



The Goldmine of Bio-Resources and Biotechnology for Food Security, Wealth Creation and National Development in Nigeria

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ABSTRACT

Nigeria possesses enormous biological resources that, if effectively harnessed through biotechnology, can serve as a catalyst for food security, wealth creation and sustainable national development. This review examines the strategic role of bio-resources and biotechnology in advancing Nigeria's food security, economic diversification and development agenda. Specifically, the paper reviews Nigeria's bio-resource endowment, assesses recent advances in biotechnology development, analyses the bio-resources-biotechnology nexus in promoting food security, evaluates their contributions to wealth creation and national development and identifies strategic pathways for maximizing their benefits. The review reveals that Nigeria is richly endowed with agricultural, forest, aquatic, microbial and genetic resources, while notable progress has been recorded in biotechnology through the commercialization of Bt cowpea, TELA maize, tissue culture technologies and strengthened biosafety regulation. Findings further indicate that biotechnology enhances food availability, accessibility, utilization, and stability through improved crop productivity, climate resilience, reduction of post-harvest losses and biofortification. Beyond food security, bio-resources and biotechnology contribute significantly to employment generation, industrial development, export diversification, poverty reduction, environmental sustainability and the transition toward a resilient bioeconomy. However, inadequate infrastructure, limited research funding, weak commercialization systems and low public awareness continue to constrain the full realization of these opportunities. The paper recommends increased investment in biotechnology research and innovation, establishment of modern biotechnology infrastructure, promotion of value-added bio-based industries, strengthening of public-private partnerships, enhancement of human capital development and implementation of robust biosafety and regulatory frameworks. Harnessing Nigeria's bio-resources through biotechnology-driven innovation offers a viable pathway for achieving food security, inclusive economic growth and sustainable national development.

Keywords: Bio-resources, Biotechnology, Food Security, Bioeconomy, Wealth Creation, Sustainable Development, Nigeria.

INTRODUCTION

The twenty-first century global economy is increasingly driven by knowledge, innovation, biological resources and biotechnology-based industries. Nations that successfully harness their biological wealth through scientific innovation are emerging as leaders in food production, industrial competitiveness, environmental sustainability and economic resilience. The growing global transition toward bio-based economies reflects the recognition that biological resources represent renewable assets capable of generating long-term economic, social and environmental benefits (Organisation for Economic Co-operation and Development [OECD], 2026). According to the Food and Agriculture Organization [FAO] (FAO, 2025), globally, food systems are facing unprecedented challenges arising from climate change, population growth, land degradation, biodiversity loss, conflicts and economic shocks. Recent global food security assessments indicate that hundreds of millions of people continue to experience acute food insecurity, particularly in developing countries. Food insecurity remains especially severe in sub-Saharan Africa, where rapid population growth and climate-related shocks continue to exert pressure on agricultural systems.

Nigeria, Africa's most populous nation, faces a paradoxical situation. Despite possessing vast agricultural resources, favourable agroecological conditions, rich biodiversity and an extensive

domestic market, the country continues to struggle with food insecurity, rural poverty, low agricultural productivity and dependence on food imports (FAO, 2026). Recent assessments indicate that approximately 30.6 million Nigerians were projected to face acute food and nutrition insecurity during the 2025 lean season, while more recent projections suggest the figure could rise to 34.7 million people by 2026 if structural challenges persist (FAO, 2025).

Yet, Nigeria's abundant biological resources provide significant opportunities to address these challenges. The country possesses over 80 million hectares of arable land, diverse ecosystems ranging from mangrove forests and tropical rainforests to savannah grasslands, extensive freshwater and marine resources and a wide range of indigenous plant, animal and microbial species (UNEP, 2026). However, the economic value embedded within these resources remains largely underutilized (Oluwaseun & Ebuka, 2022). Obembe (2017) opined that biotechnology offers a transformative pathway for unlocking the potential of these bio-resources. Through advances in genetic improvement, tissue culture, bioengineering, fermentation technologies and bio-processing systems, biotechnology can significantly enhance productivity, increase resilience to climate change, reduce production losses, improve nutritional outcomes and create new industrial opportunities.

This paper therefore examines the strategic role of bio-resources and biotechnology in advancing food security, wealth creation and sustainable national development in Nigeria. Specifically, the paper seeks to:

- i. Examine Nigeria's bio-resource endowment;
- ii. Review recent advances in biotechnology development in Nigeria;
- iii. Analyze the relationship between bio-resources and biotechnology in promoting food security;
- iv. Evaluate the contributions of bio-resources and biotechnology to wealth creation and national development;
- v. Propose strategic pathways for maximizing the benefits of bio-resources and biotechnology for sustainable national development.

DEFINITION OF CONCEPTS

Bio-Resources

Bio-resources refer to biological materials, organisms, ecosystems and genetic resources that possess actual or potential economic, environmental, industrial, agricultural, pharmaceutical, or social value (FAO, 2020). They encompass plant resources, animal resources, microbial resources, genetic resources and organic biological wastes that can be transformed into useful products and services (Amity University, 2025; MDPI, 2025).

Within the emerging global bioeconomy, bio-resources constitute the foundational raw materials from which food, feed, fibre, pharmaceuticals, biofuels, biomaterials and numerous industrial products are derived. The concept of bioeconomy emphasizes the sustainable production, utilization, conservation and regeneration of biological resources through scientific knowledge, technology and innovation to generate sustainable economic growth and societal well-being ([International Advisory Council on Global Bioeconomy](#) [IACGB], 2024). As a cross-cutting framework adopted globally, it serves to interlink land and marine ecosystems with primary manufacturing systems to provide sustainable solutions across all economic sectors (FAO, 2024). Bio-resources may therefore be broadly categorized into plant resources, animal resources, microbial resources, genetic resources and organic waste resources. These resources collectively constitute what may be described as a nation's biological capital and represent strategic assets for sustainable development.

Biotechnology

Biotechnology refers to the application of biological systems, living organisms, cellular components and biological processes to develop or modify products and processes for specific human purposes (United Nations, 1992). It integrates biological sciences with engineering, information technology and industrial processes to generate innovative solutions across agriculture, medicine, industry and environmental management.

Modern biotechnology encompasses several specialized branches, including green biotechnology for agriculture, red biotechnology for medicine, white biotechnology for industrial applications, blue biotechnology for marine resources and grey biotechnology for environmental management (Barcelos *et al.*, 2018). The significance of biotechnology lies in its capacity to improve biological resources, increase productivity, reduce environmental impacts and create entirely new economic opportunities through innovation-driven value addition (OECD, 2009).

Food Security

According to the Food and Agriculture Organization (FAO, 1996), food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food security rests upon four interrelated pillars: food availability, food accessibility, food utilization, and food stability (FAO, 2006). These pillars provide a useful framework for understanding how biotechnology and bio-resources can contribute to improved food systems and national food security outcomes.

NIGERIA'S BIO-RESOURCE ENDOWMENT

Agricultural resources constitute one of Nigeria's most important biological assets. Nigeria possesses approximately 84 million hectares of arable land, of which less than 50 percent is currently cultivated (FAO, 2024). Major crops include cassava, yam, maize, rice, sorghum, millet, cocoa, coffee, oil palm, rubber, cotton and various fruits and vegetables. Furthermore, Nigeria remains the world's largest producer of cassava and yam, while also ranking among Africa's leading producers of cocoa and oil palm (African Development Bank [AfDB], 2023). These crops provide substantial opportunities for food production, agro-industrial processing, export earnings and employment generation.

Beyond visible biological resources, Nigeria possesses significant microbial diversity that remains largely unexplored. Microorganisms found in soils, forests, aquatic environments and agricultural systems represent valuable resources for biotechnology applications in agriculture, medicine, environmental management and industrial production (National Biotechnology Research and Development Agency [NBRDA], 2026). Advances in microbiology and biotechnology increasingly demonstrate the economic importance of microbial resources in developing bio-based industries.

RECENT ADVANCES IN NIGERIAN BIOTECHNOLOGY

Nigeria has recorded notable progress in biotechnology development over the past decade. One of the most significant achievements has been the commercialization of genetically improved cowpea varieties, commonly known as Bt cowpea, alongside the deployment of TELA maize engineered to resist the destructive fall armyworm and multi-season droughts (Institute for Agricultural Research [IAR], 2024).

Simultaneously, the country has expanded the application of tissue culture technologies in crops such as oil palm, banana, plantain and cassava to rapidly multiply disease-free planting materials for large-scale agricultural investments (National Root Crops Research Institute [NRCRI], 2025). The establishment and strengthening of regulatory institutions such as the National Biosafety Management Agency (NBMA) have further enhanced the governance of biotechnology in Nigeria by administering structured risk assessments and guidelines (United States Department of Agriculture [USDA], 2024). Despite these achievements, biotechnology adoption remains relatively limited compared to its potential. Greater investment in public awareness, extension infrastructure and educational commercialization channels is strictly required to maximize these macro socio-economic benefits (Delphonso *et al.*, 2025).

THE BIO-RESOURCES-BIOTECHNOLOGY NEXUS

The relationship between bio-resources and biotechnology represents one of the most important drivers of contemporary economic transformation. While bio-resources provide the raw biological materials necessary for production and innovation, biotechnology supplies the scientific tools required to improve, transform and commercialize these resources. Together, they form the foundation of the modern bioeconomy (National Biotechnology Research and Development Agency [NBRDA], 2025). Bio-resources alone do not automatically generate wealth or development. Many resource-rich countries continue to experience poverty and underdevelopment because biological resources are

exported in raw form with limited value addition (Oluwaseun & Ebuka, 2022).

In agriculture, biotechnology contributes to the development of improved crop varieties that are resistant to pests, diseases, drought and other environmental stresses. African Technology Policy Studies Network [ATPS] (2023) reveals that biotechnology has enabled the development of disease-resistant cocoa seedlings, improved cassava varieties with higher starch content, drought-tolerant maize and tissue-cultured oil palm seedlings capable of rapid multiplication. These innovations have contributed to increased yields, improved quality and greater profitability for farmers and agribusiness enterprises.

Moreover, in the industrial sector, biotechnology supports the conversion of agricultural raw materials into high-value products such as industrial starch, ethanol, pharmaceuticals, enzymes, organic acids, biodegradable plastics, cosmetics and biofuels. These products create new markets and expand opportunities for economic diversification. In addition, microbial biotechnology further demonstrates the transformative power of this nexus. Microorganisms are increasingly used in food processing, fermentation industries, pharmaceutical manufacturing, waste management and environmental remediation. The growing importance of industrial biotechnology illustrates how biological resources can be converted into innovative products that support sustainable industrial development.

Further to this, food security remains one of the most pressing development challenges confronting Nigeria and many developing countries. Rising population growth, climate change, land degradation, conflicts and economic instability continue to threaten food production systems and household access to food (World Bank, 2026). Hence, bio-resources and biotechnology offer important opportunities for strengthening the four pillars of food security: availability, accessibility, utilization and stability. Advances in crop improvement have resulted in the development of high-yielding, disease-resistant, pest-resistant and climate-resilient crop varieties capable of producing more food under challenging environmental conditions. Increased productivity directly contributes to greater food availability and enhances national food self-sufficiency. Also, biotechnology plays a critical role in reducing production losses. Crop pests, diseases and post-harvest losses account for substantial reductions in food availability across Nigeria. Improved crop varieties, biological pest control systems, disease diagnostics and enhanced storage technologies help reduce these losses and improve overall food system efficiency (Hamdan & Tan, 2024).

Climate change adaptation represents another important contribution of biotechnology to food security. Increasing temperatures, erratic rainfall patterns, flooding, droughts and emerging pests pose significant threats to agricultural production. Biotechnology provides tools for developing climate-smart crops capable of withstanding environmental stresses while maintaining productivity (Okwor *et al.*, 2025). Food security is not only about quantity but also nutritional quality. Biotechnology contributes to improved nutrition through biofortification and the development of nutrient-enhanced crops. Examples include Vitamin A-enriched cassava, iron-rich crops and protein-enhanced food products designed to address micronutrient deficiencies and hidden hunger among vulnerable populations (HarvestPlus, 2025). The adoption of biotechnology also contributes indirectly to food accessibility through increased farmer incomes. Higher productivity and reduced losses improve farm profitability, thereby enhancing household purchasing power and access to diverse and nutritious foods (African Agricultural Technology Foundation [AATF], 2024). Collectively, these contributions demonstrate that biotechnology can significantly strengthen national food systems when supported by appropriate policies, investments and institutional frameworks (Federal Ministry of Budget and Economic Planning, 2026).

CONTRIBUTIONS OF BIORESOURCES AND BIOTECHNOLOGY TO WEALTH CREATION AND NATIONAL DEVELOPMENT

Beyond their contributions to food security, bio-resources and biotechnology possess immense potential for wealth creation and economic transformation. The concept of wealth creation extends beyond income generation to encompass enterprise development, employment creation, industrial growth, export expansion, technological advancement and improved standards of living (United Nations Development Programme [UNDP], 2026).

Bio-resources represent economic assets that can be transformed into high-value products through innovation, processing and commercialization. Countries that successfully move beyond the export of raw biological materials toward value-added production often experience significantly higher economic returns. For instance, cocoa processed into chocolate products generates substantially greater value than the export of raw cocoa beans. Similarly, cassava can be transformed into industrial starch, ethanol, sweeteners, pharmaceutical ingredients and biodegradable packaging materials. The development of bio-based industries creates opportunities for industrial diversification and economic resilience. Biological resources support numerous industries, including food and beverage manufacturing, pharmaceuticals, cosmetics, nutraceuticals, biofuels, textiles, livestock production, aquaculture, and biotechnology services. These industries contribute to gross domestic product (GDP), increase domestic value addition and strengthen national competitiveness.

Furthermore, employment generation represents another significant contribution of bio-resource-based industries. Value chains built around agriculture, forestry, fisheries and biotechnology create jobs at multiple levels, including production, processing, packaging, transportation, marketing, research, quality assurance and export management. Such employment opportunities are particularly important in rural areas where poverty and unemployment remain prevalent. In addition, the bioeconomy offers substantial opportunities for youth entrepreneurship. Emerging sectors such as precision agriculture, biotechnology services, agricultural processing, organic fertilizer production, bioenergy development and digital agricultural solutions provide attractive opportunities for young professionals and innovators. Supporting youth participation in bio-based enterprises can simultaneously address unemployment and stimulate economic growth.

Export diversification is another important pathway through which bio-resources contribute to wealth creation. Nigeria's economy has historically depended heavily on crude oil exports, making it vulnerable to fluctuations in global oil prices. Expanding exports of processed agricultural products, pharmaceuticals, biotechnology products and other bio-based commodities can reduce this dependence while generating foreign exchange earnings. The transition toward a bioeconomy therefore offers Nigeria an opportunity to transform biological wealth into sustainable economic prosperity through innovation, industrialization, and value addition (Oduwale, 2026).

In terms of National development, which encompasses improvements in economic growth, social welfare, technological advancement, environmental sustainability and institutional capacity, one of the most significant contributions is economic diversification. Resource-dependent economies often face challenges associated with commodity price volatility and limited industrial development. By promoting bio-based industries, Nigeria can diversify their economic structures and create multiple sources of income, employment and investment. Strengthening bio-resource value chains in Nigeria can reduce overdependence on petroleum revenues and stimulate growth in agriculture, manufacturing and knowledge-based industries (Central Bank of Nigeria [CBN], 2026).

Another important point is that bio-resources and biotechnology contribute significantly to poverty reduction. Millions of Nigerians derive their livelihoods from agriculture, forestry, fisheries and related activities. Improvements in productivity, market access, value addition and enterprise development can increase household incomes and enhance living standards, particularly in rural communities where poverty rates are often highest (National Bureau of Statistics [NBS], 2025).

On the other hand, environmental sustainability is equally important. Unlike many extractive industries that deplete finite resources, biological resources can be renewed through sustainable management practices. Biotechnology can further support environmental conservation through improved resource-use efficiency, reduced chemical inputs, waste recycling, bioremediation and the development of circular bioeconomy systems (United Nations Industrial Development Organization [UNIDO], 2026).

Further to this, the Sustainable Development Goals (SDGs) provide a useful framework for understanding the broader development contributions of bio-resources and biotechnology (MDPI, 2025). These sectors directly affect the socio-economic targets of SDG 1 (No Poverty), SDG 2 (Zero Hunger) and SDG 8 (Decent Work and Economic Growth) by generating sustainable employment, stabilizing rural farm incomes and boosting localized food security outputs through high-yield

agricultural inputs (Heimann, 2019).

Simultaneously, advanced biotechnology driving the modern bioeconomy underpins SDG 9 (Industry, Innovation and Infrastructure), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action). It achieves this by shifting manufacturing baselines from fossil resources to biodegradable alternative inputs, optimizing closed-loop waste valorisation, developing industrial biocatalysts and engineering climate-resilient crop varieties capable of mitigating severe environmental shocks (Asociación de Empresas de Biotecnología [AseBio], 2025).

STRATEGIC PATHWAYS FOR HARNESSING BIO-RESOURCES AND BIOTECHNOLOGY IN NIGERIA

Nigeria's transition to a biotechnology-driven bioeconomy requires an urgent shift from raw resource exploitation to high-value technological innovation. By structurally optimizing research networks, public policy, and industrial collaborations, Nigeria can translate its immense biomass capacity into sustainable economic independence. The following actionable pathways outline the execution strategy for Nigeria's bioresources-biotechnology development.

1. Research, Innovation and Knowledge Systems:

- The government should establish a competitive National Bio-Innovation Fund managed by the National Biotechnology Research and Development Agency (NBRDA) for research.
- Localized Research and Development in genetic crop improvement, localized vaccine development and diagnostic tools specifically for indigenous diseases should be prioritised.
- Linkages between University laboratories and industrial commodity processors for knowledge transfer should be standardized and strengthened.

2. Modern Biotechnology Infrastructure

- Government and private sector investors should build specialized regional biotechnology parks equipped with shared cleanrooms, genomic sequencers and incubation facilities.
- National in-vitro micropropagation centres to ensure uniform supply chains for cash crops like oil palm and cocoa should be scaled up.
- Government should deploy secure cloud data repositories to map, index and safely commercialize Nigeria's vast, unmapped soil microbial diversity.

3. Industrial Growth and Value Addition

- Government and private sector investors should incentivize private agro-processors to refine raw cassava into high-grade industrial starch, bioethanol and biochemical inputs.
- Government should offer long-term tax holidays, zero-duty imports on specialized equipment and export rebates for bioplastics manufacturers, and establish strict minimum domestic inclusion quotas for bio-based inputs within the local packaging, textile and cosmetic sectors.

4. Human Capital Development

- Government and its relevant agencies should modernize higher education to integrate advanced synthetic biology, metabolic engineering and biosafety law.
- Launch dedicated structural fellowships offering competitive matching grants to attract diaspora Nigerian scientists back to domestic hubs.
- Create rapid certification pathways for laboratory tech operations, precision farm management, and bioreactor maintenance.

5. Public-Private Partnerships (PPPs)

- Introduce government-backed partial credit guarantees to derisk early-stage commercial investments in agritech startups.
- Simplify standard licensing models for public research assets, allowing private enterprises to readily acquire and scale patented innovations.
- Formalize technical exchange programs with international networks to advance local technological acquisition.

6. Biosafety, Governance, and Regulation

- Expand the enforcement capabilities and funding of the National Biosafety Management Agency (NBMA).
- Overhaul intellectual property enforcement frameworks to secure domestic patent protections for novel biological modifications.
- Execute transparent, data-driven public awareness campaigns to demystify gene editing and foster societal trust in biotech crops.

CONCLUSION

Nigeria stands at a historic crossroads where the reliance on crude oil revenues must give way to a knowledge-driven economy. While raw biological resources establish a strong baseline foundation, they cannot generate national wealth without advanced scientific processing. Breakthroughs like Bt cowpea and TELA maize demonstrate that domestic biotechnology can directly resolve food security and rural poverty. By methodically eliminating infrastructure deficits, expanding research budgets, and ensuring regulatory clarity, Nigeria can successfully convert its rich biodiversity into permanent economic resilience.

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