# Public Facing Report for Climate-Smart Agriculture Partnership: UK-Brazil-Africa [Innovate UK]

## Enhancing Cassava Productivity in Africa:

## Connecting the dots for sustainable agriculture and higher yields in Ghana and Nigeria with microbial biological solutions

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| **Report compiled by** | Reihaneh Bashiri<br>Georgos Zangos |
| **Centre for Process Innovation Group** (CPI Group) | Wilton Centre<br>Wilton<br>Redcar<br>Cleveland<br>TS10 4RF<br>United Kingdom |
| **Telephone** | +44 (0)1642 455 340 |
| **Website** | www.uk-cpi.com |

# Contents

# 1 Summary of the topic area

Cassava is a staple crop in Africa, playing a crucial role in food security and economic livelihoods, particularly in Ghana and Nigeria. Despite its significance, cassava productivity in these regions faces numerous challenges, including low yields, soil degradation, pest and disease pressures, and climate variability. Traditional farming practices, limited access to improved agricultural inputs, and inefficient extension services further exacerbate these challenges. In addition, farmers face challenges in generating the right products for a price that is financially viable. Addressing these issues is critical to ensuring sustainable food production systems that align with climate-smart agricultural principles [1,2,3].

Microbial biological solutions present a promising approach to enhancing cassava productivity while promoting sustainability. These solutions leverage beneficial microorganisms such as plant-growth-promoting rhizobacteria (PGPR), mycorrhizal fungi, and biofertilisers to improve soil health, enhance nutrient uptake, and increase crop resilience against pests and environmental stresses. Integrating microbial solutions into cassava farming practices can contribute to higher yields, reduced reliance on chemical fertilisers, and improved overall sustainability.

The Scoping Project for Climate-Smart Agriculture Partnership: UK-Brazil-Africa seeks to build trilateral networks between the UK, Brazil, and Africa (Ghana and Nigeria) to facilitate knowledge exchange and identify collaborative opportunities for enhancing cassava productivity using microbial biological solutions. Brazil, with its advanced research and application of microbial-based agricultural solutions, provides valuable expertise that can be adapted for use in African farming systems. The UK contributes expertise in agritech innovation, sustainable farming practices, and capacity-building initiatives.

Cassava production in Ghana and Nigeria has experienced growth, with Nigeria being the world's largest producer, contributing 20% of global production [4]. However, the sector remains underdeveloped in terms of commercial processing and export, as most production is for local consumption [5]. Yield levels remain low, averaging 6.4 tonnes per hectare in Nigeria and 25.1 tonnes per hectare in Ghana, compared to much higher yields in South American and Asian countries like Guyana (41.4 tonne per hectare) and India (35.77 tonne per hectare) [6]. Brazil another important producer of cassava averages 15.4 tonnes per hectare [6]

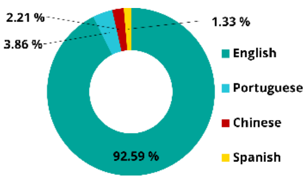
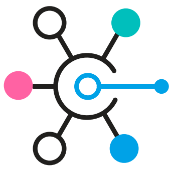
This highlights a significant yield gap that climate-smart solutions, including microbial biological interventions, can help bridge.

This project will assess the key challenges, barriers, and technology gaps impacting the adoption of microbial biological solutions in Ghana and Nigeria. It will also explore opportunities for international collaboration to transfer, develop, commercialise, adopt, and scale-out these technologies. By fostering partnerships among researchers, industry stakeholders, and policymakers, the project aims to create a sustainable framework for implementing microbial biological solutions to boost cassava productivity, enhance climate resilience, and promote food security in Ghana and Nigeria. Exchange of best practice between UK, Brazil, and Nigeria could have impacts in all countries.

## 1.1 Global trends in cassava research

Table 1, provides a brief overview of global trends in cassava research, publication, and funding based on the recent research conducted by Olutosin Ademola Otekunrin from Innovation Lab for Policy Leadership in Agriculture and Food Security (PiLAF), University of Ibadan, Ibadan, Nigeria. [4].

**Table 1**. The bibliographic insights on cassava, based on the information collated from reference [4].

| | |
|---|---|
|  | A total of 13,238 research and review articles were published on Scopus between 2000 and 2023. |
|  | English (92.59%) was the most frequently used language in the publications, followed by Portuguese (3.86%), Chinese (2.21%), and Spanish (1.33%). |
|  | The top five countries publishing the most cassava-related articles were, in order: Brazil, Nigeria, China, Thailand, and the United States.<br><br>The most cited articles focused on:<br>• Plant viruses<br>• Structure and properties of cassava starch<br>• Deep learning for cassava disease detection<br><br>However, the lead authors of these highly cited studies were from the United States and Brazil, with none from African countries.<br><br>Regarding cassava-related research collaboration, Brazil, Nigeria, China, and Colombia had significant partnerships, though not necessarily with |

each other. For example, Nigeria collaborated primarily with the UK and other African countries, forming a distinct collaboration cluster, while Brazil's collaborations were mainly with South American countries, France, and Ireland.

The top three organisations publishing cassava-related research were:

- Brazilian Agricultural Research Corporation (Embrapa), Brazil
- International Institute of Tropical Agriculture (IITA), Nigeria
- International Centre for Tropical Agriculture (CIAT), Colombia

Additionally, the University of Ibadan and the Federal University of Agriculture, Abeokuta, both in Nigeria, ranked 4th and 10th, respectively.

Brazil's National Council for Scientific and Technological Development and China's National Natural Science Foundation were the top funding sponsors of cassava research publications.

By contrast, no African funding agency appeared among the top 15 sponsors of cassava research. Despite being the largest producer of cassava—led by Nigeria, the top global producer and the second-highest contributor to cassava research publications, with a significant number of cassava scientists—Africa relies largely on external funding. This highlights the crucial role of international collaboration in advancing research capacity building.

Frequent keywords (in parenthesis) in cassava publications were clustered into five groups, focusing on:

- Genetics and plant disease (Manihot)
- Global cassava production and food security (Manihot esculenta/cassava)
- Nutrition and human health (Controlled study)
- Cassava processing products (Starch)
- Biochemical processes of cassava (Fermentation)

However, fermentation in this context specifically refers to the use of cassava starch as a feedstock for producing biofuels like ethanol, as it was primarily linked to such terms.

# 2 Challenges, Barriers, and Technology Gaps

Cassava production in Nigeria faces multiple challenges (**Table 2**) that hinder productivity, sustainability, and profitability. Key barriers include low yield performance due to poor agronomic practices, limited mechanisation, and land tenure issues that restrict large-scale farming. Soil degradation and declining fertility further reduce output, while pests and diseases, such as cassava mosaic virus and bacterial blight, threaten crop health. Farmers struggle with climate variability, including unpredictable rainfall patterns, leading to lower yields. Limited access to finance prevents smallholder farmers from investing in improved seeds, fertilisers, and modern farming techniques. Additionally, post-harvest losses due to inadequate storage and processing facilities reduce profitability. Urbanisation and land pressure shrink available farmland, while poor market access and trade restrictions prevent Nigeria from fully capitalising on its cassava production potential [7-9].

Our interactions with African stakeholders revealed ineffective fertilisation practices or complete avoidance of fertiliser use in cassava cultivation. Despite cassava's resilience to pests, water, and soil conditions, the absence of proper land management strategies has led to decreased productivity. Expanding research on soil health and promoting affordable irrigation solutions could address these long-standing challenges.

Technology gaps further compound these challenges, particularly the low availability of biofertilisers, limited adoption of microbial biocontrol solutions, and lack of automation in cassava farming. Weak integration of microbial storage solutions and low research investment in microbial innovations also hinder productivity. Addressing these gaps through climate-smart agricultural approaches, such as microbial biofertilisers, biopesticides, and biostimulants, can significantly improve cassava production.

Microbial products, including biofertilisers and biostimulants, can help restore soil health, improve nutrient uptake, and increase resistance to environmental stressors like drought and pests. These fermentation-derived solutions provide a sustainable alternative to chemical inputs, offering smallholder farmers a cost-effective means to enhance productivity and profitability [10]. However, achieving widespread adoption requires investment in research and development, infrastructure improvements, and stronger policy support to facilitate market access and encourage mechanisation.

**Table 2.** Challenges, Barriers and Technology Gaps for Cassava Production in Nigeria.

| Challenges and Barriers | Details | Ref. | Technology Gaps | Potential Solutions |
|---|---|---|---|---|
| Low Yield Performance | Nigeria's cassava yield per hectare is lower than other major producers due to inefficient agronomic practices. | 8 | Limited availability and use of biofertilisers or microbial inoculants. | Promote biofertilisers (e.g., nitrogen-fixing bacteria, phosphate-solubilising microbes) to improve soil nutrient availability. Use bio stimulants (plant growth-promoting rhizobacteria, microbial inoculants) to enhance root development and stress resistance. |
| Limited Mechanisation | Most cassava farming is done manually, making production inefficient and labour-intensive. | 8 | Lack of automation in cassava farming. | Introduce affordable (semi)-mechanised cassava planter or harvester for small-scale farmers or pay-as-you-go plans to rent such equipment. |
| Land Tenure System & Land Pressure | Small farm sizes, insecure land tenure, and urban expansion reduce available agricultural land for cassava cultivation. | 8 | Limited research on land-use planning integrating microbial soil management. | Implement land reform policies and promote agroforestry techniques that utilise microbial consortia to maintain soil productivity, even in smaller land areas. |
| Soil Degradation & Poor Fertility | Continuous cultivation without proper soil management leads to declining soil fertility and lower yields. | 9 | Poor adoption of soil-enhancing microbes. | Promote soil microbiome restoration using microbial consortia (e.g., mycorrhizal fungi, Bacillus spp.) to improve nutrient uptake. Encourage organic amendments like compost tea to restore soil fertility. |
| Climate Variability | Unpredictable rainfall patterns and drought stress negatively affect cassava growth and yield. | 9 | Lack of microbial stress-tolerant solutions. | Develop drought-tolerant cassava varieties, and microbial stress tolerance enhancers. |
| Pests & Diseases | Cassava bacterial blight, mosaic virus, and mealybugs | 8 | Limited research on microbial biocontrol agents. | Introduce bioherbicides and biopesticides derived from cassava fermentation |

| Challenges and Barriers | Details | Ref. | Technology Gaps | Potential Solutions |
|---|---|---|---|---|
| | significantly reduce crop productivity. | | | byproducts (e.g., fungal-based pest control). Use RNA interference (RNAi)-based biocontrol to target cassava mosaic virus and bacterial blight. |
| Limited Access to Finance | Smallholder farmers struggle to obtain credit for improved seeds, fertilisers, and mechanisation. | 8 | Lack of investment in microbial solutions. | Develop biotechnology incubators and funding schemes to support bio-based agritech startups. Establish farmer cooperatives focused on biofertiliser and microbial inoculant production for cassava farming. |
| Inadequate Research & Development | Slow adoption of improved varieties and farming techniques due to limited investment in research and development. | 8 | Lack of research on microbial-enhanced cassava breeding and production. | Increase investment in biotechnological research and development, including fermentation-derived biofertilisers and bioherbicides, soil microbiome analysis, and precision farming tools integrating microbiome data. |
| Post-Harvest Losses | Lack of efficient processing and storage facilities leads to significant cassava wastage. | 8 | Weak integration of microbial storage solutions. | Ferment cassava peels and wastes (starch) to bioethanol, organic acids, and biodegradable plastics, to reduce waste and produce value. Develop microbial fermentation-derived products that can be sprayed on cassava root and extend its shelf-life. |
| Limited Market Access & Trade Barriers | Despite being the largest producer, Nigeria exports very little cassava due to poor infrastructure and trade restrictions. | 8 | Low adoption of biotechnology in processing. | Use biotechnology-enhanced processing (e.g., enzymatic hydrolysis for high-quality cassava flour) to improve market competitiveness. Establish fermentation-based value chains (e.g., cassava starch for bio-packaging industries). |

| Challenges and Barriers | Details | Ref. | Technology Gaps | Potential Solutions |
|---|---|---|---|---|
| Aging Farming Population & Labor Shortages | Many young people are leaving rural areas, and most cassava farmers are aging, reducing workforce availability. | 8 | Limited adoption of automated microbial fermentation processes to reduce labour dependency. | Promote biotech-driven automation in cassava processing (e.g., microbial-assisted fermentation units). Engage youth in biotechnology entrepreneurship in cassava value addition. |
| Farmers' Overestimation of Yield | Traditional methods of predicting cassava yield often overestimate actual production, affecting planning and market supply. | 9 | Lack of AI-driven microbial soil health monitoring for accurate yield prediction. | Develop AI-driven microbial soil health monitoring systems that predict cassava yields accurately. Use fermentation-based biomarkers to assess soil nutrient status and cassava productivity. |

# 3 Opportunities for collaboration

## 3.1 Microbial Solutions

Collaboration across farmers, research institutions, industry stakeholders, and policymakers presents a unique opportunity to accelerate the adoption and scaling of microbial biological solutions in cassava production. By leveraging expertise across different regions, knowledge transfer, technology adaptation, commercialisation, and adoption by farmers can be strengthened in a way that ensures long-term sustainability.

**Facilitating Knowledge Exchange and Technology Transfer:** Innovations in microbial solutions have been successfully integrated into farming in other regions such as in Brazil, demonstrating significant improvements in soil health, yield, and climate resilience. By creating structured platforms for knowledge-sharing and technical exchange, there is potential to adapt and optimise these solutions for new agricultural landscapes. Collaboration plays a key role in this process, as lessons learned from successful microbial integration in Brazil can inform best practices in Africa.

**Advancing the commercialisation of microbial Inputs:** While microbial-based biofertilisers and biocontrol solutions have shown promising results, accessibility and affordability remain key challenges. Collaborative efforts can drive:

- Localised production models, ensuring microbial inputs are developed in a way that meets regional soil and climate needs.
- Market linkages and private sector engagement to enable efficient distribution and uptake of bio-based agricultural solutions.
- Improved supply chain mechanisms to bridge gaps in availability and ensure quality assurance, reducing concerns over product authenticity.
- Building capacity and strengthening farmer engagement

A key component of scaling these solutions is ensuring farmers have the knowledge and confidence to adopt them effectively. Collaboration between agricultural research institutions, development organisations, and industry players can enhance:

- On-farm trials and demonstration projects to showcase the tangible benefits of microbial inputs.
- Training services that integrate on-ground farmer support.
- Stronger networks between researchers and farmer cooperatives, ensuring that innovations align with real on-the-ground needs.

**Scaling Microbial Innovation Through Policy and Investment:** Beyond technical and market-driven efforts, policy alignment and investment incentives will be critical to ensuring the sustainable expansion of microbial solutions. Collaborative advocacy can focus on:

- Policy frameworks that support climate-smart and microbial-based inputs, ensuring regulatory clarity and farmer protection from substandard products.
- Investment in research and commercial scaling, helping bridge the gap between promising research and widespread farmer adoption.
- Public-private partnerships, aligning government initiatives with private-sector expertise to strengthen supply chains and reduce dependency on external agrochemical inputs.

**Enabling a Systemic Shift in Cassava Production:** By bridging research, innovation, commercialisation, and farmer adoption, collaborative approaches can unlock new efficiencies in cassava production. The potential for regional adaptation of microbial technologies not only enhances productivity but also strengthens long-term food security and climate resilience. Through targeted collaboration, cassava-producing regions can move towards a more sustainable and self-sufficient agricultural model, reducing input dependency and improving profitability for smallholder farmers.

## 3.2 Other opportunities.

The International Institute of Tropical Agriculture (IITA) in Nigeria has developed a searchable database called the Product Platform for Agricultural Solutions [11]. This platform aims to connect solution providers with their potential clients across Africa, particularly investors and large-scale adopters. A list of current cassava-related solutions available on the platform is presented in **Table 3**.

**Table 3.** IITA's Cassava-related solutions and requirements on Product Platform for Agricultural Solutions [11].

| Link to the Solution | Problem/Solution | Start-up Requirement |
|---|---|---|
| Aflatoxin management | Aflatoxin produced by Aspergillus flavus in soil contaminates cassava crops, posing health risks to humans and animals through direct consumption and contaminated products like milk and eggs. AflaSafe, a commercial fungal inoculant, uses a mixture of four non-toxin-producing Aspergillus flavus strains to outcompete toxin producers in soil, with spores coated on sorghum grains for protection, nutrient supply, and easy application. | 1) Register biocontrol agents and support health assessments, 2) Develop rollout plans based on local conditions, 3) Establish technology transfer agreements, 4) Support manufacturing, distribution, and marketing, 5) Provide training in quality assurance and safety checks. |
| "Six Steps" cassava weed management | Weeds compete with cassava for water and nutrient and reduce the yield, herbicides can reduce their impact. | 1) Raise awareness of benefits for cassava yield, input efficiency, and resilience, 2) Share decision support tools through farmer networks and extension agencies, 3) Facilitate small loans to cover initial herbicide and labour costs. |
| Cassava seed-bulking farms | Impacts the supplies of improved, disease-resistant cassava planting material across major growing regions | 1) Select cassava varieties suited to local conditions to boost demand, 2) Train farmers in seed-bulking techniques, 3) Optimise planting material production and distribution based on environment and infrastructure, 4) Provide loans for establishing seed-bulking farms. |
| Waxing Cassava roots | Slowing down cassava root deterioration using fungicide | A well-constructed packhouse is required to apply the technology. A packhouse is a facility where fresh cassava roots undergo shelf-life extension treatments before distribution. It involves operations like sorting, washing, disinfecting, drying, waxing, and packing, with simple or modern setups depending on investment capacity. |
| Herbicide calculator | Dosing herbicides correctly to make them effective | Training, android phones, data |
| Hydroponic cassava | Developing semi-autotrophic hydroponic systems for cassava multiplication offers a faster alternative to traditional seed and tissue culture methods. This | 1) Educate farmers and multipliers on the benefits of technology for multiplying cassava planting material, 2) Obtain pathogen-free seeds or in-vitro mother plants from improved cassava varieties, 3) Build a growth chamber or screen house and acquire shelves |

| Link to the Solution | Problem/Solution | Start-up Requirement |
|---|---|---|
| | approach also reduces the risk of disease and pests. | and growth media for propagation, 4) Coordinate marketing and delivery of technology through existing cassava seed system suppliers. |
| Producing value from cassava waste | Low-tech approaches for processing wet cassava peels into safe and hygienic animal feed | 1) Raise awareness among farmers and processors about the benefits of using cassava peeling waste for animal feed production, 2) Identify suitable equipment setups for cassava peel processing based on throughput volumes and available labour, 3) Develop operational protocols and business plans for processing and marketing cassava peel animal feed products, 4) Map local and district-level sources of cassava peels to assess available volumes for processing facilities. |
| Manufacturing cassava flour | Detoxifying cassava roots and processing them to food-grade flour using machines. | 1) Raise awareness among cassava farmers, agri-food companies, and manufacturers about the benefits of High-Quality Cassava Flour (HQCF) and starch, 2) Identify profitable, durable, and equitable market integration for HQCF and starch, 3) Ensure a reliable supply of cassava roots with high dry matter and starch content near the processing plant, 4) Set up processing methods with energy-efficient, labour-saving equipment like graters and dewatering machines, 5) Train machine operators and workers on maintaining quality throughout the manufacturing process. |
| Flash dryer to produce cassava flour | Flash dryers can process cassava to flour. | A flash dryer user must be able to build a processing factory where the dryer and other machines such as grater, peeler, dewatering machine, and other machines will be placed. |
| Cassava varieties with high dry matter and starch content | Breeding cassava for high dry matter and starch content to bring a higher economic yield for farmers | 1) Identify or develop cassava varieties with high dry matter and starch content suited to the value chain conditions, 2) Promote the production and marketing of high-quality cassava by multipliers and seed companies in the region, 3) Establish linkages between seed suppliers, cassava growers, food processors, and consumer groups to create demand for cassava-based products, 4) Provide financial support to local suppliers and smallholder farmers to encourage investments and purchases of improved-quality cassava. |

| Link to the Solution | Problem/Solution | Start-up Requirement |
|---|---|---|
| Golden cassava varieties (Vitamin A fortified) | Developing biofortified varieties of cassava that are rich in vitamin A to reduce malnutrition among the local people. | 1) Define quality parameters, norms, and screening methods for golden cassava varieties from the perspective of all actors in the value chain, 2) Ensure multipliers and seed companies produce and market high-quality seed with equal or higher root yield than non-biofortified varieties, 3) Link seed suppliers, cassava growers, food processors, and consumer groups to create demand for nutritional food, 4) Provide financial support to local suppliers and smallholder farmers to stimulate investments and purchases of golden cassava planting material. |
| Disease resistant cassava varieties | Breeding cassava that are resistant towards disease. | 1) Awareness-raising with multipliers, farmers and food processors about the benefits of disease resistant cassava varieties, 2) Identifying and acquiring elite immune lines that are adapted to conditions and needs in growing areas, 3) Stakeholder capacity building on propagation of healthy planting material through local delivery hubs. |
| Specialty blended fertilisers for root and tuber crops | Promoting use of inorganic fertiliser | 1) Adapt blended fertiliser formulas to meet the specific nutrient requirements of a growing area, 2) Establish manufacturing protocols for mixing various fertiliser sources, 3) Educate growers on the benefits of specialty fertiliser blends, 4) Ensure affordable access to fertilisers in local markets. |
| Mobile Cassava Processing Plant | An alternative investment approach for the private sector to avoid the problems associated with investments in expensive immobile processing factories. | The specially constructed Mobile Cassava Processing Plant (MCPP) consists of modern processing machinery and an electricity generator that housed on a six-wheel truck equipped with a loader crane. The installed machinery depends on the type of semi-processed or final cassava product desired. |
| Mechanised Cassava Planting and Harvesting | Mechanise the cassava production system to enhance the competitiveness of African farmers in the global market and prevent root damage during manual harvesting. | The farmer must have access to a suitable farmland of adequate size in an agro ecology that is suitable for cassava growing. The components of mechanised cassava production include land preparation, cassava stakes, mechanical planting, pre-emergence herbicide and its application, post-emergence herbicide and its application, fertiliser and its application, other forms of weeding, mechanical harvesting and transportation of fresh roots, and other miscellaneous activities. |

| Link to the Solution | Problem/Solution | Start-up Requirement |
|---|---|---|
| Contract mechanisation apps (e.g. Hello Tractor) | A power equipment sharing app connecting tractor owners and smallholder farmers in rural Sub-Saharan Africa. The platform promotes collaborative consumption by allowing farmers to request and pay for services via SMS and mobile wallets, creating a marketplace for equipment owners and companies. | 1) Purchase and install smart devices for tracking equipment and download the Hello Tractor app from the Google Play Store, 2) Upload tractor specifications, trained operators, and booking agents to your account, 3) Service farmers in the area through booking agents, 4) Track the movement and performance of tractors, operators, and booking agents to ensure maximum uptime, profits, and reduced fraud. |
| Cassava disease diagnosis app | A smartphone app that uses artificial intelligence to provide instant offline diagnosis of major crop damage symptoms, including cassava mosaic disease, cassava brown streak disease, and cassava green mite, with applicability to maize as well. | Nothing other than downloading from Google's PlayStore |
| Cassava Business Connector (CBC) | A digital innovation for cassava value chain integration to enhance market access for producers and buyers | ICT App for market linkage and collaboration to verify information. |

# 4 Key stakeholders and their roles

Scaling climate-smart agricultural solutions for cassava production requires a coordinated effort across research, innovation, commercialization, supply chains, and farmer adoption. The success of microbial interventions depends not only on scientific advancements but also on effective technology transfer, market accessibility, and policy support. To achieve this, the project engaged with 21 organizations across Nigeria, Ghana, Brazil, and the UK, representing a diverse mix of research institutions, agribusinesses, microbial technology developers, and farmer networks. These organizations were selected based on their expertise in agricultural research, microbial product development, and sustainable farming practices, ensuring a comprehensive, cross-sectoral approach to solving cassava production challenges.

Throughout this process, we sought to build a robust international collaboration network, reaching out to stakeholders in government research institutions such as Embrapa in Brazil, research organisations such as IITA, leading universities such as the University of Port Harcourt in Nigeria and the University of Ghana, AgriTech companies such as Legume Technology in the UK, and farmer organizations such as Ruveny Integrated Agroventures in Nigeria. Some of these organizations responded and engaged in exploratory discussions, while others provided valuable insights into regional barriers, commercial scalability, and regulatory considerations for microbial solutions. This extensive engagement process helped us identify key strategic partners whose expertise and networks align with our mission to accelerate the adoption of microbial inputs and enhance cassava productivity in West Africa.

The partnership combines Brazil's leadership in microbial research and agronomy, Nigeria's deep-rooted research expertise in cassava production, and the UK's strengths in biofertiliser innovation and commercialisation. Each stakeholder plays a crucial role in ensuring that microbial solutions move beyond laboratory research and into scalable, real-world applications for farmers. By integrating scientific research, commercial expertise, and practical field implementation, this initiative aims to deliver tangible productivity gains for cassava farmers while promoting sustainable soil health and resilience to climate change.

Finally, we have identified a core group of partners for collaboration from research organisation to industry each with important capabilities and extensive networks. The following key partners form the foundation of this collaborative effort:

## 4.1 Embrapa (Brazilian Agricultural Research Corporation)

Embrapa is a leading agricultural research institution in Brazil, renowned for its advancements in agricultural biotechnology and sustainable farming practices. Their contributions to a collaborative project can include:

**Research and Development:** Providing expertise in microbial-based agronomy, including the development of biofertilisers and biopesticides tailored for cassava cultivation.

**Technology Transfer:** Facilitating the adaptation of successful microbial interventions from Brazil to West African conditions, ensuring relevance and effectiveness.

**Capacity Building:** Offering training programs and workshops to enhance the technical skills of local researchers and extension workers in microbial technologies.

## 4.2 National Root Crops Research Institute (NRCRI, Nigeria)

The NRCRI specialises in the research and development of root and tuber crops, with a strong focus on cassava. Their role encompasses:

**Microbial Resource Development:** Extraction and isolation of local microbes that act as plant growth promoters.

**Local Research Expertise:** Conducting field trials and evaluations of microbial solutions to ensure they meet the specific agronomic needs of Nigerian cassava farmers.

**Farmer Outreach:** Utilising established networks to disseminate knowledge and promote the adoption of innovative practices among smallholder farmers.

**Policy Advocacy:** Engaging with governmental bodies to align project goals with national agricultural policies and secure necessary approvals.

## 4.3 Legume Technology (United Kingdom)

Legume Technology is a UK-based company specialising in the development and distribution of microbial inoculants and biofertilisers. Their involvement in the project includes:

**Product Development:** Leveraging their expertise to create high-quality, contaminant-free microbial products designed to enhance soil fertility and crop yields.

**Adaptation for Smallholders:** Modifying product packaging and formulations to suit the needs of small-scale farmers in Africa, making them more accessible and affordable.

**Field Trials and Validation:** Collaborating on in-country commercialisation trials to validate product effectiveness and demonstrate yield improvements.

# 5 Gender and Social Inequality

Women are central to cassava production and processing in Nigeria, playing a crucial role in the value chain despite facing significant socio-economic and institutional challenges. As listed in **Table 4**, they are often involved in labour-intensive tasks and processing activities, yet they encounter barriers such as limited access to land, credit, and modern agricultural inputs, as well as inadequate extension services. These constraints not only hinder their productivity but also limit their ability to influence decision-making and benefit economically from the cassava sector.

**Table 4**. Summary of surveys and research on challenges faced by women in cassava production in Nigeria.

| Geopolitical zone | Key Findings | Recommendations | Ref |
|---|---|---|---|
| South-South (Delta State) | Majority of women (35–44 years, married, basic education) are involved in cassava production and processing. | Encourage women to join cooperative associations and strengthen linkages with extension agencies. | [12] |
| | Women participate actively in cultivation and processing but less in land clearing, grating, and pressing. | Review land tenure systems to improve women's access to productive resources | |
| | Constraints include non-ownership of farmland, household chores, small farm sizes, and high processing costs. | | |
| North-Central (Kwara State) | Women (mostly 36–45, married, non-literate) rely on their husband's land and family labour. | Improve girl-child education and adult literacy in rural areas. | [13] |
| | Face challenges in accessing land, inputs, modern tools, and processing equipment, resulting in high post-harvest losses. | Foster cooperative associations and enhance the role of village extension agents. | |
| | Low direct access to extension services; rely on informal information channels. | Increase resources in women's hands and involve them in decision-making processes. | |

| Geopolitical zone | Key Findings | Recommendations | Ref |
|---|---|---|---|
| South-East (Imo State) | Similar socio-economic profile, participation levels, and constraints among women in cassava production and processing as in [12].<br><br>Limited access to credit and cooperative membership remains key issues. | Promote cooperative membership and establish effective extension support.<br><br>Reform land tenure policies to enhance women's access to farmland. | [14] |
| South-West (Oyo State, Osun State, Ogun State) and South-East (Imo State) | Identified 55 cassava varieties across regions with significant gender differences in trait preferences:<br><br>Women prioritise cooking/processing traits (taste, ease of processing, suitability for products like gari and fufu).<br><br>Men focus on agronomic traits (yield, pest resistance, marketability). Regional differences affect variety choice and access to planting material. | Tailor breeding programs to include gender-specific trait preferences.<br><br>Improve women's access to high-quality planting material and empower them in decision-making. | [15] |
| South-West (Oyo state) | Men dominate production while women are more involved in processing/trading; however, income inequality persists.<br><br>Women earn less than men in production despite generating income that can equalise overall inequality.<br><br>Spatial disparities and limited access to credit and extension services exacerbate income differences among smallholders. | Implement gender-inclusive policies to empower women in value addition and access to resources. Establish small-scale processing facilities and improve infrastructure.<br><br>Enhance access to credit and extension services and encourage youth engagement in the cassava value chain. | [16] |

Integrating microbial biological solutions along with improved extension services, targeted credit facilities, and supportive policies can help reduce gender and social inequalities in cassava production, ultimately contributing to a more resilient and inclusive agricultural sector in Ghana and Nigeria. To reduce gender and social inequality the following approaches are recommended:

## 5.1 Reducing Gender Inequality

**Empower Women through Resource Access:** Develop programs that provide women with direct access to microbial biofertilisers and biostimulants, which can improve soil fertility and cassava yields. These inputs, when integrated into training programs tailored for women, can boost their productivity in both production and processing.

**Enhance Extension and Cooperative Participation:** Promote the formation of women's cooperatives and strengthen linkages with agricultural extension agencies to ensure that women receive timely technical support and credit. This includes revising land tenure policies to enhance women's access to land, enabling them to engage more fully in cassava value chains.

**Leverage Digital Tools:** Use mobile platforms and decision support systems designed with gender-specific needs in mind such as simplified interfaces and language to disseminate information on microbial technologies, helping overcome literacy and information gaps.

## 5.2 Reducing Social Inequality:

**Decentralise Microbial Input Production:** Establish community-based biofertiliser production units that use microbial fermentation processes. This localised production not only reduces costs but also creates employment opportunities in rural and marginalised communities. Technology based solutions also serve to attract young people to engage in farming activities.

**Strengthen Rural Extension Services:** Expand and decentralise extension services to ensure that vulnerable smallholder farmers in remote areas receive the latest training on sustainable cassava practices, including the use of microbial solutions. This helps bridge the technology and information gap across spatially disadvantaged areas.

**Improve Post-Harvest Technologies:** Invest in affordable, decentralised processing technologies (e.g., mobile packhouses or solar-powered dryers) to reduce post-harvest losses. By lowering production costs and improving market access, these solutions can increase profitability for small-scale farmers, thereby reducing income disparities.

# 6 Barriers to Transformational Change

Transformational change in cassava productivity in Ghana and Nigeria is hindered by a mix of socioeconomic, technological, and institutional barriers. Outdated land tenure systems, limited access to credit and extension services, low adoption of advanced AgriTech (such as microbial biofertilisers and AI-driven tools) owing to cost and accessibility, and insufficient policy support all contribute to a slow pace of innovation and scaling of climate-smart solutions.

### Drivers for Transformational Change

1. **Innovation**
   - 1.1. **Required Innovations:** Development of locally adapted microbial biofertilisers, biostimulants, and digital decision-support tools is essential. Simplified manufacturing processes and tools that can be applied locally to overcome barriers presented by cost, distribution and shelf-life challenges.
   - 1.2. **Barriers:** Currently, research investment and extension capacity are limited, and technological solutions remain at an early stage. The costs for novel technologies can be prohibitive for small holders. Accessibility to products and knowledge.
   - 1.3. **Impact:** International collaborations (e.g., among the UK, Brazil, and Africa) can accelerate innovation by transferring proven technologies and tailoring them to local agro-ecologies, thereby catalysing a shift from conventional to sustainable, climate-resilient cassava production.

2. **Evidence of Effectiveness**
   - 2.1. **Proven Successes:** Microbial biological solutions have demonstrated improved soil health, enhanced nutrient uptake, and increased crop resilience in countries like Brazil and the UK.
   - 2.2. **Knowledge Sharing:** Sharing case studies and lessons learned can help adapt these solutions to Ghana and Nigeria.
   - 2.3. **Impact:** Concrete evidence reduces risk perceptions among stakeholders, accelerating the adoption of transformative technologies and practices.

3. **Capacity and Capability**
   - 3.1. **Current Limitations:** There is a significant gap in technical skills, infrastructure, and extension services needed to adopt and scale new technologies.
   - 3.2. **Needs:** Investment in training, improved research-extension linkages, and capacity-building initiatives is crucial.

**3.3. Impact:** Strengthening local capacity through international partnerships ensures that innovations are effectively implemented and sustained, leading to lasting improvements in productivity and social equity.

# 7 Conclusion

Microbiological products such biostimulants, biofertilisers and biopesticides offer a deliverable, sustainable solution to complement other innovations and opportunities identified for improving outcomes for cassava farmers. Engagement of the continuum from discovery of novel microbiology to validation, refinement, manufacturing, distribution and end use is key to impactful innovation.

Such products are proven to have positive impacts on yields, soil health and reduced use of harmful chemicals in many parts of the world. Our engagement with farmers and researchers coupled with information compiled from existing literature has highlighted the challenges that farmers (especially small holders) in Nigeria and Ghana face in accessing and using such technologies. These challenges can be met by:

- adapting international best practice to the local situation
- development of novel locally isolated microbial products backed up with strong evidence of efficacy to make products attractive to farmers
- development of simple production methods that can be conducted near-farm with locally sourced feedstocks to ease distribution, cost and accessibility challenges
- farmer engagement and education

In summary, overcoming the barriers to transformational change in cassava production requires an integrated approach that leverages innovation, evidence of effectiveness, and enhanced capacity. International collaboration is key to transferring technology, tailoring solutions to local conditions, and building the necessary capabilities to foster a more sustainable, resilient, and equitable cassava sector in Ghana and Nigeria.

# 8 References


1. Nweke, F. (2004). New challenges in the cassava transformation in Nigeria and Ghana. Environment and Production Technology Division International Food Policy Research Institute, 118, 1–92. https://hdl.handle.net/10568/157851
2. Adebayo, W. G. (2023). Cassava production in africa: A panel analysis of the drivers and trends. Heliyon, 9(9), e19939. https://doi.org/https://doi.org/10.1016/j.heliyon.2023.e19939
3. Mesele, S. A., Soremi, P. S., & Adigun, J. K. (2024). Exploring farmer's assessment of soil quality and root yield in cassava-based cropping systems. Journal of the Saudi Society of Agricultural Sciences, 23(8), 533–541. https://doi.org/https://doi.org/10.1016/j.jssas.2024.06.003
4. Otekunrin, O. A. (2024). Cassava (Manihot esculenta Crantz): a global scientific footprint—production, trade, and bibliometric insights. Discover Agriculture, 2(1), 94. https://doi.org/10.1007/s44279-024-00121-3
5. Otekunrin, O. A., & Sawicka, B. (2019). Cassava, a 21st Century Staple Crop: How can Nigeria Harness Its Enormous Trade Potentials? Acta Scientific Agriculture. https://api.semanticscholar.org/CorpusID:199535137
6. FAOSTAT-Crops and livestock products. (2023). https://www.fao.org/faostat/en/#data/QCL
7. Cassava Production Guidelines for Food Security and Adaptation to Climate Change in Asia and Africa (Issue 1840). (2018). INTERNATIONAL ATOMIC ENERGY AGENCY. https://www.iaea.org/publications/12311/cassava-production-guidelines-for-food-security-and-adaptation-to-climate-change-in-asia-and-africa
8. Ikuemonisan, E. S., Mafimisebi, T. E., Ajibefun, I., & Adenegan, K. (2020). Cassava production in Nigeria: trends, instability and decomposition analysis (1970–2018). Heliyon, 6(10), e05089. https://doi.org/https://doi.org/10.1016/j.heliyon.2020.e05089.
9. Mesele, S. A., Soremi, P. S., & Adigun, J. K. (2024). Exploring farmer's assessment of soil quality and root yield in cassava-based cropping systems. Journal of the Saudi Society of Agricultural Sciences, 23(8), 533–541. https://doi.org/https://doi.org/10.1016/j.jssas.2024.06.003.
10. Otaiku AA, Mmom PC, Ano AO. Biofertilizer Impacts on Cassava (Manihot Esculenta Crantz) Rhizosphere: Soil Microbiome Engineering, Genetic and Sustainable Agroecosystems, Igbariam, Nigeria. World J Agri & Soil Sci. 6(1): 2020. https://doi.org/10.33552/WJASS.2019.04.000578.
11. https://propas.iita.org/en/solutions/, Retrieved on 04/03/2025.
12. Amafade, U.G, Okogu, G, Eromedoghene, E.O, Nwachukwu, N. . (2024). Analysis of Gender Inequality in the Production of Cassava in Indokwa West Local Government Area of Delta State. International Journal of Academic and Applied Research (IJAAR), 8(4), 10–17. https://www.researchgate.net/publication/380818201_Analysis_of_Gender_Inequality_in_the_Production_of_Cassava_in_Indokwa_West_Local_Government_Area_of_Delta_State.

13. Karim, O., Adekunle, O., & Eniayekan, O. (2010). Challenges of Women in Cassava Production and Processing: A Case Study of Asa Local Government in Kwara State, Nigeria. Journal of Agricultural Research and Development, 9(1). https://doi.org/10.4314/JARD.V9I1.56131.
14. Onyemauwa, C. S. (2012). Analysis of women participation in cassava production and processing in Imo state, southeast Nigeria. Agricultura Tropica et Subtropica, 45(2), 72–77. https://doi.org/10.2478/v10295-012-0012-9.
15. Teeken, B., Olaosebikan, O., Haleegoah, J., Oladejo, E., Madu, T., Bello, A., Parkes, E., Egesi, C., Kulakow, P., Kirscht, H., & Tufan, H. A. (2018). Cassava Trait Preferences of Men and Women Farmers in Nigeria: Implications for Breeding. Economic Botany, 72(3), 263–277. https://doi.org/10.1007/s12231-018-9421-7.
16. Donkor, E., Onakuse, S., Bogue, J., & de los Rios Carmenado, I. (2022). Income inequality and distribution patterns in the cassava value chain in the Oyo State, Nigeria: a gender perspective. British Food Journal, 124(13), 254–273. https://doi.org/10.1108/BFJ-06-2021-0663.

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| | |
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