad (No. 16396). IZA Discussion Papers. 2023. https://hdl.handle.net/10419/279094
36. Joshua B. Current Knowledge on Biotic Stresses affecting Legumes: Perspectives in Cowpea and Soybean. Advances in Legume Research: Physiological Responses and Genetic Improvement for Biotic Stress Resistance. 2023, 2:14-36.
37. Liu T, Bruins R. J, Heberling MT. Factors Influencing Farmers' Adoption of Best Management Practices: A Review and Synthesis. Sustainability 2018, 10(2):432. https://doi.org/10.3390/su10020432
38. Mbanasor JA, Kalu C, Okpokiri C, Onwusiribe C, Nto P, Agwu N, Ndukwu MC. Climate smart agriculture practices by crop farmers: Evidence from South East Nigeria. Smart Agricultural Technology 2024, 8:100494. https://doi.org/10.1016/j.atech.2024.100494
39. Mignouna DB, Akinola AA, Abdoulaye T, Alene AD, Manyong V, Maroya NG, Aighewi BA, Kumar LP, Balogun M, Lopez-Montes A, Rees D, Asiedu R. Potential returns to yam research investment in sub-Saharan Africa and beyond. Outlook on Agriculture 2020, https://doi.org/10.1177/0030727020918388
40. Mohammed K, Batung E, Saaka SA, Kansanga MM, Luginaah I. Determinants of mechanized technology adoption in smallholder agriculture: Implications for agricultural policy. Land Use Policy 2023, 129:106666. https://doi.org/10.1016/j.landusepol.2023.106666
41. Mwamahonje A, Eleblu JS, Ofori K, Deshpande S, Feyissa T, Bakuza WE. Sorghum Production Constraints, Trait Preferences, and Strategies to Combat Drought in Tanzania. Sustainability 2021, 13(23):12942. https://doi.org/10.3390/su132312942
42. National Agricultural Research System (NARS) of Nigeria Priority Research Needs for Agricultural Transformation. Agricultural Research Council of Nigeria (ARCN). 2022.
43. Nboyine JA, Adazebra GA, Owusu EY, Agrengsore P, Seidu A, Lamini S, Zakaria M, Kwabena JY, Ali HK, Akaogu I, et al. Field Performance of a Genetically Modified Cowpea (Vigna unguiculata) Expressing the Cry1Ab Insecticidal Protein Against the Legume Pod Borer Maruca vitrata. Agronomy 2024, 14:3055. https://doi.org/10.3390/agronomy14123055
44. Ndudzo A, Sibanda Makuvise A, Moyo S, Bobo E. D. CRISPR-Cas9 genome editing in crop breeding for climate change resilience: Implications for smallholder farmers in Africa. Journal of Agriculture and Food Research 2024, 16:101132. https://doi.org/10.1016/j.jafr.2024.101132
45. Njoki, L, Sheila O, Peter W, Abigael O, James M, Margherita R, Safa O, and Truphosa A. Evaluation of agronomic characteristics, disease incidence, yield performance, and aflatoxin accumulation among six peanut varieties (*Arachis hypogea* L.) grown in Kenya. Toxins 2023, 15:2111. https://doi.org/10.3390/toxins15020111
46. Ntihinyurwa PD, De Vries WT. Farmland Fragmentation, Farmland Consolidation and Food Security: Relationships, Research Lapses and Future Perspectives. Land, 2021, 10(2):129. https://doi.org/10.3390/land10020129

47. Nwozor A, Olanrewaju JS. The ECOWAS agricultural policy and the quest for food security: assessing Nigeria's implementation strategies. Development Studies Research 2020, 7(1):59-71. https://doi.org/10.1080/21665095.2020.1785904
48. Obianefo CANJ, Mzyece A, Masasi B, Obiekwe NJ, Anumudu OO. Technical Efficiency and Technological Gaps of Rice Production in Anambra State, Nigeria. Agriculture 2021, 11(12):1240. https://doi.org/10.3390/agriculture11121240
49. Okotie S. The Nigerian Economy Before the Discovery of Crude Oil. The Political Ecology of Oil and Gas Activities in the Nigerian Aquatic Ecosystem 2017:71-81. https://doi.org/10.1016/B978-0-12-809399-3.00005-7
50. Olomola AS, Nwafor M. Nigeria agriculture sector performance review: A background report for the Nigeria 2017 agriculture joint sector review. 2018. https://fscluster.org/sites/default/files/documents/nigeria_agric_sector_review_report_august_2018.pdf
51. Olomu MO, Ekperiware MC, Akinlo T. Agricultural sector value chain and government policy in Nigeria: issues, challenges and prospects. African Journal of Economic and Management Studies 2020, 11(3):525-538 DOI: 10.1108/AJEMS-03-2019-0103
52. Olufemi-Phillips AQ, Igwe AN, Ofodile OC, Louis N. Analyzing economic inflation's impact on food security and accessibility through econometric modeling. GSC Advanced Research and Reviews 2024, 21(02):102-128. https://doi.org/10.30574/gscarr.2024.21.2.0411
53. Oyedele OB, Ojo OS, Arowolo OO. Information and Training Needs of Plantain Farmers in Edo State, Nigeria. Horticultural Society of Nigeria 2022, 27(1):1-8. 38.
54. Pillay M, Tenkouano A, Hartman J. Bananas and plantains: future challenges in Musa breeding. In Crop Improvement . CRC Press. 2024:223-252.
55. Rouamba A, Shimelis H, Drabo I, Shamuyarira KW, Mrema E. Management of the Striga epidemics in pearl millet production: a review. CABI Agric. Biosci. 2024, 5:11 https://doi.org/10.1186/s43170-023-00210-1
56. Sodedji FAK, Agbahoungba S, Nguetta SPA, Agoyi EE, Ayenan MAT, Sossou SH, Kone D. Resistance to legume pod borer (Maruca vitrata Fabricius) in cowpea: genetic advances, challenges, and future prospects. Journal of Crop Improvement 2020, 34(2):238-267.
57. Ugwu CN, Okon MB. Fostering Food Security through Enhanced Fertilizer Production: Examining Policy Frameworks. INOSR Experimental Sciences 2024, 13(1):31-37. https://doi.org/10.59298/INOSRES/2024/1.31.3710
58. Wakdok SS, Bleischwitz R. Climate Change, Security, and the Resource Nexus: Case Study of Northern Nigeria and Lake Chad. Sustainability 2021, 13(19):10734. https://doi.org/10.3390/su131910734
59. World Bank. Enhancing Agricultural Productivity in Nigeria: Opportunities and Constraints. 2020. https://www.worldbank.org
60. Wumbei A, Gautier SKN, Kwodaga JK, Joseph DF, Galani YJH. State of the art of yam production. In: Root vegetable. IntechOpen. 2022. https://doi.org/10.5772/intechopen.106504

8/6/2025