



TECH MEETS TABLE Artificial Intelligence and the Quest for Global Food Security



STEPHEN OLUWOLE AWOKOYA
FOUNDATION FOR SCIENCE EDUCATION (SOAFSE)



The 28th Annual Lecture of the Legacy of
Professor (Chief) Stephen Oluwole Awokoya

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Our distinguished Chairman, Sen. Dr. Olorunnimbe Mamora, CON. The Guest of Honour, Engr Wole Ogunsanya, FNSE. The Chair of the Board of Trustees of Stephen Oluwole Awokoya Foundation, Olorogun Dr. Sonny Folorunso Kuku, OFR, FAS, FAMedS, the Ogbeni Oja of Ijebuland Prof. A.F. Ogunye, FNSE, FAEng and other members, Professor Oluwatoyin Ashiru (OON), Dr. Folarin Awokoya, Chief J. O. Anyigbo, Otunba Otukayode Otufale, Dr. Olutayo Martins, Miss Simisola Awokoya, Dr Omolaraeni Awokoya, and Mrs. Yetsa Kehinde Osara, - the Executive Director SOAFSE.

The Honourees: Mrs. Folashade Alli, SAN and Professor Rahamon Bello, FNSE, FAEng. Family members, Eminent Scholars here present, Scholarship Awardees, Friends of the Stephen Oluwole Awokoya Foundation for Science Education, Esteemed Guests, Gentlemen of the Press, Distinguished Ladies and Gentlemen.

Dear esteemed audience, permit me to acknowledge the profound privilege to be mentored within the engineering profession by **Engr. Professor Toyin Ashiru, OON, FNSE, FAEng, FNIMEchE**, the Pro-Chancellor and Chairman of the Governing Council at Olabisi Onabanjo University, Ago Iwoye. Through his distinguished mentorship and steadfast commitment to the advancement of engineering, Professor Ashiru has been instrumental in shaping both my technical proficiency and professional trajectory. I remain deeply grateful for his invaluable guidance and his unwavering support of my professional journey.



Chapter 1: INTRODUCTION



1. Honoring a Legacy of Vision and the AI Imperative

Each year, the Stephen Oluwole Awokoya Foundation for Science Education convenes a distinguished assembly of educators, scientists, policymakers, and thought leaders. This annual gathering is more than a ceremonial event; it is a living testament to the enduring legacy of Dr. Stephen Oluwole Awokoya, whose vision for education as a catalyst for development continues to inspire generations across Nigeria and beyond. The Foundation Day is more than an annual event; it is a convergence of minds, a celebration of legacy, and a clarion call to action that aligns with Dr. Awokoya's core values: equity, scientific rigor, and the transformative power of education. As the Foundation's Chairman remarked at the 2024 lecture, “In the infinite wisdom of our Creator, each generation is provided with a leading light, a forerunner, to tender and guide humanity as they struggle to understand their environment, adapt and grow within. We have such a leading light in Stephen Oluwole Awokoya”.

Today, our world faces unprecedented challenges in food security, the 2026 Foundation Day stands as a beacon of hope and innovation. The significance of Foundation Day is deeply rooted in the Foundation's mission: to promote science education in Nigeria and beyond, empower scholars, and foster discourse on critical issues. This year's theme, “Tech Meets Table: Artificial Intelligence and the Quest for Global Food Security,” reflects the urgency and complexity of the global food crisis, and the transformative potential of AI in addressing it.

The intersection of technology and agriculture is not merely a trend; it is a necessity. With over 700 million people globally struggling with hunger, and Nigeria hosting the highest number of food-insecure people worldwide, the imperative for innovation is clear. Artificial Intelligence (AI) offers new pathways for productivity, resilience, and sustainability. The theme invites participants to explore how AI can revolutionize food systems, from precision farming and supply chain optimization to nutrition and policy design.

1.1 The Legacy of Stephen Oluwole Awokoya in Science Education

Professor (Chief) Stephen Oluwole Awokoya's legacy is not only in policy but in the lives, he touched, the institutions he built, and the ideals he championed. His motto, "Only the best is good enough," continues to inspire generations of educators, scientists, and leaders.






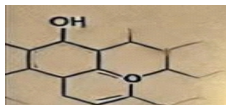
Stephen Oluwole Awokoya was born on July 9, 1913, in Awa Ijebu, Nigeria. His academic journey began at Yaba College, Lagos, where he consistently excelled, later becoming the first Nigerian to obtain a degree in Chemistry from University College London in 1946. Awokoya's early career as a teacher at St. Peter's School, Ibadan, and St. Andrew's College, Oyo, laid the foundation for his lifelong commitment to education.

Awokoya's tenure as Minister of Education in the Western Region (1952–1956) was marked by bold reforms. He championed the Universal Free Primary Education Scheme, overcoming resistance from colonial authorities and local factions. His approach was comprehensive, integrating indigenous goals and promoting science and technology as catalysts for development.

Awokoya's policies led to significant growth in primary school enrollment, teacher numbers, and educational infrastructure. He also challenged gender disparities, advocating for increased participation of women in education, a stance that resonates with contemporary efforts to empower women in agriculture and technology.

Beyond ministerial duties, Awokoya played pivotal roles in regional, national and international education policy. As Chief Federal Adviser on Education, Awokoya was instrumental in the establishment of the National Manpower Board, the National University Commission, and the Bureau of External Aid for Education. At UNESCO and the United Nations, he rose to the position of Deputy Director-General for Science, influencing global policy on science education and capacity building across Africa.

Table 1: Legacy Highlights of Stephen Oluwole Awokoya

	Legacy Area	Description
	Universal Primary Education	Architect of Free and Compulsory UPE in Western Nigeria (1952–1956)
	Science Teacher Training	Expanded Teacher Training Institutions and Introduced Secondary Technical Education on
	Policy Advocacy	Advocated for Indigenous Development, Gender Equity, and Comprehensive Educational Reform
	International Leadership	Served as Chief Federal Adviser on Education, UNESCO Director and Professor at at University of Ife
	Adult Education	Initiated Adult Literacy Programs in nine Indigenous Languages, supported Community Development
	STEM Promotion	Championed Science, Technology, Engineering, and Mathematics in Curricula ara and Research

Awokoya's vision for science education was transformative. He believed that education should not merely replicate colonial models but should foster indigenous innovation, industrial growth, and self-reliance. His legacy is evident in the enduring strength of institutions like Molusi College and the continued relevance of his educational philosophy.

1.2 The Stephen Oluwole Awokoya Foundation Lecture Series

Founded in 1995, the Stephen Oluwole Awokoya Foundation for Science Education (SOAFSE) has become a cornerstone of science advocacy in Nigeria. The annual lecture captures the evolution of the Foundation Day's intellectual agenda, reflecting shifts in societal priorities and technological advancements. Early lectures focused on foundational issues in science education and national development, while more recent themes have addressed the urgent challenges of climate change, digital transformation, artificial intelligence and agriculture. The diversity of speakers; from university professors to government ministers, illustrates the Foundation's commitment to fostering a holistic dialogue that bridges academic, policy, and practical domains. The Foundation Day thus embodies Dr. Awokoya's famous dictum: **“Education is the seed; development is the harvest.”** This guiding principle resonates through every aspect of the event, from keynote addresses to policy dialogues, reminding participants that the pursuit of knowledge is inseparable from the quest for societal progress.

1.2.1 Connecting Past and Future: Contributions to Agricultural Discourse

Over the years, the lecture series has catalyzed discussions on agricultural innovation, food security, and sustainable development. Topics have ranged from biotechnology and climate resilience to digital transformation and gender equity. The Foundation's scholarship program has supported nearly 100 postgraduate scholars in science and science education, amplifying its impact on capacity building.

The enduring relevance of Stephen Oluwole Awokoya's vision is manifest in the contemporary nexus of artificial intelligence and agriculture. Awokoya's belief that **“education is the seed; development is the harvest”** finds new resonance in the digital age, where knowledge and technology are the driving forces behind sustainable food systems. His advocacy for indigenous development, scientific rigor, and inclusive education laid the groundwork for the innovations that now define AI-powered agriculture.

Today, the challenges of global hunger, climate change, and resource scarcity

demand solutions that are both technologically sophisticated and socially equitable. The integration of AI into agriculture through precision farming, predictive analytics, and market access platforms embodies the spirit of interdisciplinary collaboration that Awokoya championed. As the ITU-FAO-WFP-IFAD Global Initiative on AI for Food Systems emphasizes, **“AI must be designed with and for farmers, integrated into public systems, and supported by sustainable finance”**.

Awokoya's legacy is thus not confined to the annals of history; it is a living blueprint for the future. His commitment to bridging the gap between classrooms and farmlands, chalkboards and code, continues to inspire efforts to harness technology for the common good. Today, at this august gathering we shall reflect on his contributions and the challenges ahead, we are reminded that **“From classrooms to farmlands, from chalkboards to code, his legacy feeds the future.”** Let us take an insightful, informative and memorable ride into the Lecture, **“Tech Meets Table: Artificial Intelligence and the Quest for Global Food Security”**.

1.3 Introducing the Topic: Why AI Matters for Global Food Security

Food security has become a major policy issue in many countries with the increase in food prices worldwide. Food security is defined as having sufficient food to generate a calorie requirement of about 2200-2300 calories per day for adult females and 2900-3000 calories per day for adult males. The prices of staple food in sub-Saharan Africa (SSA) have surged

It is a paradox that is hard to ignore: we live in a world with enough food to feed every human being, and yet hunger continues to rise. The FAO's 2024 State of Food Security and Nutrition Report estimates that approximately 735 million people suffer from chronic hunger, while nearly 2.4 billion experience moderate or severe food insecurity. At the same time, the world wastes over 1.3 billion tons of food annually, climate shocks relentlessly erode yields, and production systems remain tethered to increasingly fragile global supply chains. Conflicts: from Sudan to Ukraine to Gaza, disrupt agricultural regions and threaten the livelihoods of millions, creating a fragile web of scarcity amid plenty.

In this landscape of contradiction, Africa occupies a uniquely urgent position. The continent holds 60% of the world's uncultivated arable land, yet it imports tens of billions of dollars' worth of food every year. With climate shocks, fragile infrastructure, and fragmented markets, the continent is simultaneously one of the most vulnerable and most promising regions for agricultural transformation.

Nigeria, in particular, exemplifies both the challenge and the opportunity. Over 220 million people live there, more than 70% of the country's food is produced by smallholder farmers, and post-harvest losses for staples like maize, rice, and cassava can reach 40–45%. These figures are not mere statistics, they represent meals missed, livelihoods disrupted, and a generational gap between potential and reality.

The global hunger crisis is compounded by economic, environmental, and social factors. Food price inflation, conflict, and climate variability have eroded gains made in previous decades, setting back progress toward Sustainable Development Goal 2 (Zero Hunger) by nearly 15 years. In Africa, the situation is particularly dire: **20.4% of the population faces hunger**, and **58% experience moderate or severe food insecurity**. The cost of a healthy diet remains prohibitive for over 70% of people in low-income countries, compared to just 6% in high-income regions.

Table 1 below, highlights stark regional disparities in both undernourishment and the adoption of AI technologies in agriculture. **Sub-Saharan Africa** faces the highest rates of hunger and food insecurity, yet lags in AI adoption due to infrastructural and financial constraints. **South Asia** has made moderate progress, leveraging remote sensing and advisory platforms to improve yields. **Latin America** demonstrates high AI adoption, particularly in supply chain optimization and market access, contributing to lower rates of undernourishment. **Europe & Central Asia** lead in precision farming and robotics, benefiting from robust infrastructure and investment.

Traditional agriculture in such contexts has often been reactive. Farmers wait for rains that may come too late or not at all. Crop yields are determined as much by luck as by skill. Extension services struggle to reach the most remote communities, and early warning systems for drought, pests, and floods remain underdeveloped. In markets, prices fluctuate wildly, leaving both producers and consumers exposed to sudden shocks. Against this backdrop, artificial intelligence offers a transformative promise, not to replace agriculture as we know it, but to reframe it.

The transformative potential of AI in agriculture is increasingly recognized as a strategic imperative for addressing global food security. AI enters the agricultural landscape as a tool for understanding, predicting, and managing complexity. Predictive analytics can forecast yields months in advance, anticipate pest outbreaks, and model climate risks with unprecedented precision. Robotics and smart irrigation systems optimize water and nutrient use, reducing both waste and input costs. Intelligent supply chain platforms streamline logistics, reduce post-harvest losses, and connect rural producers to urban and global markets. For

Nigeria and the broader African context, these capabilities are not luxuries; they are lifelines. They allow countries to plan proactively, protect vulnerable communities, and channel resources efficiently, even amid uncertainty.

AI-driven technologies such as precision farming, predictive analytics, market access platforms, and climate forecasting are revolutionizing the way food is produced, distributed, and consumed. Precision farming leverages data from sensors, drones, and satellites to optimize resource use, reduce waste, and enhance crop yields. Predictive analytics enable farmers to anticipate pest outbreaks, disease, and adverse weather, facilitating timely interventions that minimize losses. Market access is another critical area where AI is making a difference. Digital platforms powered farmers track commodities, optimize logistics, and access real-time market information. AI-based climate forecasting tools are providing hyper-local weather predictions, enabling farmers to adapt to climate variability and mitigate risks, reducing post-harvest losses, and connecting smallholder farmers to broader markets. In Nigeria, platforms like Trade Buza and AGROVESTO are helping

Globally, the stakes are rising. Climate change is altering rainfall patterns, intensifying droughts, and creating new pest and disease pressures. According to the Intergovernmental Panel on Climate Change, crop yields in tropical and subtropical regions could decline by up to 30% by 2050 if adaptation measures are not implemented. These effects are compounded by economic volatility, rising energy costs, and geopolitical instability. AI, in this context, functions as an early warning system, a resource optimizer, and a decision-making amplifier.

Africa's opportunities in AI-enabled agriculture are significant but underutilized. The continent's vast land resources, young population, and growing digital infrastructure provide a platform for leapfrogging traditional agricultural limitations. Satellites can monitor fields in real-time across vast regions. Mobile platforms allow millions of smallholders to access weather updates, market intelligence, and digital advisory services. Drone-based sensors can map soil health and crop stress, while machine-learning models translate these data into actionable insights for farmers, cooperatives, and policymakers.

Nigeria, once again, exemplifies both the promise and the challenge. The country's agricultural system is highly fragmented, with over 70% of farming conducted on small plots averaging less than two hectares. Rainfed agriculture dominates, making yields highly sensitive to climatic variability.

Table 2: Regional Comparison of Undernourishment and AI Adoption in Agriculture (2023)

Region	Undernourishment (%)	Food Insecurity (%)	AI Adoption in Agriculture	Cost of Healthy Diet (PPP \$/day)
Sub-Saharan Africa	23.2	58.0	Low (pilot projects, mobile apps)	3.73
South Asia	13.9	24.8	Moderate (remote sensing, advisory platforms)	4.28
Latin America	5.4	28.2	High (supply chain, market access)	3.74
Europe & Central Asia	<2.5	24.7	Very High (precision farming, robotics)	3.57

Figure 3. IFPRI Global Hunger Index vs EIU Food Insecurity Index

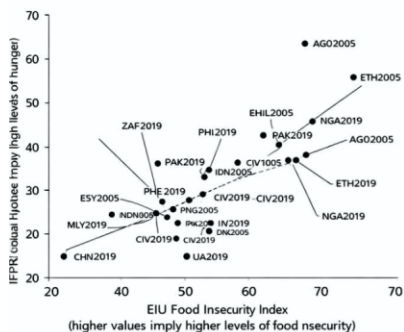
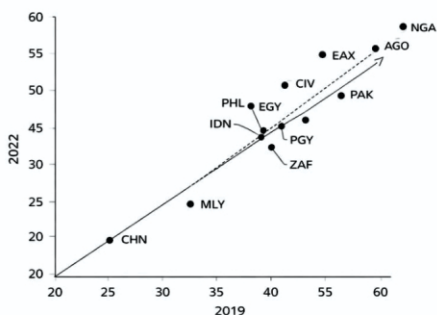


Figure 4. EIU Food Insecurity Index Score (2019 vs 2022)



Source: IFPRI Global Hunger Index and EIU Food Security Index

Supply chains remain largely informal, with rural roads and market linkages insufficient to prevent losses. Post-harvest losses alone account for an estimated \$4 billion in annual wasted value. Nigeria also has one of the fastest-growing technology sectors in Africa. Mobile phone penetration exceeds 90%, fintech and agritech startups are emerging in Lagos, Kano, and Abuja, and national digital agriculture initiatives are beginning to align with broader food

security policies.

AI can help address these gaps on multiple fronts. Predictive models can map where drought or flood risk is highest, allowing governments to allocate irrigation resources, subsidize resilient seed varieties, and time extension services. Disease and pest detection systems can alert farmers before infestations spread, protecting yields and reducing reliance on indiscriminate pesticides. Market-forecasting algorithms can anticipate price swings, enabling both producers and consumers to plan more effectively. At the institutional level, AI dashboards can integrate weather, yield, and supply chain data to inform national planning and buffer stock management, reducing the likelihood of shortages or sudden price spikes.

The value of AI, however, is not purely technological; it is social and economic as well. By increasing predictability and efficiency, AI allows farmers to invest with confidence, women to participate in market networks more effectively, and youth to see agriculture as a viable and profitable livelihood. It can also democratize access to knowledge, bringing the expertise of agronomists, climatologists, and economists to the fingertips of smallholder farmers in even the most remote villages.

AI is not without challenges. Data gaps, connectivity issues, institutional capacity, and concerns over privacy and data ownership all require careful attention. Without deliberate policy frameworks, investments in AI can deepen inequities, favour large-scale operators or foreign technology providers while leaving smallholders behind.

In Africa and Nigeria, the imperative is clear: AI must be implemented alongside supportive infrastructure, training, and governance mechanisms to ensure that its benefits are inclusive, equitable, and sustainable. AI is transforming agriculture, markets, and resilience in today's rapidly changing world. Africa and Nigeria in particular has the resources, the talent, and the urgency to lead a new era in agriculture. With the right policies, investments, and community engagement, the continent can move from reactive, fragile food systems to resilient, data-informed, and inclusive agricultural economies. AI is not a panacea, but it is a powerful lever: one that, if wielded wisely, can help ensure that the paradox of hunger amid plenty becomes a problem of the past.

Recent discussions at the United Nations General Assembly have raised the importance of achieving zero hunger (SDG 2), as this is closely related to other important interconnected issues, including poverty eradication, climate action, migration, land degradation, economic prosperity and creation of peaceful societies. Understanding the current changes throughout agrifood systems (i.e.

from food production, food processing, and food distribution and procurement, to consumer behaviors) require the adoption of artificial intelligence and the growing connectivity and interlinkages of AI and food security.

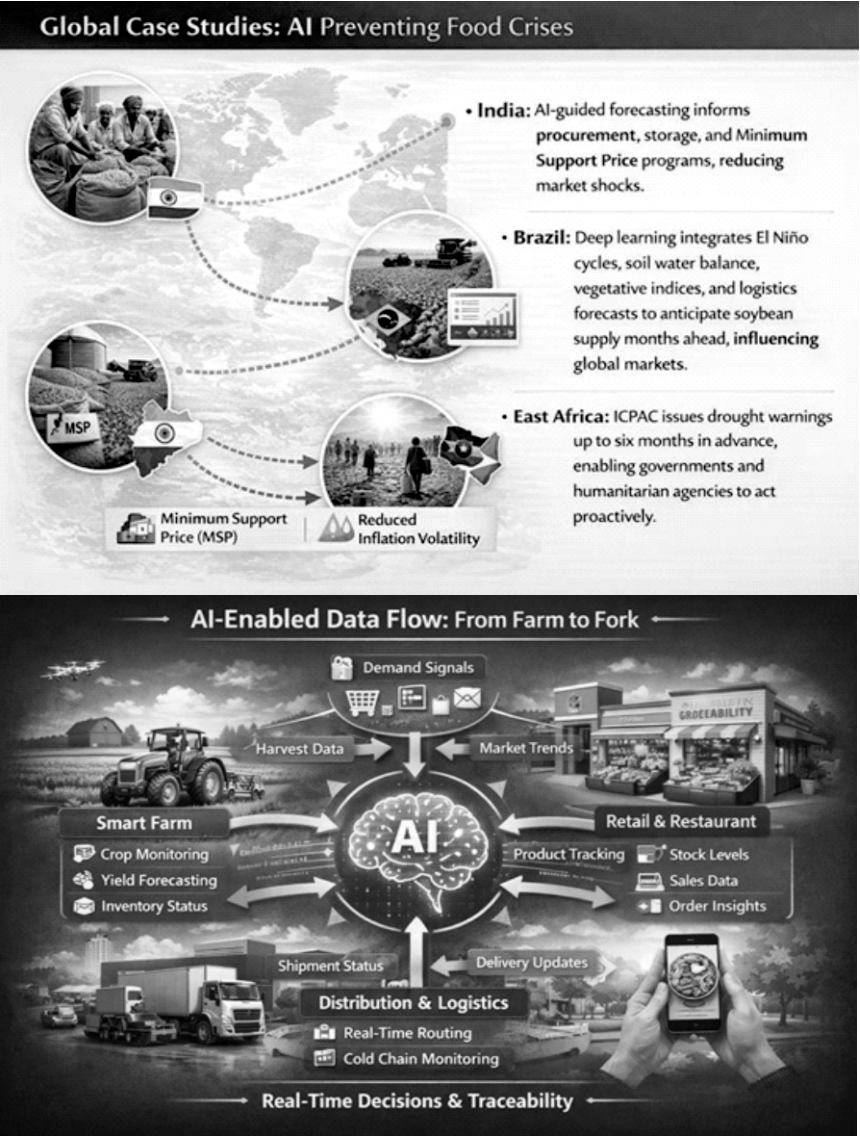



Fig. 2: Why AI Matters for Global Food Security

This lecture presents something simple yet overdue: tell a clear, grounded story about where AI genuinely strengthens food systems, where it may create new risks, and how countries, especially across Africa and Nigeria can shape a future where technology brings more and nutritious food in a sustainable manner to our tables. It shall explore these dynamics, weaving together global perspectives, African contexts, and Nigerian case studies to provide a holistic view of AI's role in agriculture. It will examine predictive analytics for crop yields and climate risk, robotics and smart irrigation, supply chain optimization, and the ethical dimensions of data use. Nonetheless, the related links between artificial intelligence and the affordability of healthy diets, and the resulting implications for food security and nutrition shall be explored in this Lecture. Technology alone is insufficient; what matters is how it is deployed, governed, and integrated into food systems that are socially just, economically viable, and resilient to the shocks of a changing world. The transformative potential of AI and the practical steps required to harness it effectively, will be explained.



Chapter 2: FOOD SECURITY AND AI INTEGRATION



2. Food Security and AI Integration

There is a way agriculture sits at the center of almost every worry we have about the future. Hunger, climate shocks, rising food prices, political fragility, even youth unemployment, they all circle back to the question: **can we grow enough, and can we do it fairly?** Artificial Intelligence is not a magic wand, but it is the most powerful new instrument agriculture has encountered since the Green Revolution, unlike past waves of innovation, AI does not rely on land or water or heavy infrastructure. It relies on data, connectivity, and a bit of imagination.

Food security is one of the most pressing challenges of the twenty-first century, shaping the health, stability, and prosperity of societies across the globe. Despite decades of progress in agricultural innovation and international development, hunger and malnutrition remain stubbornly persistent. The United Nations has enshrined the eradication of hunger as a central pillar of the Sustainable Development Goals (SDGs), recognizing that without secure access to food, other dimensions of human development such as education, health, and economic growth cannot be fully realized. In recent years, the integration of artificial intelligence (AI) into agricultural and food systems has emerged as a promising frontier, offering new tools to address the complexity of global hunger. To understand the scope of this challenge and the potential of AI, it is essential to begin with a clear definition of food security, an assessment of current global hunger statistics, an appreciation of the importance of international cooperation, and an exploration of how AI is reshaping the landscape of food systems.

2.1 Defining Food Security

Food security is defined by the United Nations as the condition in which all people, at all times, have physical, social, and economic access to sufficient, safe,

and nutritious food. Achieving this requires not only increasing agricultural productivity but also ensuring that food is distributed efficiently and equitably. The concept of food security is multidimensional, encompassing **availability, access, utilization, and stability**.

- **Availability** refers to the physical presence of sufficient quantities of food. This dimension is shaped by agricultural production, distribution networks, and trade flows. A country may have fertile land and high yields, but if infrastructure is weak or trade barriers exist, availability can be compromised.
- **Access** concerns the economic and physical ability of individuals to obtain food. Even when food is available in markets, poverty, inequality, or geographic isolation can prevent households from securing adequate nutrition. Rising food prices, as seen in recent years, often erode access for vulnerable populations.
- **Utilization** relates to the proper biological use of food, requiring not only calories but also nutrients, safe water, and adequate health care. Malnutrition is not simply a matter of insufficient food but also of poor dietary diversity, unsafe sanitation, and limited knowledge of nutrition.
- **Stability** emphasizes the consistency of food security over time. A household may be food secure today but vulnerable to shocks tomorrow due to climate change, conflict or war and economic crises. **Stability ensures that availability, access, and utilization are not disrupted by external shocks.**

Together, these four pillars provide a holistic framework for assessing food security. They highlight that hunger is not merely a matter of producing more food but of ensuring equitable distribution, sustainable consumption, and resilience against shocks.

2.1.1. The Challenge of Global Food Security

The multidimensional nature of food security makes it a global challenge that transcends borders. Global hunger statistics reveal the scale of the challenge. The State of Food Security and Nutrition in the World (SOFI) 2025 demonstrate that hunger is not confined to low-income countries but is a universal issue requiring coordinated global action. However, the global food system is riddled with inefficiencies:

- **Post-harvest losses:** Up to 30% of food produced is lost or wasted due to poor storage, transportation, and distribution.
- **Supply chain disruptions:** Natural disasters, pandemics, and geopolitical conflicts can halt food flows across borders.

- **Market volatility:** Prices fluctuate due to unpredictable weather, demand shocks, and speculative trading.
- **Climate change impacts:** Rising temperatures, droughts, and floods reduce yields and destabilize production.

2.1.2. Current Global Hunger Statistics

The **State of Food Security and Nutrition in the World (SOFI) 2025 report**, jointly published by FAO, IFAD, UNICEF, WFP, and WHO, paints a sobering picture. It estimates that **between 638 and 720 million people, implying, 7.8 to 8.8 % of the global population faced hunger in 2024** (UN World Food Programme). This represents a slight decline compared to the peak years of the COVID-19 pandemic, the numbers remain above pre-pandemic levels, underscoring the fragility of progress. The report further highlights:

Regional disparities: Hunger continues to rise in Africa and Western Asia, while modest improvements are observed in parts of Asia and Latin America.

- **Nutrition outcomes:** Child stunting fell to **23.2 percent in 2024**, yet millions of children remain affected. Micronutrient deficiencies, particularly iron and vitamin A, persist across low-income regions (UNICEF DATA).
- **Food price inflation:** Elevated inflation has undermined purchasing power, especially among low-income populations, making healthy diets increasingly unaffordable (Food and Agriculture Organization).

Diet quality: The cost of nutritious food remains out of reach for billions, leading to reliance on calorie-dense but nutrient-poor diets.

Table 3: Global Hunger Statistics by Region (SOFI 2025 Estimates)

Region	Undernourished Population (millions)	% of Population Undernourished	Key Challenges
Africa	282	19.7%	Conflict, climate shocks, poverty
Asia	381	8.3%	Rapid urbanization, inequality
Latin America	43	6.5%	Economic instability, food price spikes
North America & Europe			Food waste, diet-related health issues
Oceania	6	7.2%	Geographic isolation, climate change

Source: FAO, IFAD, UNICEF, WFP, WHO — SOFI Report 2025

With the 2025 SOFI report, the world is **not on track to achieve SDG 2 (Zero Hunger) by 2030**. The persistence of hunger despite global economic growth illustrates **the structural nature of food insecurity**, which requires systemic solutions beyond short-term aid. Asia accounts for the largest absolute number (381 million), while Africa has the highest proportion (~20% of its population). Latin America, Oceania, and Europe/North America show smaller shares but face localized challenges.

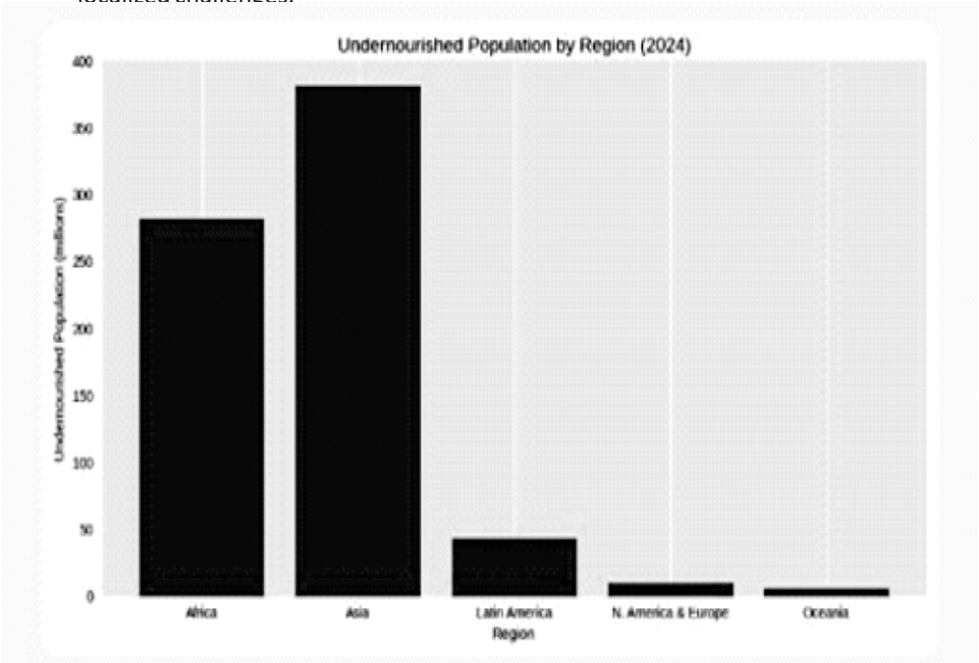


Fig.3: Regional distribution of undernourished populations in 2024 (SOFI 2025)

Analysis: The regional breakdown underscores the uneven geography of hunger. Asia's large population means it carries the greatest absolute burden, though its percentage is lower than Africa's. Africa's 282 million undernourished people represent nearly one in five individuals, reflecting the compounded effects of conflict, climate change, and poverty. Latin America's 43 million highlight the impact of economic volatility and food price inflation. Europe and North America have relatively low hunger rates, but issues of food waste and diet-related diseases dominate. Oceania's small but significant figure reflects geographic isolation and climate vulnerability.

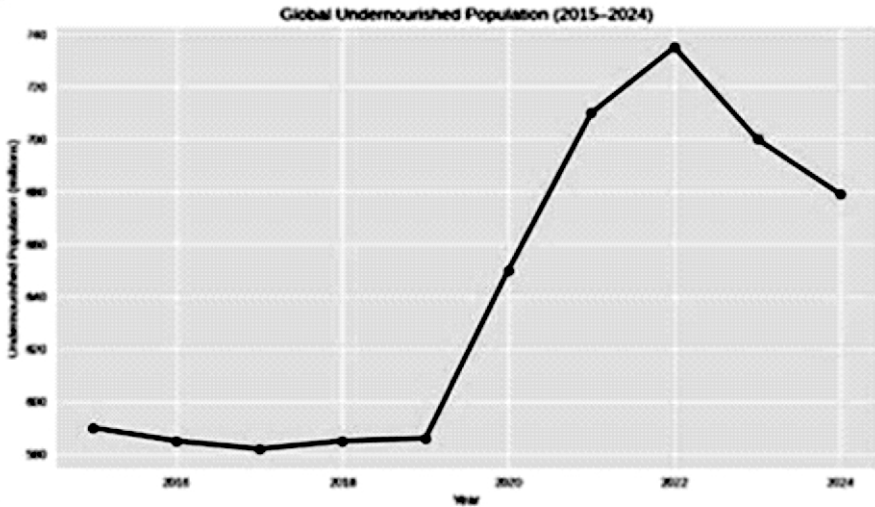


Fig.4: Global undernourished population (millions), 2015–2024. peaking at ~735 million in 2022, followed by a modest decline to ~679 million in 2024.

Analysis: After years of relative stability (2015–2019), the pandemic triggered disruptions in supply chains, job losses, and reduced household incomes, pushing millions into hunger. Although recovery efforts have reduced the numbers slightly, the global figure remains significantly higher than pre-2015 levels. This suggests that structural vulnerabilities such as climate shocks, conflicts or wars and economic instability continue to undermine progress toward SDG 2. **The plateau after 2022 indicates that without systemic reforms, hunger will persist despite economic rebounds.**

2.1.3. Importance of International Cooperation

Food security is inherently a global issue. No country can address hunger in isolation, as food systems are interconnected through trade, climate, migration, and geopolitics. International cooperation and policy coordination are therefore indispensable. With international **policy coordination**, organizations such as the FAO provide guidance on agricultural policies, ensuring that national strategies align with global goals. Without coordination, unilateral trade restrictions or subsidies can destabilize global markets. Agencies like IFAD channel investments

into rural communities, leveraging international finance to empower smallholder farmers. These farmers produce a significant share of the world's food but often lack access to credit, technology, and markets. This is possible through international **resource mobilization**.

Humanitarian response through the WFP plays a critical role in emergency contexts, delivering food aid in conflict zones and disaster-stricken regions. Its operations depend on international solidarity and funding. **Knowledge sharing** via AI facilitates the exchange of best practices, research, and technology. For example, climate-resilient crop varieties developed in one region can benefit farmers elsewhere. The importance of **international cooperation and AI** is further underscored by global challenges such as climate change, which transcends borders. Droughts in one region can disrupt global grain markets, while conflicts in another can trigger refugee flows and strain food systems elsewhere. Only through collective action and **adoption of AI**, can the world build resilient food systems capable of withstanding such shocks.

2.2. AI in Agriculture and Food Systems

The introduction of AI into food systems represents a paradigm shift, offering new tools to tackle the multidimensional challenge of food security. Artificial intelligence is increasingly recognized as a transformative force in the quest for food security. However, technology alone cannot solve hunger. It must be embedded within international frameworks such as SDG 2 and supported by the coordinated efforts of organizations like FAO, IFAD, and WFP.

In East Africa, AI-enabled drones have been deployed to monitor and control locust swarms, preventing massive crop losses. In Asia, machine learning models are used to predict rice yields, helping farmers plan planting and harvesting. Globally, AI is being integrated into hunger mapping, allowing agencies to identify hotspots with unprecedented accuracy. Across the world, AI is already

improving food security outcomes but Africa, and Nigeria in particular, face a dual reality: high vulnerability and high potential. If governments and regional blocs adopt bold, actionable policy steps, AI can anchor a new era of resilient agriculture. Artificial Intelligence is reshaping global food systems in three big arcs:

1. **Predictive Intelligence:** AI now forecasts yields, rainfall, pests, and market shocks with accuracy unthinkable a decade ago, enabling governments, farmers, and agribusinesses to plan rather than react.
2. AI's integration into **Precision Agriculture** is not limited to large-scale farms. Initiatives in India, Kenya, and Nigeria demonstrate that mobile-based advisory platforms and affordable sensor networks can empower smallholders with actionable insights, provided that digital infrastructure and training are in place.
3. **Automation and Optimization:** From robot harvesters to satellite-guided irrigation systems, AI-powered tools reduce losses, stabilize supply chains, and improve productivity with fewer inputs.

Table 4: AI in Precision Agriculture - Data-Driven Productivity and Sustainability

Application	Technology/Method	Impact/Outcome	Example/Region
Weed Detection & Control	Computer Vision, Drones	77–90% reduction in herbicide use, higher yields	John Deere, USA
Yield Prediction	ML, Satellite Data	15–30% yield increase, risk mitigation	Solinftec, Brazil
Precision Irrigation	IoT, ML	25–50% water savings, energy reduction	CropX, Israel/Global
Autonomous Planting	Robotics, AI	40% labor cost reduction, improved efficiency	Japan
Pest/Disease Detection	Deep Learning, Sensors	Early intervention, reduced crop loss	CropIn, India

4. **Governance, Ethics, and Data Sovereignty:** As agriculture becomes data-rich, questions emerge about ownership, privacy, equity, and algorithmic bias, especially for African nations historically marginalized in global technology markets



Fig. 5: AI in Precision Agriculture

2.2.1. AI Applications in Food Systems

AI applications span the entire food system, from production to consumption:

- **Production:** AI enables precision agriculture, where sensors and algorithms monitor soil health, predict pest outbreaks, and optimize irrigation. This reduces waste and increases yields, particularly important in regions facing resource constraints.
- **Distribution:** AI optimizes supply chains by predicting demand, reducing food waste, and ensuring timely delivery. For organizations like WFP, AI-driven logistics can mean faster response times in emergencies.
- **Consumption:** AI-powered nutrition apps help individuals make healthier dietary choices, while predictive models identify populations at risk of malnutrition.
- **Resilience:** AI enhances disaster preparedness by forecasting droughts, floods, and crop failures. Governments and aid agencies can use these insights to pre-position resources and mitigate impacts.

Key Applications of AI in Agriculture

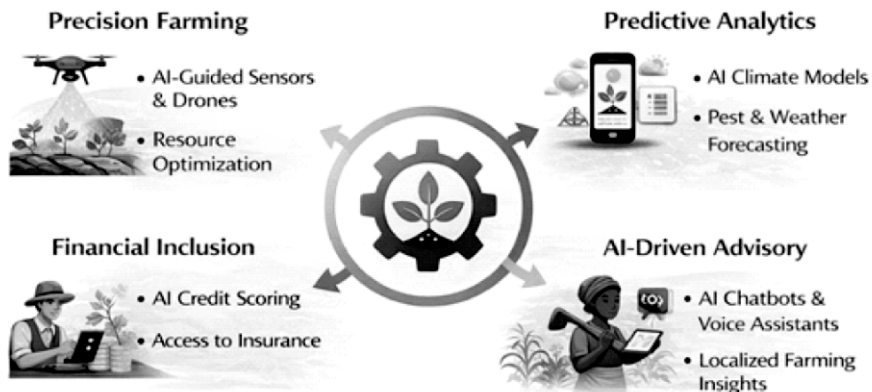


Fig. 6: AI in Agriculture and Food Systems

The persistence of hunger, as highlighted by the SOFI 2025 report, underscores the urgency of action. By combining clear definitions of food security, accurate assessments of global hunger, robust international cooperation, and the innovative potential of AI, the world can move closer to the vision of Zero Hunger by 2030. The promise of AI is not without challenges. The **digital divide** means that many smallholder farmers lack access to the infrastructure needed to benefit from AI. Data privacy and governance issues also loom large, as farmers' information must be protected from exploitation. Ethical frameworks are therefore essential to ensure that AI serves as a tool for empowerment rather than exclusion.

2.3. Policy Instruments as Tools for Governance and Accountability

Addressing food insecurity requires more than technical solutions; it demands robust governance frameworks and accountability mechanisms. Policy instruments serve as the backbone of international efforts to combat hunger, providing states and institutions with guidelines, funding mechanisms, and monitoring tools. They transform abstract commitments into actionable strategies, ensuring that governments and organizations are held accountable for progress.

Food security is a global challenge that requires coordinated action across multiple dimensions. Policy instruments serve as essential tools for governance and accountability, ensuring that commitments are translated into action. Policy instruments can take different forms. Normative frameworks, such as the Voluntary Guidelines on the Right to Food, establish principles and standards

rooted in human rights. They emphasize participation, accountability, and nondiscrimination, guiding states in designing policies that respect and fulfill the right to adequate food. Financial instruments, such as the Global Agriculture and Food Security Program (GAFSP), mobilize resources to support country-led agricultural investment plans, focusing on smallholder farmers and vulnerable populations. Together, these instruments illustrate the dual approach needed: normative guidance to shape policy behavior and financial mechanisms to implement concrete projects.

The importance of policy instruments lies in their ability to bridge the gap between global aspirations and local realities. Without governance frameworks, commitments to end hunger risk remaining rhetorical. Without financing mechanisms, ambitious plans cannot be translated into tangible outcomes. Policy instruments thus serve as both compass and engine, directing efforts and providing the means to achieve them.

2.3.1. Why GAFSP and 'The Right to Food' Matter

The Voluntary Guidelines on the Right to Food, adopted by FAO in 2004, represent a landmark in the recognition of food as a fundamental human right. They provide states with a comprehensive framework to respect, protect, and fulfill the right to adequate food. By emphasizing participation, accountability, and transparency, the guidelines ensure that food security policies are not merely technocratic but rooted in human dignity and social justice. They empower citizens to hold governments accountable and encourage states to integrate the right to food into national legislation and strategies.

The Global Agriculture and Food Security Program (GAFSP) was launched in April 2010 as part of the international response to the 2007–2008 global food price crisis. Recognizing the urgent need to strengthen food systems and protect vulnerable populations, G8 leaders later endorsed by the G20 pledged support for coordinated investments in agriculture, culminating in US\$22 billion in commitments announced at the L'Aquila Summit in 2009. In response, the World Bank Group worked with donors to establish GAFSP, a dedicated global fund designed to translate these pledges into practical, country-led interventions.

GAFSP's initial contributors included the Bill & Melinda Gates Foundation, Canada, the Republic of Korea, Spain, and the United States. Over time, additional donors such as Australia, Germany, Ireland, Japan, the Netherlands, Norway, and the United Kingdom joined the initiative, reflecting broad international support for the program's mandate. Beyond financing, GAFSP has played a strategic role in global coordination, serving as a founding member of

the Global Alliance Against Hunger and Poverty, officially launched during the G20 Leaders' Summit in Rio de Janeiro in November 2024. Through these partnerships, GAFSP continues to act as a catalytic mechanism, linking international commitments to on-the-ground investments that strengthen resilient and sustainable food systems worldwide.

Since its inception, it has mobilized US\$2.4 billion in grants and concessional finance to governments, producer organizations, agribusinesses, and financial intermediaries, reaching an estimated 32 million people. Despite these efforts, hunger, malnutrition, and food insecurity remain widespread, intensified by conflict, climate shocks, economic slowdowns, and structural inequalities. Persistent gaps in access to finance for smallholder farmers and early-stage agribusinesses underscore the continued importance of GAFSP in building resilient, sustainable food systems and expanding equitable financing at scale.

2.3.2. GAFSP Priorities for 2026

In 2026, GAFSP is positioned to advance a series of priority actions aimed at strengthening global food and nutrition security, with emphasis on system-wide transformation and targeted support to vulnerable populations.

1. Operationalizing Vision 2030: GAFSP will begin implementing its Vision 2030 Strategic Plan, developed in response to escalating global food-security pressures. In 2024, an estimated 720 million people experienced hunger, while conflict, fiscal constraints, and recurring shocks continued to limit food production and affordability across multiple regions. Vision 2030 outlines a coordinated strategy for addressing these conditions and directs the program toward:

- **Incentivizing** investments in innovative, integrated agrifood system solutions that produce multiple co-benefits;
- **Connecting** actors across sectors to strengthen partnerships that benefit smallholder women and men;
- **De-risking** agrifood value-chain investments to encourage larger public and private capital flows.

2. Expanding Support to Smallholder Farmers and Producer Organizations:

A central priority for 2026 is scaling direct financing to smallholder farmers and the producer organizations that serve them. This includes expanded access to technology, training, financial services, improved market linkages, and employment opportunities. Such support is essential for improving productivity and household incomes in low-income countries, where smallholders account for a significant share of national food supply.

The **Eighth Call for Proposals** under the Producer Organization–led investment

track will be allocated in 2026, further strengthening farmers' ability to obtain inputs, secure credit, and invest in infrastructure such as storage, processing, and digital tools. The PO-led track remains a distinctive instrument that channels resources directly to farmer-led institutions.

3. Increasing the Use of Blended Finance Tools: Through its Private Sector Window and the newly established **Business Investment Financing Track (BIFT)**, GAFSP will continue mobilizing blended finance to unlock greater private capital for agribusinesses and rural enterprises that typically face limited access to formal financing. The program's mix of grants and concessional instruments is intended to reduce investment risk and expand financial opportunities for underserved agricultural actors.

4. Deepening Engagement in Africa: In 2026, GAFSP will strengthen collaboration with the African Union by aligning its country-led financing window with the AU's **Comprehensive Africa Agriculture Development Programme (CAADP) Kampala Strategy**. This partnership supports national priorities aimed at increasing agricultural productivity, enhancing resilience, improving nutrition outcomes, and contributing to the AU's broader **Agenda 2063** framework.

5. Addressing Food Insecurity in Fragile and Conflict-Affected Settings: More than 40 percent of GAFSP's grant portfolio already targets countries affected by fragility, conflict, and violence. In 2026, the program will maintain its focus on 29 such countries, ranging from Haiti to Somalia, where conflict continues to disrupt production, supply chains, and rural livelihoods. Feedback from farmers in these regions indicates that GAFSP's interventions play a significant role in restoring livelihoods and rebuilding local food systems in high-risk environments.

6. Supporting the World Bank Group's AgriConnect Initiative:

GAFSP's work will also complement the goals of the World Bank Group's **AgriConnect** initiative, which aims to help smallholder farmers transition from subsistence production to market-oriented surplus. The initiative prioritizes improvements in organizational capacity, skills development, policy reforms that strengthen market access, and expansion of financial opportunities for food-system actors. AgriConnect leverages the combined expertise of the International Finance Corporation (IFC), the World Bank, and the Multilateral Investment Guarantee Agency (MIGA), backed by a commitment to mobilize **US\$9 billion annually**. It operates with support from several partners, including the African Development Bank (AfDB), the International Fund for Agricultural Development (IFAD), the Inter-American Development Bank (IDB), as well as private sector actors such as Bayer and Google.

2.4. The African Development Bank (AfDB) Story

Food security is not merely a development goal; it is the foundation of peace. The African Development Bank is committed to ensuring that Africa not only feeds itself but becomes a global breadbasket. The African Development Bank has emerged as one of the continent's most consistent forces for advancing food security, investing not just in crops or infrastructure but in the confidence and capacity of Africa's farmers. Across rural landscapes: from the rice valleys of Liberia to the highlands of Tanzania, from the maize belts of Nigeria to the drylands of the Sahel. The Bank's mark is visible in places where families now plant earlier, harvest more, and rely less on uncertain rains or unpredictable markets.

Much of this progress is strengthened through the Bank's partnership with the Global Agriculture and Food Security Program (GAFSP). Together they manage more than US\$450 million in projects across ten countries, reaching over 2.3 million farmers. These operations are designed not as stand-alone interventions but as system builders: irrigation where rainwater is no longer reliable, storage where post-harvest losses drain incomes, and credit where collateral has always been a barrier.

In Nigeria, the AfDB's contributions to food security have become increasingly central. Under the Bank's Feed Africa strategy, investments have expanded irrigation networks, strengthened staple crop processing zones, and opened new market corridors for rice, cassava, sorghum, and horticultural value chains. AfDB's support for Nigeria's Special Agro-Processing Zones is helping cluster production, processing, logistics, and energy in ways that reduce costs for farmers and attract private investors. These zones are reshaping the rural economy by creating jobs for youth, improving access to agro-inputs, and lowering post-harvest losses through better storage and processing systems.

The Bank has also financed large-scale programs improving climate-smart agriculture across northern Nigeria, where desertification and climate shocks threaten yields. Initiatives like the Inclusive Basic Service Delivery and Livelihood Empowerment program bring water management, small-scale irrigation, and livelihood support to communities living on the edge of food insecurity. Through AfDB and GAFSP financing, farmers are gaining access to drought-tolerant seed varieties, improved extension services, and community-level infrastructure that helps stabilize food production even when the rains falter. In practice, this means more consistent harvests, stronger rural incomes, and fewer families pushed toward crisis during lean seasons.

Elsewhere, the Bank's steady influence is equally evident. In Liberia, GAFSP-financed projects overseen by the AfDB strengthened rice valleys, feeder roads,

seed systems, and farmer-producer linkages. In Tanzania, AfDB-supported investments helped the national farmer organization MVIWATA reach isolated mountain communities with climate adaptation tools and new market access. These efforts now link to AfDB's broader work on aflatoxin control, drying facilities, testing labs, and storage systems that protect food safety and unlock export opportunities.

The AfDB's real contribution lies not only in the scale of its investments but in its ability to make agriculture bankable. Many governments hesitate to borrow for smallholder-focused programs or women-led cooperatives. AfDB, supported by GAFSP grants, reduces that hesitation by de-risking the first step. The Bank's agro-input risk-sharing facilities, blended-finance pipelines, and support for agribusinesses create a pathway from grant-funded pilots to investments backed by development banks and commercial actors. At a moment when food insecurity is rising across the continent, the African Development Bank is helping build the foundations that will outlast today's crises: resilient farmers, stronger markets, safer food, and institutions capable of carrying Africa's agriculture into the future. The work is already taking shape, one irrigation canal, one cooperative, one farming family at a time, and its momentum continues to grow.

AfDB Contributions to Food Security since 2018

AfDB has scaled up investments in agriculture and food systems, focusing on irrigation, mechanization, **climate-smart farming**, and value chain development:

Table 5: AfDB Contributions to Food Security since 2018

Year	Initiative / Facility	Financial Commitment (Approx.)	Focus Area	Geographic Scope
2018	Technologies for African Agricultural Transformation (TAAT) – Scale-up	\$1 billion+ (leveraged financing)	Climate-resilient seeds, mechanization, fertilizer optimization	30+ African countries
2019	Enable Youth & Agripreneur Programs	\$300 million+	Youth employment in agriculture value chains	Continental
2020	COVID-19 Response Facility (Agriculture Window)	\$10 billion total facility (multi-sector; agriculturesupported)	Input supply stabilization, food system resilience	Africa-wide
2021	Feed Africa Strategy Implementation Acceleration	Ongoing portfolio > \$6 billion (agriculture investments)	Value chains, agroprocessing, infrastructure	Continental
2022	African Emergency Food Production Facility	\$1.5 billion	Wheat, maize, rice, soybean production expansion; fertilizer access	20+ countries
2023	Climate Action Window (Agriculture-relevant financing)	\$429 million initial envelope	Climate adaptation for vulnerable states, including food systems	Fragile & lowincome states
2024	Feed Africa Strategy Progress Scaling	Multi-billion ongoing commitments	Food sovereignty, agroindustrial zones, digital agriculture	Continental

The Policy Instruments

- 1. Feed Africa Strategy (2016–2025):** A flagship program targeting agricultural transformation.
- 2. Special Agro-Industrial Processing Zones (SAPZs):** Linking farmers to markets and reducing post-harvest losses.
- 3. Climate-Smart Agriculture Financing:** Supporting drought-resistant crops and irrigation.
- 4. Partnerships with WFP & IFPRI:** Joint investments in innovative food systems in Nigeria and beyond.

Future Projections (2025–2035)

Looking ahead, AfDB envisions:

- **\$10 billion annual investment** in food systems by 2030.
- **50 million farmers empowered** from 2025 – 2035, with access to digital tools.
- **Integration of AI and digital platforms** for precision farming and market intelligence.

Chapter 3: PREDICTIVE ANALYSIS FOR CROP YIELDS AND CLIMATE RISK

3. Predictive Analytics for Crop Yields and Climate Risk

Agriculture has always been an exercise in anticipating the future. Farmers plant, fertilize, and irrigate with hope: the hope that rains arrive on time, pests remain in check, and markets offer fair returns. Traditionally, these decisions relied on local knowledge, intuition, and experience. In a world of climate change, population pressures, and volatile markets, intuition alone is no longer sufficient. **Artificial intelligence (AI) now offers a profound shift:** predictive analytics enables farmers, governments, and agribusinesses to anticipate challenges and make informed decisions weeks or months before crises emerge.

AI in Climate-Smart Agriculture

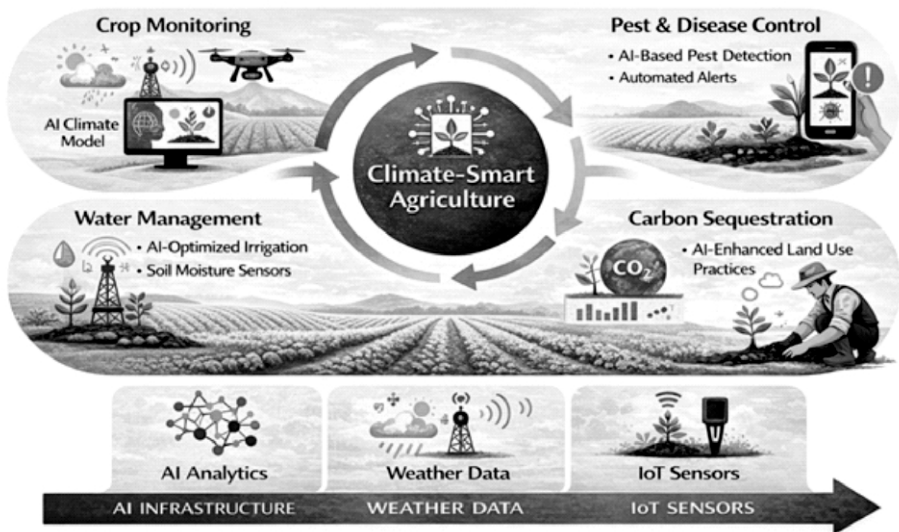


Fig. 7: Climate Smart-Agriculture for Food Security

At its core, **predictive analytics in agriculture blends multiple sources of information: satellite and drone imagery, climate models, soil and nutrient maps, machine learning algorithms, historical yield databases, and market and price data.** These inputs converge to produce forecasts that are actionable. Governments can plan buffer stocks months in advance. Farmers can time planting and harvest to optimize yield. Agribusinesses can anticipate demand and adjust logistics accordingly. Even humanitarian agencies can deploy resources to prevent localized famine before it escalates. Together, these tools deliver forecasts directly to farmers' smartphones, government dashboards, agribusiness supply planners, and humanitarian agencies.

Table 6: Key Data Sources for Predictive Agriculture

Data Type	Example Platforms/Agencies	Notes
Satellite Imagery	NASA MODIS, Sentinel-2, Planet Labs	Daily coverage, continentwide
Climate & Weather Data	ECMWF, NOAA, National Meteorological Services	Supports microclimate modeling
Soil & Nutrient Maps	ISRIC, African Soil Information Service	Precision fertilizer planning
Pest & Disease Observations	FAO DLIS, PlantVillage Nuru, CABI	Early outbreak detection
Market & Price Data	Local commodity markets, Agri-business platforms	Supports logistics and planning

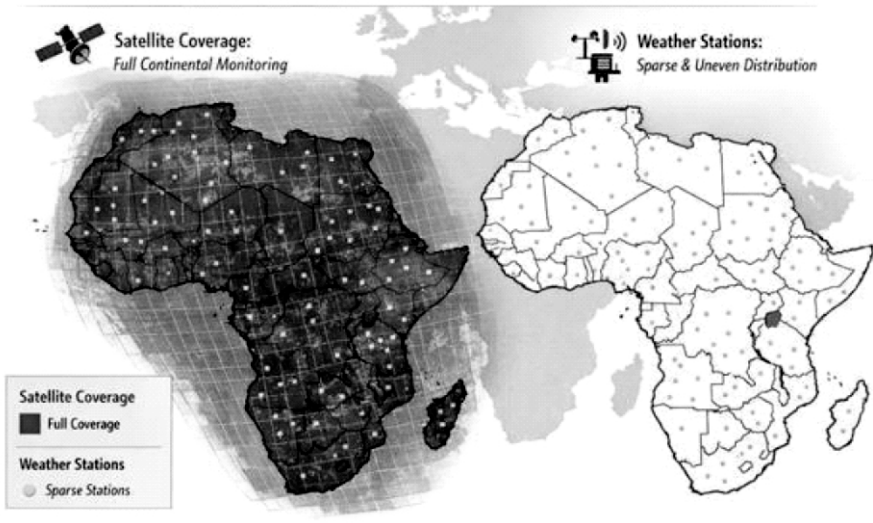
Fig. 8: NDVI Vegetation Health in Nigeria's Maize Belt (A heatmap showing stressed regions in Northern Nigeria)

Satellite-based vegetation monitoring forms one of the most powerful tools in this toolkit. Platforms like NASA's MODIS, Sentinel-2, and Planet Labs generate highresolution data on crop health, soil moisture, canopy stress, and evapotranspiration. AI models translate these signals into predictive insights, estimating crop yields months before harvest. In Africa, where traditional data collection is often sparse, satellites cover the entire continent, making **remote sensing** an indispensable resource. AI converts these signals into yield forecasts months before harvest. In Africa, where ground observation networks are sparse, satellites provide near-complete coverage.

Hyperlocal weather forecasting is another frontier. Standard meteorology often fails to capture the microclimates that determine success or failure at the farm level. AI-powered systems now downscale global climate models, simulate rainfall anomalies, detect early drought patterns, and predict flood risks at the village level. In Nigeria, where rainfall variability is growing, these forecasts are critical for smallholder farmers, particularly in northern states dependent on the rainy season.

AI also strengthens pest and disease management. **Tools such as the FAO's Desert Locust Information System, Plant Village Nuru's disease recognition app, and CABI's pest risk models detect outbreaks before they spread.** They can leverage satellite imagery, weather patterns, and even farmer-submitted smartphone photos to issue early alerts. In Nigeria, where the Fall Armyworm has devastated maize yields, such tools can prevent significant losses and protect food security.

Globally, predictive analytics has already proven its worth. In India, AI-enabled forecasting guides procurement, storage, and Minimum Support Price programming, reducing market shocks and stabilizing food reserves. **Brazil uses deep-learning models to integrate El Niño–Southern Oscillation patterns, soil water balance, vegetative indices, and logistics congestion forecasts** to predict national soybean supply months ahead, influencing global markets.



Satellite imagery covers every region of Africa, compensating for sparse weather station networks and enabling predictive analytics.

Fig. 9: Satellite Coverage vs. Weather Station Density in Africa

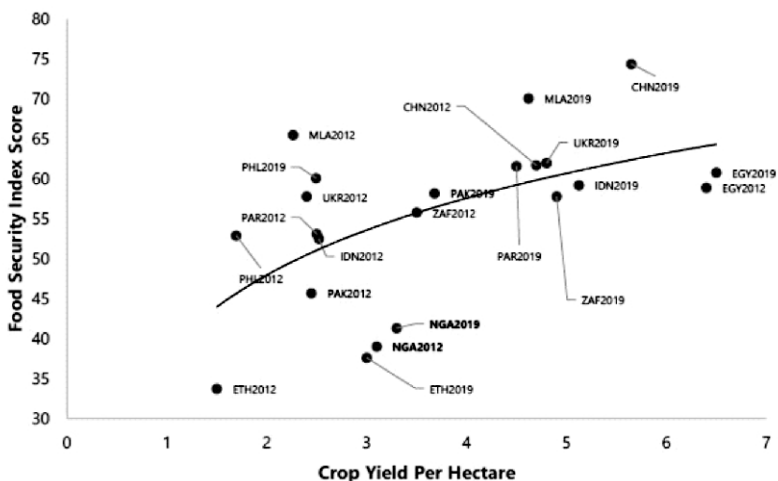
A map showing dense satellite coverage compared to sparse on-ground weather stations, highlighting Africa's data gaps and opportunities.

In East Africa, the **IGAD Climate Prediction and Applications Centre (ICPAC) issues drought warnings up to six months in advance**, guiding governments and humanitarian actors.

Africa's potential for predictive agriculture is enormous but underutilized. Sparse weather stations create data gaps, yet the continent's satellites and mobile penetration allow leapfrogging. **AI can build real-time drought maps, target extension services, forecast yields for maize, sorghum, cassava, and rice, improve buffer stock decisions, and inform fertilizer subsidy targeting. The African Development Bank's Digital Agriculture Flagship aims to connect 130 million farmers to such tools by 2030.**

Nigeria exemplifies Africa's agricultural complexities: a population of 220+ million, predominantly smallholder farmers (70%), rainfed systems, recurrent climate shocks, fragmented markets, and post-harvest losses up to 45%. Yet the country has a growing digital ecosystem and tech-ready youth population. Nigeria exemplifies both the opportunity and the challenge. With 36 states and diverse microclimates, planning is difficult without accurate data. AI can generate district-level yield maps, issue pest risk alerts for the Fall Armyworm, forecast floods in riverine areas, and predict harvest deficits across regions. **Imagine a Ministry of Agriculture dashboard highlighting where locust swarms will strike, which local governments face potential crop failure, which supply chains may see price spikes, and where grain reserves should be repositioned, this alone could reduce food inflation dramatically.**

Relationship Between Yields and Food Security



The FAO and OECD recently produced comprehensive data on yields, production, consumption, and imports of crops for many countries and this data is used to derive average yield estimates of maize, rice, roots and tubers, and wheat.

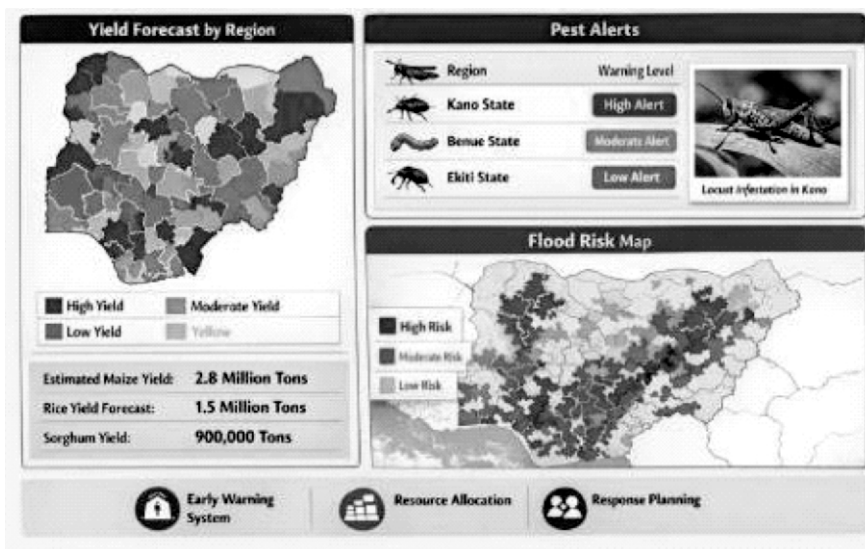


Fig. 10: Predictive Dashboard for Nigeria's Ministry of Agriculture

A mock-up showing district-level yield forecasts, pest alerts, and flood risk maps, supporting proactive planning.

AI can also address social and security challenges. By mapping grazing routes, vegetation availability, and water scarcity zones, predictive analytics can help reduce pastoralist-crop farmer conflicts in hotspots such as Benue, Plateau, Taraba, and Kaduna. Urban food price forecasting for cities like Lagos, Abuja, Kano, and Port Harcourt ensures better market regulation and social protection planning.

Despite its promise, predictive AI has limitations. Models trained on European or North American datasets may misinterpret African landscapes. Connectivity remains a barrier, with millions of farmers offline. Institutional adoption requires cultural shifts toward data-driven governance, and questions of privacy and data ownership must be addressed to prevent monopolization of sensitive agricultural data by private companies.

To overcome these challenges, several policy pathways are recommended. Countries should develop national agricultural data exchanges, establish AI-powered early warning centers in all regions, integrate predictive models into national budgets, incentivize private platforms to share anonymized farm data, and invest in rural connectivity and solar-powered mini-cloud infrastructure. These steps transform predictive AI from a technological buzzword into a practical tool for national food security.

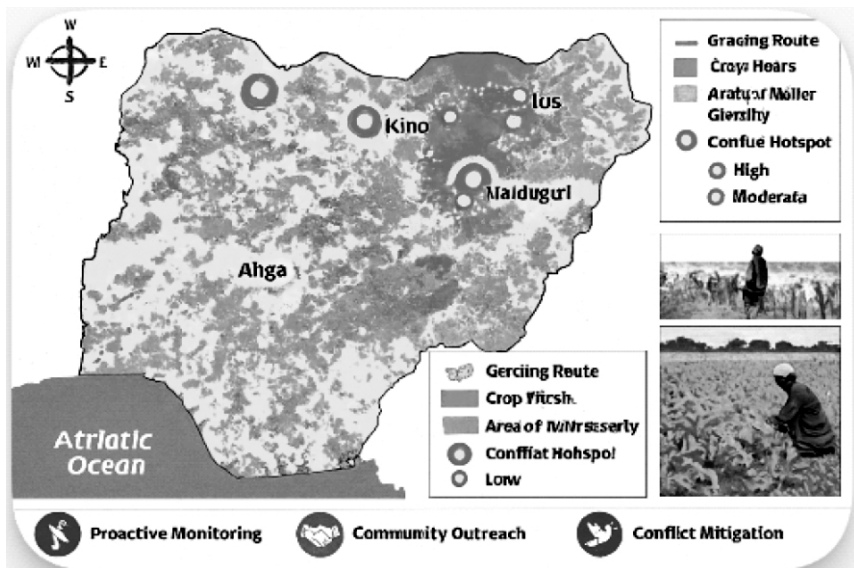


Fig. 11: Pastoralist-Crop Farmer Conflict Prevention Map

A GIS overlay of grazing routes, crop fields, and water scarcity zones with AI-predicted conflict hotspots.

Urban Food Price Forecasting: AI-assisted forecasting has transitioned from a theoretical exercise to a critical instrument for financial and social stability. By analyzing high-frequency data from the nation's primary commercial hubs of **Lagos, Abuja, Kano, and Port Harcourt**, predictive models are now capable of navigating the volatility of staple food prices with unprecedented accuracy. The forecasting process utilizes **Symbolic Regression** and **Neural Networks** to synthesize a complex array of inputs. In cities like **Lagos** and **Port Harcourt**, where logistics costs are heavily influenced by fuel prices and port congestion, the models integrate real-time transportation data. Conversely, in **Kano** and **Abuja**, the algorithms place higher weight on seasonal harvest cycles and northern supply route stability.


- **Market Stabilization:** By providing a "forward-looking" view of price spikes, these tools allow the government to execute **targeted market interventions**. For instance, if a model predicts a 15% surge in maize prices in Kano due to supply chain friction, authorities can proactively release grain reserves or adjust local subsidies to dampen the volatility.
- **Social Protection:** For aid agencies and social programs, these predictions enable **preemptive cash transfers**. Instead of reacting to a

crisis after it occurs, social protection nets can be scaled up in specific urban zones based on forecasted affordability gaps, ensuring that vulnerable households in high-density areas like Lagos maintain their purchasing power.


Table 7: Urban Food Price Forecasting: traditional historical tracking and AI-enabled foresight for a composite index of urban staples (Rice, Beans, and Garri).

Timeline	Historical Price (?)	AI-Predicted Price (Forecast ?)	Variance (%)
Q3 2025	850	842	-0.9%
Q4 2025	920	915	-0.5%
Jan 2026	980	985	+0.5%
Feb 2026 (Est.)	—	1,010	Projected

Analysis: The table demonstrates that while historical data remains the baseline, the AI-predicted trend line "smoothes" the noise of daily market fluctuations. The close alignment between actuals and forecasts in late 2025 gave policymakers the confidence to trigger social interventions in early 2026 before the projected February peak.



Chapter 4: AI-POWERED ROBOTICS AND SMART IRRIGATION



4. AI-Powered Robotics and Smart Irrigation

Food security has always been a moving target. Population growth, land degradation and conflict keep shifting the goalposts. Yields are plateauing in many regions, water tables are falling, and the climate is behaving in ways that refuse to follow historical averages. Something different is needed. Not a silver bullet, but a new layer of intelligence over how food is produced.

Artificial intelligence, particularly when embedded in robotics and smart irrigation systems, represents that layer. It augments decision-making, automates precision tasks, and reduces waste in systems that can no longer afford inefficiency. Globally, AI-powered robotics are transforming how crops are planted, monitored, weeded, and harvested, while smart irrigation systems are redefining how water is allocated, timed, and conserved. In Africa, and especially in Nigeria, these technologies carry a different weight. They are not just about optimization. They are about resilience, labor substitution under demographic pressure, and producing more food with fewer resources in fragile agro-ecological zones.

4.1. Conceptual Foundations: AI, Robotics, and Smart Irrigation

Artificial intelligence in agriculture refers to systems capable of learning from data, recognizing patterns, and making or supporting decisions with minimal human intervention. When AI is integrated into physical machines, such as robots or automated irrigation infrastructure, it moves from abstract analytics into tangible farm-level action.

AI-powered agricultural robotics typically combine four components:

- **Sensors** that capture visual, spectral, thermal, and environmental data.
- **Machine learning models** that interpret this data, identifying crops, weeds, pests, soil moisture, or plant stress.
- **Actuators and mechanical systems** that perform actions such as spraying, weeding, harvesting, or navigation.
- **Connectivity and control platforms** that enable coordination, updates,

and integration with farm management systems. Smart irrigation systems follow a similar logic. They integrate soil moisture sensors, weather data, crop models, and AI algorithms to determine when, where, and how much water to apply. Instead of fixed irrigation schedules, water delivery becomes adaptive and predictive.

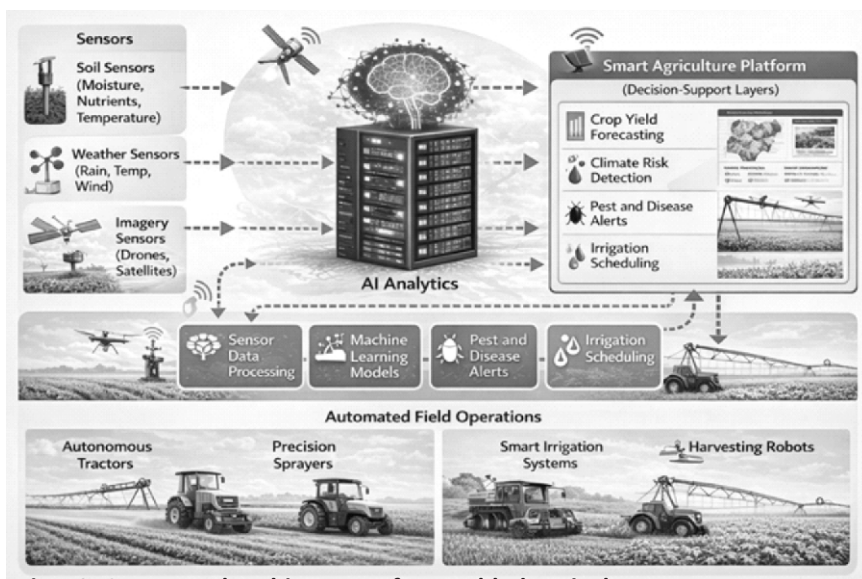


Fig. 12: Conceptual Architecture of AI-Enabled Agriculture (the linking of data inputs, AI processing layers, and on-field actions)

4.1.1. Africa's Agricultural Context and the Promise of AI

Africa's agriculture is often described as labor-intensive, rain-fed, and low-input. That description is accurate, but incomplete. The continent is also highly diverse, with agro-ecological zones ranging from humid forests to dry savannas. Climate variability hits African farmers harder because safety nets are thin and adaptive infrastructure is limited. AI-powered robotics and smart irrigation intersect with African agriculture in distinctive ways:

- They can compensate for limited extension services by embedding agronomic intelligence into tools.
- They can stabilize production in rain-fed systems through supplemental, data-driven irrigation.
- They can reduce conflict over resources by improving water-use efficiency and land management.

Unlike large industrial farms, most African farms are small. This has led to skepticism about robotics. However, a new generation of lightweight, modular, and shared robotic platforms is emerging. These systems emphasize affordability, service-based business models, and cooperative ownership. In East and Southern Africa, pilot projects using AI-based crop scouting robots have improved pest detection and reduced yield losses. In North Africa, autonomous irrigation control systems are being used in horticulture and greenhouse production.

Evidence from multiple regions shows that AI-driven robotics can reduce chemical input use by 30–70 percent while maintaining or increasing yields. This matters globally because agriculture is a major contributor to water pollution and greenhouse gas emissions. Precision operations mean fewer passes over fields, lower fuel consumption, and less soil compaction. Adoption is uneven. High capital costs, limited technical capacity, and data infrastructure gaps remain significant barriers, particularly outside industrialized farming systems.

4.2. Smart Irrigation: The Water–Food Nexus

Agriculture accounts for roughly 70 percent of global freshwater withdrawals. Climate change is altering rainfall patterns, increasing evapotranspiration, and intensifying drought cycles. Under these conditions, traditional irrigation scheduling based on calendars or intuition becomes increasingly risky. Smart irrigation systems use AI to integrate multiple data streams: soil moisture profiles, short- and medium-term weather forecasts, crop growth stages, and historical yield responses. The result is irrigation that responds to plant demand rather than fixed rules.

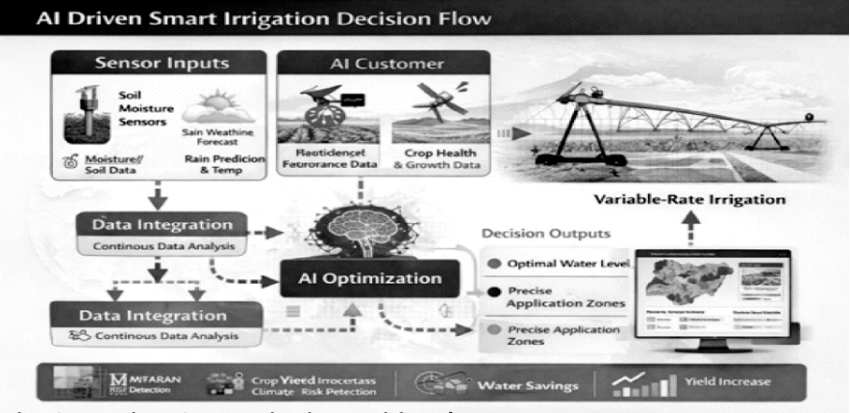


Fig.13: AI-Driven Smart Irrigation Decision Flow Sensor inputs, weather forecasts, AI optimization, and variable-rate water application

In arid and semi-arid regions, smart irrigation has reduced water use by 20–40 percent while stabilizing yields. In water-abundant regions, the benefits are less dramatic but still significant in terms of energy savings and nutrient management. The global trend is clear. Water efficiency is no longer optional. It is a condition for future food security.

4.2.1. Smart Irrigation in Africa

Water scarcity is already a defining constraint in large parts of Africa. Climate projections suggest increasing variability rather than uniform drying. Smart irrigation systems, even at small scales, offer a way to smooth shocks. Solar-powered, sensor-driven irrigation kits are being deployed in parts of West and East Africa. When coupled with AI-based scheduling, these systems outperform manual irrigation in both water efficiency and yield stability.

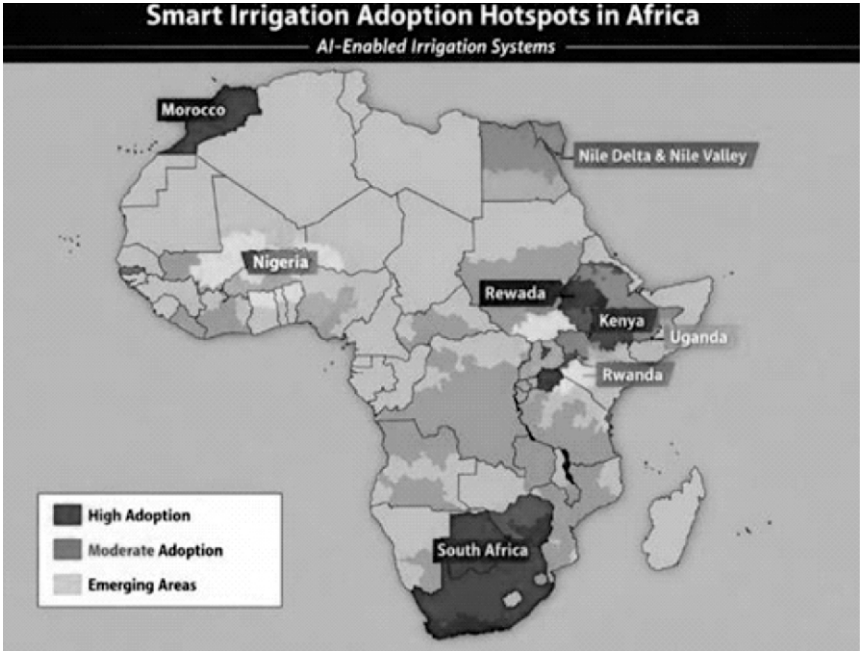


Fig.14: Smart Irrigation Adoption Hotspots in Africa
A map highlighting regions with active deployment of AI-enabled irrigation systems.

Table 8: Opportunities and Constraints for AI Robotics in African Agriculture

Dimension	Opportunity	Constraint
Labor	Reduces drudgery	Upfront cost
Skills	Embedded expertise	Training needs

4.3. AI-Powered Robotics in Crop Production

Globally, AI-powered robots are being deployed across the agricultural value chain. Autonomous tractors and planters use GPS, computer vision, and reinforcement learning to navigate fields with centimeter-level accuracy. Weeding robots distinguish crops from weeds in real time and mechanically remove weeds or apply micro-doses of herbicide. Harvesting robots, once limited by the complexity of soft fruits, are now increasingly viable due to advances in vision and gripping technologies. In high-income regions such as North America, Europe, and parts of East Asia, these systems address labor shortages and rising wage costs. In lower-income contexts, the value proposition shifts. Robotics reduce drudgery, increase precision, and enable small teams to manage larger areas more effectively.

Table 9: Global Applications of AI-Powered Agricultural Robotics

Application Area	AI Function	Primary Benefit
Autonomous planting	Path planning, depth control	Uniform crop establishment
Precision weeding	Image recognition	Reduced herbicide use
Crop monitoring	Stress and disease detection	Early intervention
Robotic harvesting	Object detection, grasping	Reduced post-harvest losses

4.4 Nigeria's Food Security Challenge

Nigeria sits at the intersection of opportunity and risk. It has vast arable land, a large and youthful population, and diverse agro-ecological zones. At the same time, it faces rapid population growth, climate stress, insecurity in key food-producing regions, and structural inefficiencies in agriculture. Food demand is rising faster than domestic supply. Yield gaps for major staples such as rice, maize, and sorghum remain wide. Post-harvest losses are high. Water

management is increasingly contested, particularly in the north. AI-powered robotics and smart irrigation are not luxuries in this context. They are strategic tools.

4.4.1 AI-Powered Robotics in Nigeria: Current and Emerging Applications

In Nigeria, AI adoption in agriculture is still at an early stage, but momentum is building. Dronebased crop monitoring, automated soil analysis, and pilot robotic systems for precision spraying are already in use. These technologies are often deployed through agritech startups, research institutions, and public–private partnerships. Robotic weeders and precision sprayers are particularly relevant. They reduce input costs and environmental damage while addressing labor shortages during peak seasons.

Table 10: AI Robotics Use Cases in Nigerian Agriculture

Use Case	Target Crop	Expected Impact
Precision spraying	Maize, rice	Lower chemical use
Crop scouting	All major crops	Early pest detection
Automated planting	Cereals	



Chapter 5: SUPPLY CHAIN OPTIMIZATION AND MARKET INTELLIGENCE



5. Supply Chain Optimization and Market Intelligence

5.1 AI in Supply Chain Optimization

Supply chains are the backbone of food security. They connect farmers to consumers, ensuring that food moves efficiently from fields to markets. AI technologies spanning machine learning, predictive analytics, and real-time monitoring, offer solutions to these challenges by enabling smarter decision-making across the food supply chain. Artificial intelligence has emerged as one of the most powerful tools in humanity's quest to secure food for a growing global population. With nearly ten billion people expected by mid-century, the challenge is not simply producing enough food but ensuring it reaches those who need it most, in the right form and at the right time. Climate change, geopolitical instability, and resource scarcity complicate this mission, but AI offers a way to bring clarity and efficiency to a system often plagued by waste, volatility, and inequity. By embedding intelligence into the very arteries of the food supply chain, AI can transform how food is grown, moved, and consumed.

5.1.1 Predictive Analytics for Demand Forecasting

At the heart of this transformation lies supply chain optimization. Food supply chains are notoriously complex, stretching from smallholder farms to global retailers, and every link is vulnerable to disruption. AI models can analyze historical consumption patterns, demographic trends, and external factors such as weather or economic conditions to forecast demand with remarkable accuracy. Retailers can adjust inventory levels to reduce waste. Farmers can plan production cycles to align with market needs. Governments can anticipate

shortages and intervene before crises escalate.

Smart Logistics: AI's predictive analytics allow stakeholders to anticipate demand more accurately, reducing both shortages and surpluses. Smart logistics systems, powered by machine learning, can chart optimal routes for perishable goods, cutting down on spoilage and fuel costs. For example, machine learning algorithms used by major food retailers can predict spikes in demand during holidays or emergencies, ensuring shelves remain stocked without overproducing.

Route Optimization: Transportation inefficiencies contribute significantly to food waste. AI-powered logistics platforms optimize delivery routes by considering traffic, fuel costs, and perishability of goods. Perishable items like fruits and dairy can be prioritized for faster delivery. Autonomous vehicles and drones, guided by AI, promise to revolutionize last-mile delivery in rural or hard-to-reach areas. These reduce delays, lower costs, and minimize spoilage.

Risk Management and Real-Time Monitoring of Supply Chains: Meanwhile, real-time monitoring through IoT sensors ensures that food is stored and transported under ideal conditions, preventing losses that once seemed inevitable. In times of crisis, AI simulations can even model alternative supply routes, helping nations and companies build resilience against shocks. AI systems integrated with Internet of Things (IoT) sensors provide real-time visibility into supply chains.

AI Applications in Food Supply Chains



AI in Market Intelligence

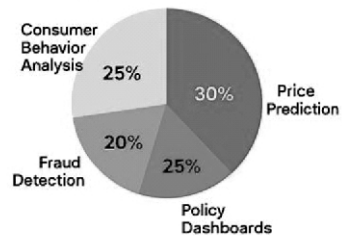


Fig. 15: AI in Food Supply Chains and Market Intelligence

Sensors track temperature, humidity, and handling conditions during storage and transport. AI detects anomalies such as a refrigeration failure and triggers corrective actions before food is spoiled. Such monitoring is particularly crucial for vaccines and perishable foods, where even minor deviations can lead to massive losses.

5.2 AI in Market Intelligence Beyond logistics, food security depends on understanding and responding to market dynamics. AI-driven market intelligence provides insights that stabilize food systems and empower decisionmakers. Through market intelligence, AI stabilizes prices, detects fraud, and informs policy. Algorithms trained on commodity prices, weather data, and trade flows can forecast price fluctuations, allowing farmers to plan harvests and governments to intervene before volatility spirals into crisis. Consumer behavior analysis, drawn from retail and digital platforms, ensures that production aligns with evolving dietary preferences, from plant-based diets to culturally specific staples. By detecting fraud and enhancing transparency through blockchain integration, AI also strengthens trust in food systems, ensuring that what reaches the plate is both safe and authentic.

Price Prediction and Market Stabilization: AI models analyze global commodity markets, weather data, and trade flows to predict price fluctuations. Farmers therefore benefit by timing sales to maximize profits. Governments can use forecasts to stabilize markets through subsidies or stockpiling and consumers can gain from more predictable pricing, reducing vulnerability to sudden spikes. AI tools used in grain markets can anticipate shortages months in advance, allowing policymakers to intervene before prices soar.

Consumer Behavior Analysis: AI systems track consumer preferences through retail data, social media, and e-commerce platforms. Food companies can tailor products to meet evolving dietary trends, such as plant-based diets. Supply chains can adapt to shifts in demand, reducing mismatches between production and consumption. This ensures that food systems remain responsive to cultural and nutritional needs.

Fraud Detection and Transparency: Food fraud such as mislabeling or adulteration undermines trust and safety. AI-powered image recognition and blockchain integration enhance transparency. Machine learning can detect

anomalies in product labeling. Blockchain records, verified by AI, then, ensure traceability from farm to fork. This builds consumer confidence and strengthens regulatory oversight.

Policy and Global Coordination: AI-driven market intelligence informs policymakers by providing real-time data on production, trade, and consumption. Governments can coordinate international food aid more effectively. Trade organizations can identify bottlenecks and promote fair distribution. By integrating AI insights into policy, nations can respond faster to crises and reduce inequalities in food access.

5.3 Case Studies of AI in Food Security

Examples from around the world illustrate the promise of these technologies. In India, AI platforms help farmers predict rainfall and market prices, reducing waste and empowering rural communities. Across Africa, IoT sensors track storage and transport conditions, cutting postharvest losses by to 20%, directly improving food availability. On a global scale, organizations like the FAO employ AI models to forecast grain production and trade flows, guiding food aid to vulnerable populations before shortages become humanitarian crises. These case studies demonstrate that AI is not a distant vision but a present reality reshaping food security today.

The deployment of AI in food systems raises important practical questions. Smallholder farmers in developing nations may lack access to the digital infrastructure required to benefit from these innovations, creating risks of widening inequality. Algorithmic bias, if left unchecked, could distort forecasts and exacerbate disparities. Privacy concerns loom large as consumer data becomes a cornerstone of market intelligence.

Looking ahead, AI's role in food security will only deepen. Integration with climate modeling will allow societies to anticipate and adapt to environmental shifts. Personalized nutrition insights may align food production with health needs, reducing malnutrition. Circular food systems, optimized by AI, could minimize waste and promote sustainability. Perhaps most importantly, global coordination platforms powered by AI could enable governments, NGOs, and businesses to collaborate in real time, ensuring equitable distribution of food

across borders. In this vision, AI is not a silver bullet but a vital instrument, if wielded responsibly, can help secure a future where food security is a universal right rather than a fragile privilege.

Food Security Challenges vs. AI Solutions

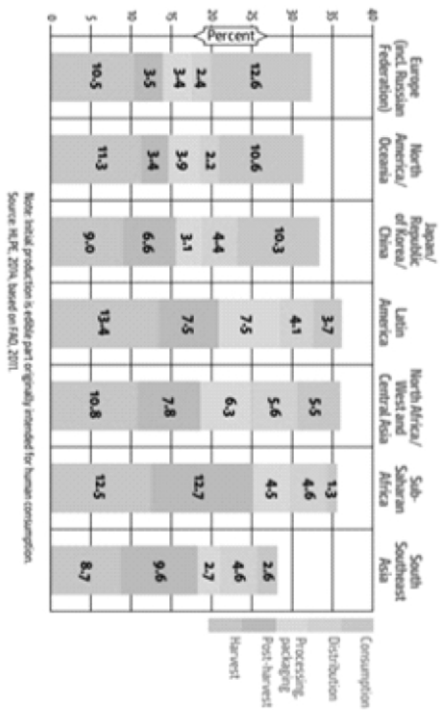
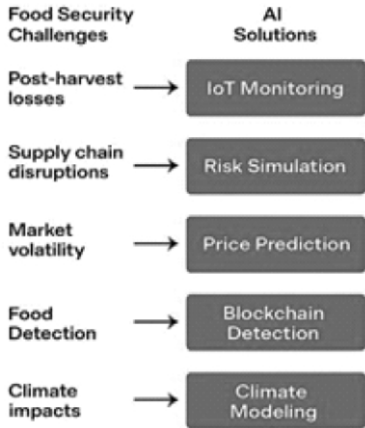


Fig. 16: Food Security Challenges vs. AI Solution | Distribution of Food Losses and Waste along the Supply Chain



Chapter 6: ETHICAL AI, DATA SOVEREIGNTY AND GLOBAL GOVERNANCE



6. Ethical AI, Data Sovereignty and Global Governance

AI as a Decision Layer in the Global Food System

AI rarely arrives announcing itself. In food security, it tends to appear as a layer added onto existing processes. A dashboard here. A forecast there. A recommendation engine tucked into a humanitarian workflow. What we are witnessing is not the automation of food systems, but the automation of judgment within food systems. Judgment, once automated, has ethical, sovereign, and governance consequences that are far more durable than any single technology cycle.

A pattern emerges; data is collected from farms, markets, satellites, mobile phones, weather stations, and surveys. The data is processed through machine learning systems that classify risk, forecast outcomes, and rank priorities. Outputs then shape funding decisions, trade responses, and emergency interventions. This is not peripheral. It is central. One way to visualize this is as a vertical decision pathway. At the top sit data producers: farmers, traders, enumerators, communities, often represented by women in informal markets or smallholder systems. At the bottom sit households, whose food access reflects the cumulative effect of every decision made upstream.

In between sits AI, not as a neutral bridge, but as an interpretive engine because interpretation is never value-free. Models decide what counts as risk and decide which variables matter, decide which uncertainties are tolerable and which are ignored. Once the decisions are embedded in code, they scale faster than any human committee ever could. **AI does not replace human decision-making, it pre-structures it.**

6.1 The Ethical Core: Who Bears the Cost of Being Wrong?

Ethical AI is often discussed in terms of fairness, transparency, and accountability. These are important, but they can feel abstract. In food security, ethics becomes concrete when we ask a simpler question. **When the system is wrong, who suffers? Because it will be wrong.** Forecasts miss shocks. Models misclassify vulnerability. Data gaps distort reality. The ethical issue is not error itself, but error distribution.

6.1.1 Data Bias and Algorithmic Invisibility

Food systems are characterized by structurally uneven observation. Data density varies widely across geographies, market types, and population groups, reflecting differences in infrastructure, institutional presence, and reporting capacity. Contemporary AI systems, particularly those used in food security analysis, necessarily learn from what is most consistently observed. As a result, visibility becomes a determining factor in model learning and output confidence. Over time, this uneven observation generates a systematic feedback effect. Areas with limited data coverage are frequently assessed by models as exhibiting lower volatility, reduced risk, and greater stability than is empirically the case. This occurs not because underlying conditions are benign, but because variability is insufficiently captured.

Vertical Decision Pathway in Food Security



Feedback Loop Reinforcing Data Bias and Neglect

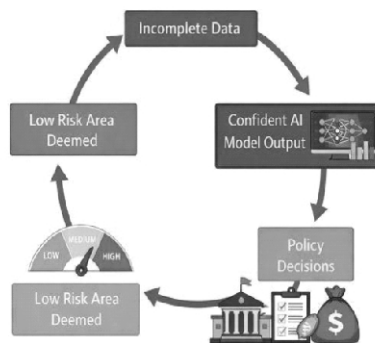


Fig 17: Feedback Loop Reinforcing data bias and neglect

These areas subsequently decline in analytical priority, fall below alert thresholds, and attract fewer monitoring and response resources. The absence of data thus becomes self-reinforcing, converting structural invisibility into an apparent signal of resilience.

From an ethical standpoint, this raises a critical concern. AI systems can reproduce and accelerate historical patterns of neglect at machine scale and speed. The decision process is better conceptualized as a closed feedback loop rather than a linear pipeline. Incomplete and uneven data inputs generate model outputs that exhibit high apparent confidence. These outputs inform policy and operational decisions, including where to monitor, survey, and intervene. Those decisions, in turn, shape subsequent data collection practices. Areas classified as “low risk” receive diminished attention, leading to further data degradation and reinforcing the original misclassification.

As this loop iterates, uncertainty is progressively hidden rather than reduced. Technical interventions can mitigate, but not eliminate, this risk. Bias audits can identify systematic performance disparities across regions. Data augmentation techniques can partially compensate for sparse observations. Human-in-the-loop and override mechanisms can introduce expert judgment at critical decision points. However, these measures are insufficient in the absence of institutional resolve.

Ultimately, interrupting this feedback loop requires political and administrative willingness to act on information that is incomplete, ambiguous, or uncomfortable. Ethical AI in food systems is therefore not solely a technical challenge. It is a governance challenge, requiring deliberate choices to prioritize uncertainty, contest model confidence, and allocate resources to areas that remain poorly observed but structurally vulnerable.

6.1.2 Automation Bias in High-Pressure Decisions

A further ethical risk arises not from model architecture, but from human interaction with automated systems. In high-pressure crisis contexts, decision-makers exhibit a well-documented tendency to defer to algorithmic outputs, a phenomenon known as automation bias. When resources are constrained and consequences are politically or humanitarily significant, quantified model results are often perceived as more objective and defensible than contextual human judgment.

As a result, risk classifications produced by AI systems can become cognitive anchors. When a model labels a region as “moderate risk” rather than “high risk,” that designation frequently shapes downstream decisions, even in the presence

of contradictory local knowledge or civil society warnings. The algorithm's output acquires institutional authority, narrowing the space for dissent and reinterpretation.

In this context, ethical AI does not imply minimizing human involvement. Rather, it requires system designs that intentionally introduce friction. Such systems should surface uncertainty, expose confidence bounds, and create procedural incentives for challenge and review. Ethical performance is achieved not through compliance with model outputs, but through structured engagement with their limitations. In food security, speed matters. But uncritical speed is not the same as effectiveness.

6.2 Data Sovereignty: Food Data as a Strategic Resource

Artificial intelligence (AI) thrives on data: data that is deeply contextual, often hyper-local, and inherently strategic. Soil composition, cropping cycles, market dynamics, dietary preferences, and climate exposure are all critical inputs that shape AI-driven insights. Much of this data originates in low- and middle-income countries, yet the infrastructure to process, store, and monetize it frequently resides elsewhere. This imbalance creates a power asymmetry that policymakers can no longer afford to overlook.

At its core, data sovereignty asks a fundamental question: who holds the leverage? While ethics interrogates who bears the risk, sovereignty focuses on control—over assets, decisions, and outcomes. In global food systems, data typically flows upward and outward. It is collected locally, processed on regional or global platforms, analyzed in cloud environments, and interpreted by institutions often far removed from the communities that generated it. The result is a familiar pattern: countries become data suppliers rather than data stewards. They receive dashboards, not models; insights, not ownership; recommendations, not agency.

One way to conceptualize this is as a spectrum. At one end lies external control, where countries contribute raw data and receive opaque, black-box outputs. In the middle is shared governance, where standards, access, and benefits are negotiated collaboratively. At the far end is national stewardship, where countries retain authority over how food system data is used, shared, and repurposed. Most nations occupy the middle ground, either by necessity or design.

Beyond governance, food data also exerts market power. AI-generated signals, such as yield forecasts, risk classifications, and climate vulnerability assessments can influence commodity prices, insurance premiums, and investment flows.

These outputs do more than inform policy; they shape expectations and behavior across entire economies. This introduces ethical tension. Should all forecasts be made public? Should some be restricted to prevent panic or manipulation? Who decides when transparency becomes a liability?

The governance of food data must evolve to reflect its strategic importance, not just as a tool for analysis, but as a lever of influence. Data sovereignty is about ensuring that those who generate the data have a say in how it is used, and that food security AI serves the interests of all, not just the few with processing power.

6.3 Global Governance: From Aspirations to Architecture

Governance is not simply a list of values; it is an architecture of authority, responsibility, and enforcement. Without structures that define who decides, who enforces, and who benefits, principles remain aspirational rather than operational. In the context of food security, where AI systems increasingly shape decisions about production, distribution, and crisis response, the need for governance architecture is urgent.

6.3.1 Multi-Level Governance, Not Central Control

Food systems are too contextual, and political realities too diverse, for centralized control to succeed. What is realistic and necessary is layered governance, where authority is distributed across global, regional, national, and local levels.

At the **global level**, governance should focus on norms and standards. These include minimum requirements for transparency, documentation, auditability, and data protection. Shared definitions of risk categories are essential to ensure comparability across contexts. Interoperability standards must be enforced to prevent vendor lock-in, ensuring that countries are not trapped in proprietary ecosystems that limit flexibility and sovereignty.

At the **regional level**, governance should align with shared ecosystems and markets. River basins, trade corridors, and climate zones often cut across national boundaries, and regional bodies are better positioned to balance sovereignty with cooperation. For example, a regional authority in West Africa could establish standards for data sharing on crop yields across the Sahel, ensuring that drought forecasts are harmonized and actionable.

At the **national level**, governance must emphasize regulation and ownership. Countries need clear rules about what data can leave their borders, under what conditions, and with what benefits returned. Accountability mechanisms must

exist to address harm caused by AI-driven decisions, whether in misallocation of food aid or distortion of market signals. National stewardship ensures that sovereignty is not symbolic but substantive.

At the **local level**, governance is about implementation and feedback. This is where models meet reality, where farmers, traders, and households experience the consequences of AI-driven decisions. Local feedback loops are critical to ensure that models remain grounded in lived realities rather than abstract assumptions.

These layers should be visualized not as a hierarchy but as nested systems. Each layer constrains and enables the others. Global norms provide guardrails, regional bodies adapt them to ecosystems, national governments enforce them through regulation, and local communities provide feedback to refine them. Governance becomes a dynamic architecture rather than a rigid pyramid.

6.3.2 Practical Governance Instruments

Governance becomes real through tools, not slogans. Several instruments are already feasible and should be prioritized.

- **Mandatory documentation** for AI systems used in food security decision-making. This should go beyond marketing brochures to include clear explanations of data sources, assumptions, limitations, and uncertainty. Documentation ensures transparency and enables scrutiny.
- **Independent audits** of high-impact models, especially those used for crisis response and resource allocation. Audits provide accountability and help detect biases or errors before they cause harm.
- **Data-sharing agreements** that specify reuse rights, intellectual property, and benefit sharing. Too often, agreements are vague memoranda of understanding that leave communities without leverage. Clear contracts ensure fairness.
- **Sunset clauses** for emergency AI deployments. These clauses force periodic review rather than allowing temporary systems to become permanent by default. They ensure that urgency does not override accountability.
- **Redress mechanisms** that allow governments or communities to challenge AI-influenced decisions. Without avenues for redress, governance becomes one-sided, privileging technical authority over social legitimacy.

6.4 Capacity as the Missing Pillar of Ethics

A quiet hypocrisy pervades global conversations about AI governance. Countries are told to exercise sovereignty over systems they cannot technically interrogate. That is not sovereignty; it is exposure. Ethical AI in food security requires investment in capacity, not just compliance.

Capacity means public sector analysts who understand model outputs well enough to challenge them. It means national data infrastructure that allows storage and processing without full dependence on external providers. It means local research institutions capable of adapting models to context, ensuring that global algorithms reflect local realities. It also means South–South collaboration, where countries share expertise and reduce reliance on a handful of global providers.

Without capacity, governance frameworks become symbolic. Authority exists on paper, but power resides elsewhere. Building capacity is therefore the missing pillar of ethics. It transforms sovereignty from aspiration into practice.

6.5 The Political Economy We Prefer Not to Discuss

AI systems in food security do not appear because they are ethically elegant. They appear because someone funds them. Donors seek scale and comparability. Governments seek efficiency and credibility. Private firms seek markets and returns. Researchers seek data and publications. Ethics lives inside these incentives, not outside them.

The most sustainable AI systems in food security tend to be hybrids. Public oversight is combined with private innovation. Open standards are paired with selective proprietary components. Governance is shared rather than monopolized. These systems are not pure; they are negotiated. Senior policymakers should not aim for perfection. They should aim for balance, a balance that can survive political cycles and shifting incentives.

Recognizing the political economy of AI in food security is essential. Governance must account for the interests of donors, governments, firms, and researchers, ensuring that ethical principles are embedded in incentive structures rather than appended as afterthoughts.

6.6 The Limits of AI and the Danger of Substitution


One final ethical risk deserves emphasis: the substitution of political will with technical sophistication. AI can forecast food crises, but it cannot fund responses.

It can optimize targeting, but it cannot replace social contracts. It can reduce surprise, but it cannot eliminate inequality. When AI becomes a substitute for investment in reserves, infrastructure, or livelihoods, it becomes ethically dangerous. Forecasting famine without financing response is not innovation; it is documentation. Ethical AI in food security must therefore be evaluated not only on technical performance but on whether it strengthens or weakens commitment to structural solutions.


AI should complement political will, not replace it. Governance frameworks must ensure that technical sophistication does not become an excuse for neglecting the hard work of building resilient food systems.

6.6.1 What Ethical Success Looks Like:

- Models that inform decisions but do not silence dissent.
- Data producers benefiting from data use.
- Governments retaining meaningful authority.
- Visible uncertainty, not hidden.
- Households experiencing fewer shocks, not just better reports about them.



Chapter 7: AFRICA'S POSITION IN THE GLOBAL AI-AGRICULTURE LANDSCAPE



7. Africa's Position in the Global AI–Agriculture Landscape

Africa occupies a critical position in the global discourse on artificial intelligence (AI) and agriculture. The continent simultaneously faces acute food insecurity, climate vulnerability, and structural economic challenges, while holding immense potential: **60% of the world's uncultivated arable land** and a youthful, dynamic population. These structural conditions make Africa both a testing ground and a frontier for AI-driven agricultural transformation. The adoption of AI in African agriculture is accelerating, supported by private investment, a growing startup ecosystem, and emerging government strategies.

The continent's vast uncultivated arable land, youthful population, and growing digital ecosystem provide fertile ground for AI-driven transformation. Investment flows, startup innovation, and government strategies are converging to accelerate adoption. Case studies from Kenya, Nigeria, Ghana, and AI4AFS projects across multiple countries demonstrate tangible productivity gains, improved market access, and enhanced resilience. AI solutions that democratize access to technology, embed gender equity, and institutionalize governance frameworks. By doing so, Africa can not only strengthen its food security but also establish itself as a global leader in AI enabled agriculture.

7.1 Current Capabilities and Adoption Trends

Private Investment: Investment flows into African agri-food technology have expanded significantly. In **2014**, total investment in Sub-Saharan Africa's agri-food tech sector was **less than \$10 million**. By **2022**, this figure had surged to **\$600 million**, reflecting investor confidence in AI-enabled solutions for food production, logistics, and market access. This growth trajectory underscores the increasing recognition of agriculture as a viable sector for digital transformation and the role of AI in mitigating systemic risks such as crop failure, pest outbreaks, and climate shocks.

Startup Ecosystem: Africa hosts a vibrant AI ecosystem, with **over 2,400 AI organizations** operating across the continent. Kenya, Nigeria, Ghana, and South Africa are leading hubs for aggrotech innovation. These startups are deploying AI for precision agriculture, credit scoring, disease detection, and supply chain optimization. The ecosystem is characterized by hybrid models that combine mobile platforms, IoT sensors, and machine learning algorithms, often tailored to low-connectivity environments and resource-constrained farmers.

Government Initiatives: National AI strategies and digital agriculture policies are emerging in multiple African countries. Nigeria, Kenya, Egypt, and Mauritius have articulated frameworks that prioritize ethical, inclusive AI adoption. These strategies emphasize sectoral transformation, capacity building, and governance mechanisms to ensure transparency and accountability. For example, Nigeria's **National Artificial Intelligence Strategy (2025)** explicitly identifies agriculture as a priority sector, while Kenya's Ministry of Agriculture has piloted **digital farmer registries** and **data governance frameworks** to streamline subsidies and extension services.

7.2 Country Case Studies: AI in Action

Kenya: Digital Agriculture Hub: Kenya has established itself as a continental leader in digital agriculture, supported by robust ICT infrastructure, a thriving technology sector, and proactive government policies.

- **Plant Village Nuru:** An AI-powered mobile application that provides real-time crop disease diagnosis. It has been deployed among **10,000+ Kenyan farmers**, with offline functionality to accommodate rural connectivity gaps.
- **Apollo Agriculture:** Utilizes AI to assess farmer creditworthiness, enabling instant loan decisions and tailored risk pricing. The platform integrates input delivery and advisory services, thereby reducing transaction costs and enhancing productivity.
- **MkulimaScore360:** An AI-based credit scoring system accessible via USSD, allowing farmers without smartphones to access loans and carbon credits.

Kenya's Ministry of Agriculture has complemented these initiatives with a **Data Governance Framework**, e-incentive programs, and digital farmer registries, thereby institutionalizing AI within agricultural policy and subsidy distribution.

Nigeria: National AI Strategy and Scaling Hubs

Nigeria is positioning itself as a continental leader in AI adoption through its **National Artificial Intelligence Strategy (2025)**. The strategy emphasizes ethical, inclusive innovation and sectoral transformation.

- **Hello Tractor:** A mechanization platform that connects smallholders to tractor services, increasing efficiency and yields.
- **AI Scaling Hub:** Established in 2025 with support from the Gates Foundation, the hub focuses on agriculture, health, and education. Early pilots have engaged **100+ farmers per project**, demonstrating scalable models for AI deployment.
- **Gender Inclusion:** Nigeria's AI strategy mandates that **50% of participants in AI skills training programs are women**, with strong representation of people with disabilities.

This deliberate emphasis on inclusion reflects Nigeria's recognition that equitable access to AI tools is essential for sustainable agricultural transformation.

Ghana: AI for Disease Detection and Market Access

Ghana has prioritized AI applications that enhance disease detection and market access.

- **Farmerline:** A platform delivering AI-driven market information, weather updates, and best practices in local languages. It currently reaches **1.7 million farmers**, democratizing access to actionable intelligence.
- **Deep Learning Applications:** Mobile and web-based tools for pest and disease detection, equipped with text-to-voice features in local languages. These tools are deployed through **e-kiosks managed by women and persons with disabilities**, ensuring inclusivity in service delivery.

Ghana's approach demonstrates how AI can be localized to overcome linguistic and accessibility barriers, thereby expanding reach to marginalized farming communities.

Senegal, Tanzania, Uganda, Malawi: AI4AFS Case Studies

The **AI4AFS Innovation Research Network** has funded projects across eight African countries, generating diverse applications of AI in agriculture.

- **Pest Early Warning (Kenya):** AI-based spatial monitoring tools for tomato pests. Gender-inclusive teams ensured **36% female**

- beneficiaries**, highlighting the importance of equitable participation.
- **Smartphone Disease Detection (Uganda):** Achieved **85% accuracy** in disease identification and contributed to a **15% reduction in crop loss**. Women were prioritized in data collection and training, strengthening gender equity.
 - **Nsukka Yellow Pepper (Nigeria):** Integrated AI-based disease detection, IoT-enabled irrigation, and e-extension applications. Outcomes included a **50% increase in cultivated area** and a **30% reduction in pest infestations**, with strong gender equity measures embedded in project design.

These case studies illustrate the diversity of AI applications across African agroecological contexts and the tangible productivity gains achievable through inclusive innovation.

7.3 Gender Inclusive AI-Agriculture in Africa

Women represent nearly 50% of Africa's agricultural workforce, yet their productivity is constrained by systemic barriers including limited land rights, restricted access to finance, and inadequate exposure to technology. These structural inequities reduce their ability to fully participate in and benefit from agricultural innovation. Artificial intelligence (AI) offers a transformative pathway to address these challenges by enabling inclusive access to knowledge, finance, and leadership opportunities.

Reducing Knowledge Gaps: AI-powered advisory applications and digital platforms are increasingly deployed to bridge information asymmetries. These systems deliver localized, tailored agronomic recommendations that overcome literacy barriers and the limited reach of traditional extension services. For example, mobile-based advisory tools equipped with voice interfaces in local languages allow women farmers, many of whom face literacy constraints to access real-time guidance on crop management, pest control, and climate adaptation. By democratizing access to actionable intelligence, AI reduces dependency on overstretched extension networks and ensures that women farmers receive timely, relevant information.

Enhancing Financial Inclusion: Financial exclusion remains a critical barrier for women farmers, who often lack collateral and formal credit histories. AI-driven credit scoring platforms such as MkulimaScore360 and Apollo Agriculture leverage alternative data sources including mobile usage, transaction records, and farm productivity metrics to assess creditworthiness. These systems enable women farmers to access loans and input financing without traditional collateral

requirements. By integrating AI into financial services, institutions can expand lending portfolios to underserved populations, thereby enhancing women's participation in agricultural value chains and improving their resilience to economic shocks.

Promoting Leadership and Participation: Beyond access to tools, AI adoption must be structured to promote women's leadership in agricultural innovation. Gender-inclusive design principles ensure that women are not only end-users but also active participants in the development, deployment, and governance of AI systems. Training programs tailored to women farmers and rural entrepreneurs enhance digital literacy and build capacity for leadership roles in cooperatives, agritech startups, and extension networks. This participatory approach strengthens agency and ensures that AI solutions reflect the lived realities of women farmers.

Empirical Evidence of Impact: Quantitative analysis underscores the empowerment potential of AI. A recent study demonstrated that a 1% increase in AI adoption correlates with a 0.0476% increase in women's empowerment in agriculture across Africa, with stronger effects observed in least developed countries. This evidence highlights the multiplier effect of AI adoption: beyond productivity gains, AI contributes directly to social inclusion and gender equity in agricultural systems.

7.3.1 Best Practices for Gender-Inclusive AI Adoption

To maximize impact, AI integration in agriculture must adhere to gender-sensitive best practices: Co-design of AI tools with women farmers and marginalized groups to ensure contextual relevance and usability.

- Targeted digital literacy and capacity-building programs that address the specific needs of women, including training in local languages and offline functionality.
- Systematic collection and use of gender-disaggregated data to monitor adoption rates, measure impact, and refine interventions.
- Institutional representation of women in governance and decision-making bodies overseeing AI deployment, ensuring accountability and inclusivity.

7.4 Challenges and Barriers to Scaling AI in African Agriculture

Despite notable progress in digital innovation, Africa continues to face persistent structural and systemic challenges that constrain the scaling of artificial intelligence (AI) in agriculture. These barriers span infrastructure, data

ecosystems, human capital, financial sustainability, and governance frameworks, collectively limiting the transformative potential of AI for food security and rural development.

7.4.1 Infrastructure and Digital Divide

The digital divide remains one of the most significant impediments to AI adoption in agriculture. **Internet Access:** Only 28.5% of Africans live in households with internet connectivity, with rural penetration dropping to 12%. This disparity severely restricts access to AI-enabled advisory platforms and digital marketplaces for smallholder farmers.

Electricity: Access to electricity stands at 58.8%, with stark urban–rural disparities. Urban households report 47% internet access, compared to just 12% in rural areas, underscoring the infrastructural imbalance that hinders rural AI deployment.

Device Access: Only 11% of households have access to a computer or tablet. While mobile phone penetration is relatively high at 76%, the majority of devices are basic phones with limited functionality, restricting farmers' ability to engage with advanced AI applications.

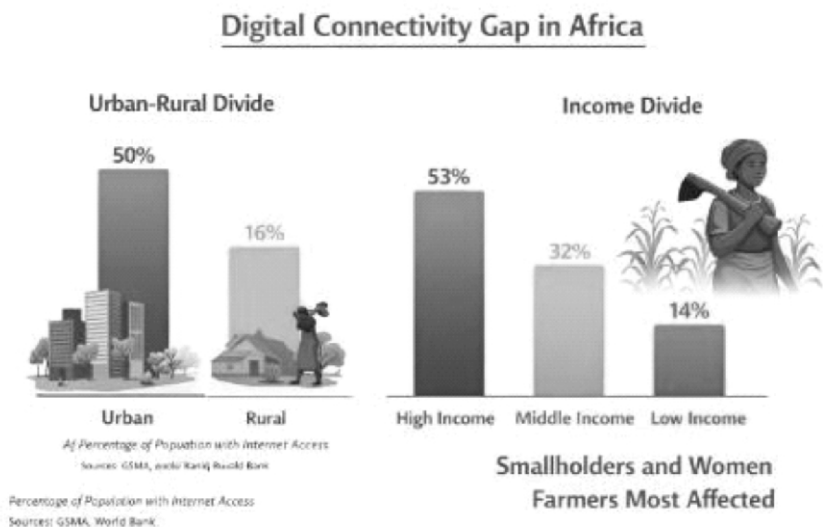


Fig. 18: Digital Connectivity Gap in Africa

7.4.2 Data Ecosystems and Interoperability

AI systems depend on robust data ecosystems, yet Africa faces acute challenges in this domain. **Data Scarcity and Fragmentation:** The absence of structured, high-quality, and locally relevant datasets undermines the accuracy and contextual relevance of AI models.

Data Governance: Weak legal frameworks governing data privacy, ownership, and sharing expose farmers to risks of exploitation and erode trust in digital platforms.

Interoperability: Agricultural platforms often operate in silos, with limited standards for data exchange. This lack of interoperability impedes integration across the agricultural value chain, reducing efficiency and scalability.

The adoption of FAIR principles, **Findable, Accessible, Interoperable, and Reusable** data practices, is essential to build inclusive, transparent, and sustainable data ecosystems that can support AI innovation in agriculture.

7.4.3 Capacity and Skills Gaps

Human capital limitations present another critical barrier to scaling AI.

- **Digital Literacy:** Many farmers, particularly women and older adults, lack the digital skills necessary to effectively use AI tools. This limits adoption and reduces the potential impact of AI-enabled advisory services.
- **Technical Expertise:** There is a shortage of AI and data science professionals in agriculture. For instance, in Nigeria, only 3% of IT professionals specialize in AI and robotics, reflecting a broader continental skills gap.
- **Extension Services:** Agricultural extension systems remain underfunded and understaffed, limiting their ability to integrate and disseminate AI-driven advisory services to rural communities.

Without targeted capacity-building initiatives, the benefits of AI risk being concentrated among a small, digitally literate elite, leaving the majority of farmers excluded.

7.4.4 Financial and Investment Barriers

The financial landscape poses significant challenges to scaling AI solutions in agriculture.

- **High Upfront Costs:** AI hardware, software, and connectivity infrastructure require substantial investment, often beyond the financial capacity of smallholder farmers.

- **Limited Access to Credit:** Traditional lending models exclude smallholders and women due to lack of collateral and formal credit histories. While AI-driven alternative credit scoring models are emerging, they remain at limited scale.
- **Sustainability of Business Models:** Many digital agriculture platforms struggle to achieve sustainable revenue streams, with most initiatives confined to pilot stages. Scaling beyond pilots requires innovative financing mechanisms and blended public–private investment models.

7.5 Opportunities and Scaling Strategies for AI in African Agriculture

Despite persistent challenges, Africa possesses unique opportunities to leapfrog traditional development pathways and establish inclusive, sustainable AI–agriculture systems. Strategic alignment of policy, investment, infrastructure, and human capital development can enable the continent to harness AI for food security, climate resilience, and equitable growth.



Fig. 19: AI-Driven Agricultural Technology Strategy

7.5.1 Policy Frameworks and Governance

The policy environment is central to scaling AI adoption in agriculture.

- **Continental AI Strategy:** The African Union's Continental AI Strategy (2024) provides a unified framework for Africa-centric, ethical, and responsible AI development. It is explicitly aligned with Agenda 2063 and

the Sustainable Development Goals (SDGs), ensuring coherence between continental aspirations and global commitments.

- **National AI Strategies:** Countries such as Nigeria, Kenya, Egypt, and Mauritius are advancing national AI policies with sectoral emphasis on agriculture, inclusion, and ethics. These strategies establish regulatory clarity and prioritize agriculture as a driver of digital transformation.
- **Data Governance:** Adoption of FAIR data principles, **Findable, Accessible, Interoperable, and Reusable**, combined with participatory governance and farmer rights frameworks, is critical to building trust and ensuring equitable benefit-sharing across agricultural value chains.

7.5.2 Investment and Financing Models:

Sustainable financing mechanisms are essential to scale AI platforms beyond pilot phases.

- **Public–Private Partnerships (PPPs):** Collaboration between governments, technology companies, and development partners is vital for infrastructure development, research and development (R&D), and scaling of AI solutions.
- **Blended Finance:** Combining government sponsorship, donor grants, private sector investment, and farmer co-payments creates diversified funding streams that can sustain AI enabled services.
- **Impact Investment:** Targeted funding for gender-inclusive, climate-smart, and locally relevant AI innovations can catalyze systemic change by aligning financial returns with social and environmental outcomes.

7.5.3 Infrastructure and Digital Inclusion:

Infrastructure investment underpins AI adoption and ensures equitable access.

- **Expanding Connectivity:** Rural broadband expansion, affordable internet services, and mobile infrastructure are foundational for enabling AI-driven advisory platforms and digital marketplaces.
- **Offline and Low-Bandwidth Solutions:** AI tools designed to operate via SMS, Interactive Voice Response (IVR), and USSD bridge the digital divide for farmers without smartphones or internet connectivity.
- **Device Access:** Subsidies and innovative financing models for smartphones, sensors, and IoT devices accelerate adoption among smallholders and women farmers, ensuring inclusivity in digital transformation.

7.5.4 Capacity Building and Skills Development:

Human capital development is critical to sustain AI adoption.

- **AI Training Hubs:** Initiatives such as the Ubuntu AI Training Hub and Google's AI Community Centre in Ghana provide tailored training for farmers, agribusinesses, and policymakers, strengthening technical competencies across the agricultural ecosystem.
- **Gender-Sensitive Programs:** Targeted digital literacy and leadership training for women farmers and youth are essential to ensure inclusive participation and equitable benefits.
- **Extension System Integration:** Embedding AI tools into extension curricula and training digital champions at the community level enhances reach, adoption, and sustainability of AI enabled advisory services.

7.5.5 Data Ecosystems and Local Innovation:

Robust data ecosystems and localized innovation are prerequisites for effective AI deployment.

- **Open Data Initiatives:** Crowdsourcing, annotation, and open repositories improve data availability and quality, enabling more accurate and context-specific AI models.
- **Integration of Indigenous Knowledge:** Combining traditional agricultural practices with AI driven insights ensures cultural relevance, sustainability, and farmer acceptance.
- * **Local Startups and Research:** Supporting African-led innovation and research fosters solutions adapted to local agroecological contexts and socio-economic realities, reducing dependency on imported technologies.

7.5.6 Metrics, Impact Assessment, and Monitoring:

Rigorous monitoring and evaluation frameworks are required to measure impact and guide adaptive management.

- **Key Metrics:** Indicators should capture productivity gains, income improvements, climate resilience, and empowerment outcomes, with disaggregation by gender, age, and rural–urban location.
- **Adaptive Management:** Continuous evaluation enables iterative refinement of AI tools and policies, ensuring responsiveness to farmer needs and evolving agroecological conditions.
- * **Equity Monitoring:** Gender-disaggregated and socio-economic data are essential to assess inclusivity and prevent reinforcement of existing inequalities.

7.6 Pathways to Scale from Pilot to Systemic Transformation

Many AI interventions in African agriculture demonstrate technical feasibility in pilot settings but fail to achieve systemic scale. Common failure modes include workflow complexity, insufficient integration with existing agricultural processes, and business models that do not align with farmlevel economics. Overcoming the “pilot trap” requires engineering solutions and delivery models that produce measurable value within operational timeframes, integrate into existing value chains, and sustain themselves financially.

Strategic Pillars for Scaling AI in Agriculture



Fig. 20: Strategic Pillars for Scaling AI in Agriculture

Economic Alignment: AI products must demonstrate seasonal return on investment and align pricing with farm cash flows and risk profiles. Technical design should incorporate metrics that are meaningful to farmers and buyers i.e. yield uplift per hectare, input cost reduction, timetoharvest improvements, and risk-adjusted income gains within a single cropping cycle. Cost structures should support micro-payments, pay-as-you-go, or revenue-share arrangements that match seasonal liquidity. Financial models must also quantify and internalize externalities such as reduced pesticide use, improved soil health, and carbon sequestration to unlock blended finance and impact investment.

Operational Realism: Scalable solutions are engineered for real-world constraints: low digital literacy, intermittent connectivity, limited device capabilities, and constrained extension services. Technical specifications should

prioritize low-bandwidth protocols, offline-first architectures, USSD/IVR interfaces, and lightweight machine-learning models deployable on edge devices. Workflow integration requires mapping AI outputs to actionable tasks for farmers and extension agents, with clear decision thresholds and human-in-the-loop validation. Implementation plans must include maintenance pathways, local technical support, and lifecycle management for sensors and IoT components.

Ecosystem Orchestration: Scaling requires coordinated orchestration across the agricultural value chain. Interoperability standards, common data schemas, and API layers enable data exchange among farmers, input suppliers, aggregators, buyers, insurers, and regulators. Incentive alignment is essential: data sharing agreements, revenue-sharing mechanisms, and contractual frameworks must distribute value equitably to encourage participation. Governance constructs, data trusts, cooperative data platforms, and federated learning arrangements, can preserve farmer sovereignty while enabling model improvement. Operationally, scaling programs should define roles, service level agreements, and escalation pathways across stakeholders to ensure continuity and accountability.

7.7 Role of International Organizations and Donors

International organizations and donors are catalytic in three technical domains:

- **Funding Innovation:** Multilateral and philanthropic capital underwrite R&D, pilot-to-scale transitions, and the capital expenditures required for rural connectivity and sensor networks. Funding instruments should prioritize de-risking commercial models and co-financing infrastructure that yields public goods.
- **Policy and Standards:** Continental and global bodies provide normative frameworks for ethical AI, data protection, and interoperability standards. Harmonized policy guidance reduces regulatory fragmentation and enables cross-border scaling of platforms and services.
- **Knowledge Sharing:** Networks and consortia facilitate the transfer of operational best practices, open datasets, and validated algorithms. Structured knowledge exchange accelerates replication by documenting integration patterns, failure modes, and cost benchmarks.

7.8 Strategic Priorities for Policymakers

Policymakers must prioritize three interdependent domains to enable scalable, equitable AI adoption in agriculture.

- **Digital Infrastructure:** Invest in rural broadband, reliable off-grid power, and affordable device access to ensure baseline connectivity for AI services. Infrastructure planning should include low-latency backhaul for real-time analytics and edge compute capacity for offline operation.
- **Data Governance:** Establish legal and technical frameworks for data privacy, ownership, and sharing that implement FAIR principles and enable federated or cooperative data models. Regulatory instruments should mandate transparency, auditability, and recourse mechanisms for algorithmic harms.
- **Gender-Inclusive Capacity Building:** Allocate resources for targeted digital literacy, technical training, and leadership programs for women and marginalized groups. National AI strategies should embed gender targets and monitoring indicators aligned with continental and global frameworks.

National AI strategies must be harmonized with continental guidance to reduce regulatory fragmentation and to facilitate cross-border data interoperability and market integration.

7.9 Operational Roles for Agricultural Agencies

Agricultural agencies are the operational bridge between AI technologies and farm-level impact and must adapt institutional processes accordingly.


- **Integration into Extension Services:** Embed AI tools into extension workflows, equipping agents with decision support dashboards, mobile advisory interfaces, and training on interpreting model outputs.
- **Support for Local Innovation:** Provide incubation, procurement pathways, and validation testbeds for locally developed AI solutions to ensure contextual relevance and sustainability.
- **Participatory Design and Inclusion:** Institutionalize co-design protocols that involve women farmers and marginalized groups in requirement gathering, user testing, and iterative refinement to maximize usability and adoption.

Agencies should also standardize monitoring protocols to collect gender-disaggregated and geospatially referenced impact data for adaptive management.


7.10 Implementation Principles

To translate potential into systemic change, interventions must adhere to four implementation principles.

- **Design: Equity by** Embed inclusion metrics and affirmative access mechanisms from project inception to prevent exclusionary outcomes.
- **Contextual Robustness:** Design AI systems for low-resource environments using offline-first architectures, lightweight models, and multimodal interfaces (SMS, IVR, USSD).
- **Economic Viability:** Align pricing and revenue models with seasonal cash flows through pay-as-you-go, subscription, or revenue-share arrangements that demonstrate measurable value within a cropping cycle.
- **Ethical Accountability:** Implement algorithmic audits, bias mitigation protocols, and transparent grievance mechanisms to maintain trust and legitimacy.



Chapter 8: NIGERIA AGRICULTURAL TRANSITION: AI IN PRACTICE



8. Nigeria Agricultural Transition: AI in Practice

8.1 The Global Food Security Landscape and Why Nigeria Matters

In 2024, an estimated 2.3 billion people, 28% of the global population were moderately or severely food insecure, a figure that has risen over the past decade. AI is positioned as a key enabler of the “fourth agricultural revolution,” building on the legacy of the Green Revolution but leveraging data, automation, and advanced analytics to optimize every stage of the food system.

Nigeria's agricultural sector is both a microcosm of global challenges and a laboratory for innovation. With over 200 million people, 70% of whom are engaged in agriculture, Nigeria's food system is characterized by smallholder dominance, fragmented supply chains, and high vulnerability to climate and security shocks. The country faces a persistent food deficit, with over 30 million people projected to experience acute food insecurity in 2025–2026.

At the same time, Nigeria is experiencing a surge in agritech innovation, with over 230 startups as of 2024, and a national AI strategy aimed at harnessing digital transformation for inclusive growth. The convergence of urgent need, entrepreneurial energy, and policy momentum makes Nigeria a critical testing ground for AI-driven solutions to food security.

8.1.1 The Current State of Food Security in Nigeria (2024–2026)

Food Security Metrics and Trends: Recent analyses by the Food and Agriculture Organization (FAO), the Nigerian government, and humanitarian partners reveal a worsening food and nutrition security situation.

Table 11: Food Security Status in Nigeria (2025–2026)

Indicator	Value (2025–2026)
Population (2025)	217.9 million
Food insecure (CH Phase 3+)	30.6 million (14%)
Malnourished (%)	12.6%
Children under 5 stunted (%)	37%
Annual food import bill	\$6+ billion
Agricultural GDP contribution	~24%
Smallholder share of production	80%

Acute Food Insecurity: Over 30.6 million Nigerians are projected to face acute food and nutrition insecurity at Crisis (CH Phase 3) or worse during the June–August 2025 lean season.

- **Malnutrition:** Acute malnutrition rates remain high, with 12.6% of the population malnourished and 37% of children under five stunted.
- **Geographic Hotspots:** The northwest and northeast (Borno, Adamawa, Yobe) are the most affected, with conflict, displacement, and climate shocks as primary drivers.
- **Structural Deficits:** Nigeria remains a net food importer, spending over \$6 billion annually on agricultural imports, with a widening trade deficit.

Table 12: Typical Price Trend in Nigeria's Major Cities (2024–2025)

Food Item	Unit	2024 Peak Price (Avg)	2025 Q1/Q2 Price (Avg)	Trend Analysis
Local Rice	1kg	₦ 1,830 – ₦ 1,900	₦ 1,450 – ₦ 1,600	Slight Decrease: Prices peaked in late 2024 but eased slightly in early 2025.
Brown Beans	1kg	₦ 2,450 – ₦ 2,800	₦ 1,700 – ₦ 1,950	Declining: Significant drop in early 2025 following the harvest season.
Garri (White)	1kg	₦ 1,150 – ₦ 1,300	₦ 850 – ₦ 1,050	Moderate Drop: Prices stabilized after hitting historic highs in mid-2024.
Yam Tuber	1kg	₦ 1,800 – ₦ 2,050	₦ 1,200 – ₦ 1,500	Seasonal Volatility: Sharp decline in 2025 compared to the mid-2024 scarcity peak.
Tomatoes	1kg	₦ 2,300 – ₦ 2,500	₦ 1,100 – ₦ 1,400	High Volatility: Prices crashed from 2024 peaks but remain sensitive to transport costs.
Beef (Boneless)	1kg	₦ 3,800 – ₦ 4,500	₦ 4,000 – ₦ 4,800	Increasing: Unlike staples, protein costs have remained sticky or increased.

The persistence of food insecurity is driven by a combination of factors: climate variability, conflict (notably farmer-herder clashes), inflation, weak infrastructure, and limited access to finance and technology.

8.2 Institutional Context

Nigeria's policy architecture has progressively foregrounded digitalization and artificial intelligence as strategic enablers for agricultural modernization. Recent national frameworks articulate an integrated approach that links technology adoption, climate resilience, and inclusive value-chain development, while also establishing governance principles for ethical and responsible AI deployment. These instruments collectively signal a shift from ad hoc digital pilots toward a coordinated, policy-driven agenda that positions agriculture as both a priority use case for AI and a domain for public-private collaboration.

The **National Agricultural Technology and Innovation Policy (NATIP 2022–2027)** codifies a systems view of agricultural modernization in which digital tools and innovation ecosystems are core components. NATIP prioritizes: digital transformation of extension and input distribution; integration of climate-smart practices through data-driven decision support; and strengthening of inclusive value chains that connect smallholder producers to markets. The policy emphasizes institutional coordination, research-to-practice pathways, and mechanisms for scaling proven technologies across agroecological zones.

The **National Artificial Intelligence Strategy (2025)** establishes a national vision for AI that balances innovation with safeguards for ethics, transparency, and social inclusion. Agriculture is identified as a priority sector for AI application, with strategic objectives that include: developing sector-specific datasets and models; promoting explainable and contextually appropriate AI systems for agronomic advice and supply-chain optimization; and building regulatory frameworks that mitigate bias, protect data subjects, and ensure accountability across public and private actors.

The **Digital Agriculture Strategy** operationalizes the intersection of ICT and agronomy by focusing on three implementation pillars: scaling digital tools (e.g.,

remote sensing, mobile advisory platforms, digital marketplaces); capacity building for farmers, extension agents, and agribusinesses; and structuring public-private partnerships to mobilize investment and technical expertise. The strategy foregrounds interoperability standards, user-centered design for lowresource contexts, and metrics for monitoring uptake and impact.

8.2.1 Implementation Gaps and Institutional Challenges

Despite coherent policy design, significant implementation gaps constrain impact. **Rural connectivity** deficits limit the reach of mobile and cloud-based services, undermining real-time data flows and remote sensing applications. **Data infrastructure** remains fragmented: there is limited availability of high-quality, interoperable agricultural datasets, weak data governance arrangements, and insufficient capacity for data curation and model development. **Regulatory clarity** is nascent; sectoral rules for data sharing, privacy, and AI accountability are incomplete, creating uncertainty for private investors and public implementers. Institutional fragmentation across ministries, research institutes, and subnational authorities further complicates coordinated rollout and scaling. Addressing these operational bottlenecks is essential to translate policy intent into scalable, equitable, and resilient agricultural transformation.

8.3 Nigeria AI Technologies in Agriculture: From Theory to Practice

Nigeria is transitioning from conceptual exploration of artificial intelligence in agriculture to operational deployment across multiple value chain nodes. Current applications, technical approaches, and operational considerations for AI systems support precision agronomy, pest management, climate resilience, mechanization services, market integration, and financial inclusion. **Precision Farming and Soil Intelligence:** AI-enabled precision farming in Nigeria integrates remote sensing, machine learning, and mobile computing to optimize input use

and increase yield efficiency. **Satellite and remote sensing systems** ingest multispectral and temporal imagery which convolutional and transformer-based models process to generate crop health indices, biomass estimates, and yield forecasts at field scale. These models produce hyper-local advisories by fusing satellite data with ground truth from sensors and farmer reports. **Soil intelligence** leverages spectral analysis and digital soil mapping pipelines that convert proximal sensor readings into quantitative estimates of nutrient concentrations, moisture content, and soil organic carbon, dramatically reducing turnaround time compared with laboratory assays. **Mobile advisory applications** operationalize these analytics through lightweight neural network models that infer soil properties and prescribe crop-specific fertilizer regimes; localization layers provide language support and simplified decision rules for low-literacy users.

Pest and Disease Detection: AI systems address pest and disease risk through image analytics, predictive modeling, and alerting architectures that enable early, targeted interventions. **Image recognition pipelines** employ convolutional neural networks trained on annotated leaf and canopy images captured by drones and smartphones to detect symptomatic patterns at the lesion and infestation stages. **Predictive analytics** combine meteorological variables, crop phenology, and historical outbreak records in time-series and ensemble models to forecast outbreak probability and spatial spread. These forecasts feed **early warning systems** that deliver realtime alerts and treatment recommendations via SMS, mobile apps, or extension dashboards, enabling precision application of agrochemicals and biological controls and reducing expected crop losses.

AI-Enabled Precision Farming Workflow



Fig.21: AI-enabled Precision Farming

Climate Resilience and Early Warning: AI contributes to climate resilience by producing fieldlevel forecasts and decision support that translate probabilistic climate information into operational actions. **Hyper-local weather forecasting models** integrate satellite observations, in-situ sensor streams, and historical climate data using hybrid physical-statistical approaches to generate short-term and seasonal risk estimates for drought, flood, and heat stress. **Decision support systems** convert these risk estimates (climate data) into actionable advisories for planting windows, irrigation scheduling, and contingency planning, delivering outputs through low-bandwidth channels (SMS or app.) to ensure accessibility in constrained connectivity environments.

Mechanization-as-a-Service: AI and Internet of Things technologies are enabling scalable mechanization models that reduce capital barriers for smallholders.

Hello Tractor: Dubbed the “Uber for Tractors,” this platform uses AI and IoT to match tractor owners with farmers, optimize routes, and manage bookings, reducing costs and boosting productivity. **Predictive maintenance modules** analyze telematics and sensor telemetry to detect anomalous vibration, temperature, or usage patterns and schedule preventive service, thereby reducing downtime and lifecycle costs for mechanized assets.

Digital Marketplaces Supply Chains and Traceability: AI transforms market linkages and supply chain transparency by automating price discovery, demand forecasting, and provenance verification. **Digital marketplaces** integrate real-time pricing engines such as Crop2Cash, FarmCrowdy, and Soupah Farm-en-Market to connect farmers directly to buyers, providing realtime pricing, digital payments, and supply chain traceability. **Blockchain Traceability:** AI and blockchain are used to track produce from farm to fork, meeting export standards

and unlocking premium markets.

Agri FinTech Credit Scoring and Insurance: Access to finance is a perennial constraint. AI is enabling alternative, data-driven models such as **Alternative Credit Scoring**, where AI analyzes satellite data, transaction histories, and behavioral data to generate credit scores for unbanked farmers, increasing loan approval rates by 40–60%. The **Index-Based Insurance entails the use of AI** models to assess weather and yield risks, automating payouts and reducing fraud.

Operational Considerations and Integration Challenges: While these AI applications demonstrate technical promise, operationalizing them at scale requires attention to data quality, connectivity, and governance. **Data pipelines** must ensure interoperability, provenance tracking, and representative training datasets to avoid model bias and degradation. **Connectivity constraints** in rural areas necessitate edge computing and model compression strategies to deliver inference under limited bandwidth. **Governance frameworks** should define data sharing protocols, privacy safeguards, and performance validation standards to build trust among farmers, aggregators, and regulators. Addressing these engineering and institutional requirements is essential to move AI in Nigerian agriculture from isolated pilots to resilient, equitable systems that deliver measurable productivity and livelihood gains.

8.4 The Nigerian Agritech Landscape: Startups, Scale, and Impact

Leading Startups and Platforms: Nigeria's agritech sector is vibrant and diverse, with over 230 startups as of 2024, spanning precision agriculture, fintech, mechanization, and supply chain solutions. These startups are supported by a growing ecosystem of accelerators, government initiatives (e.g., NITDA, NAIRS), and international partners.

Table 14: Selected Nigerian Agritech Startups and Their Focus Areas

Startup	Focus Area	AI Application
Kitovu	Precision advisory, soil testing	Remote sensing, AI-driven recommendations
AirSmat	Drone analytics, yield optimization	AI for image analysis, farm management
Hello Tractor	Mechanization-as-a-service	IoT, AI for route optimization
Thrive Agric	Input finance, market access	Predictive analytics, digital dashboards
Crop2Cash	Digital payments, supply chain	Data analytics, blockchain
FarmCrowdy	Input finance, extension, markets	AI for matching, market intelligence
GreenCoast AgriTech	Disease detection, early warning	Computer vision, predictive analytics
Releaf	Supply chain, processing	AI for logistics, quality control
Zensus	Soil sensors, smart farming	IoT, AI for soil and crop analytics

8.4.1 Case Studies of AI Implementation

Kitovu: Data-Driven Advisory and Storage: Kitovu's YieldMax platform uses AI and remote sensing to provide personalized agronomic advice, increasing yields by up to 30% and reducing input costs by 20%. Its StorageX solution leverages electronic warehouse receipts and IoT-based management to reduce post-harvest losses by 20% and increase farmer incomes by 40% in pilot projects.

Hello Tractor: Mechanization for Smallholders: Hello Tractor's AI-enabled platform has serviced over 2.5 million smallholder farmers, boosting incomes by 227% and reducing land preparation time from weeks to days. Its pay-as-you-go model and offline functionality ensure accessibility for rural, low-literacy users. Mechanization-as-a-service can reduce farming costs by 20–40% and increase land productivity by 25–35%.

GreenCoast AgriTech: Disease Early Warning: GreenCoast's AI-powered app provides realtime disease detection and early warning, achieving over 95% accuracy and reducing crop losses by 40% for participating farmers. With mobile apps: Farmers can upload photos of affected plants; AI algorithms diagnose the issue and recommend treatments, even in local languages

Soupah Farm-en-Market: Digital Market Access: Soupah's USSD-based platform connects rural farmers to urban markets, offering end-to-end traceability and 50% higher prices compared to traditional channels. Mobile payments encourage

digital wallets and mobile money platforms facilitate secure, transparent transactions. These innovations are unlocking capital for inputs, reducing risk, and supporting investment in productivity.

Precision Farming and Soil Management: Soil degradation and nutrient depletion are chronic challenges for Nigerian agriculture. AI is enabling a shift from guesswork to data-driven soil management. AI-powered spectral soil testing provides rapid, affordable assessments with 85–95% accuracy, replacing slow lab-based methods. Apps like GeaGrow use AI to predict soil properties and recommend crop-specific fertilizer regimes, improving yields and reducing environmental impact.

8.5 Gender and Inclusion: Role of Women in Nigerian Agriculture

Women constitute **over half of Nigeria's agricultural labor force**, performing essential roles across production, processing, and marketing. Women's centrality to food systems contrasts with persistent structural disadvantages that constrain productivity, income, and agency. Addressing these disparities is critical for equitable agricultural modernization and for realizing the full potential of AI and digital technologies in food security. Women face three interrelated constraints that reduce their capacity to benefit from technological interventions:

- **Land ownership and tenure security.** Women typically hold less secure land rights, which limits collateral for credit and discourages long-term investments in soil health, irrigation, and mechanization.
- **Digital divide.** Lower rates of device ownership and digital literacy among women reduce access to mobile advisory services, remote sensing outputs, and app-based marketplaces.
- **Exclusion from decision-making.** Underrepresentation in cooperatives, extension services, and policy fora restricts women's influence over resource allocation, technology selection, and service design.

8.5.1 AI as an Enabler and a Risk

AI and digital platforms can materially expand women's economic opportunities when interventions are deliberately inclusive, but they also carry the risk of reinforcing existing inequalities if design and deployment ignore gendered realities.

Enabling Pathways

- **Inclusive design.** Co-design approaches, exemplified by initiatives such

as AI4AFS, engage women and marginalized groups in requirements gathering and iterative testing to ensure tools are relevant, usable, and culturally appropriate.

- **Capacity building.** Targeted digital literacy and technical training increase women's confidence and competence with AI-driven advisory systems, raising adoption rates and improving decision quality.
- **Mobile microfinance.** AI-driven credit scoring and underwriting that leverage alternative data sources expand access to microcredit for women, enabling investments in inputs, storage, and adaptive practices.
- **Cooperatives and peer networks.** Digital platforms that facilitate cooperative membership, collective marketing, and peer learning strengthen women's bargaining power and market access.

Risks and Failure Modes

- **Cultural norms.** Gendered social norms can restrict women's mobility, control over income, and access to devices, limiting the reach of otherwise well-designed digital services.
- **Platform design mismatches.** Interfaces and workflows optimized for male users or for literate, smartphone-native populations can exclude women who rely on feature phones, oral communication, or shared devices.
- **Data bias.** AI models trained on datasets that underrepresent women's plots, cropping practices, or market behaviors risk producing inaccurate recommendations and perpetuating systemic bias.

8.5.2 Evidence and Best Practices

Empirical interventions demonstrate measurable benefits when gender-sensitive approaches are applied:

- **Inclusive training.** The IFAD Women Farmers' School in Nigeria reported a **30% yield increase** among participants, indicating that targeted agronomic training combined with practical support can translate into productivity gains.
- **Digital microcredit.** Mobile microfinance applications have demonstrably increased women's access to credit; however, success depends on **simplified onboarding** processes and integrated financial literacy support to ensure effective use and repayment capacity.
- **Cooperative participation.** Women's cooperatives that leverage digital

platforms for aggregation, quality control, and market linkage show improved productivity and economic outcomes, particularly when platforms provide transparent pricing and logistics coordination.

Table 15: Key Drivers of Women's Adoption of Sustainable Practices

Driver	Impact on Adoption (%)
Digital Training Access	+1.12 (largest effect)
Formal Agri. Training	+0.85
Cooperative Participation	+0.67
Digital Microcredit Uptake	+0.41
Broadband Access	Negligible

8.6 Barriers to AI Adoption in Nigerian Agriculture

Infrastructure and Connectivity: Rural areas in Nigeria exhibit limited internet penetration and unreliable electricity, which constrains the deployment and continuous operation of AI-enabled systems. The high capital cost of end-user devices such as smartphones and field sensors restricts uptake among smallholder farmers. Intermittent power supply further degrades system availability by preventing regular data collection, real-time analytics, and the charging of edge devices, thereby reducing the operational reliability of AI solutions.

Digital Literacy and Human Capital: Adoption is impeded by low digital literacy across farming populations, with pronounced deficits among women and older adults who often lack the skills required to operate AI interfaces or interpret model outputs. There are also capacity gaps within the agricultural support ecosystem; extension agents and local technicians frequently lack the technical training necessary to deploy, maintain, and troubleshoot AI tools, limiting local support and long-term adoption.

Data and Algorithmic Challenges: AI model performance is constrained by data scarcity, specifically the absence of high-quality, localized datasets that capture Nigeria's agroecological diversity and management practices. Models trained on non-representative datasets introduce bias and explainability problems, producing recommendations that may be inaccurate or that reinforce existing inequalities. Additionally, privacy and consent frameworks for agricultural data remain underdeveloped, leaving questions about data ownership, informed consent, and algorithmic transparency unresolved.

Economic and Business Model Constraints: The affordability barrier is twofold: upfront capital requirements for devices, sensors, and connectivity, and recurring costs for data and platform services, both of which are prohibitive for many smallholders. Many AI interventions remain at the pilot stage and lack validated pathways to scale, indicating sustainability risks and limited evidence of viable, long-term business models that can deliver continuous value to farmers and service providers.

8.7 Policy Environment and National AI Strategy Implications

Nigeria's **National Artificial Intelligence Strategy (2025)** articulates a national vision for responsible, ethical, and inclusive AI deployment, explicitly prioritizing agriculture alongside health and finance. The strategy's core pillars prescribe investment in **foundational infrastructure** like high-performance computing, data centers, and clean energy clusters to support large-scale model training and edge deployments. **Ecosystem development** targets startups, research institutions, and talent pipelines, while **sector transformation** establishes roadmaps for AI integration across priority sectors. Governance measures include the creation of an **AI Ethics Commission** and the adoption of the **NIST AI Risk Management Framework** to standardize risk assessment and promote trusted AI systems. Implementation, however, faces material constraints: funding is limited, policy instruments remain fragmented, and human capital is scarce, only **3% of IT professionals** specialize in AI and robotics, exacerbating brain drain and slowing operationalization.

8.8 Capacity Building, Extension Services, and Human Capital

Scaling AI in agriculture depends on deliberate human capital development. National and civil society initiatives such as the **NITDA AI Developers Group** and **Data Science Nigeria** aim to expand AI and digital skillsets at scale, targeting millions of trainees. At the service delivery level, **AI-enabled extension** such as chatbots, voice assistants, and digital advisory platforms, augments traditional extension by delivering localized, near-real-time agronomic guidance. Capacity programs are increasingly **inclusive by design**, with curricula adapted for women, youth, and marginalized groups, delivered in local languages and engineered for offline functionality to accommodate connectivity constraints. Strengthening the technical competencies of extension agents and local technicians' remains critical to sustain deployment and to translate model outputs into actionable farm practices.

8.9 Infrastructure Needs Connectivity Power and Sensors

Operationalizing AI across Nigeria's agricultural landscape requires coordinated investment in three infrastructure domains. **Rural broadband** expansion (mobile and fixed) underpins data flows and remote management; recent rural download speed improvements (for example, **T2mobile's 24.9 Mbps** in select rural areas) demonstrate progress but are uneven. **Reliable power** is essential for edge devices, sensor networks, irrigation, and cold-chain systems; solarbased microgrids and off-grid solutions are priority interventions. Finally, **affordable sensing and end-user devices** through subsidies, shared-economy models, and pay-as-you-go financing are necessary to lower adoption barriers for smallholders and to enable dense, localized data collection.

8.10 Economic Impacts Business Models Security and Conflict Mitigation

AI-driven agritech is producing measurable economic outcomes and new commercial models. **Precision agriculture** techniques can increase yields by up to **30%** while reducing input costs by **20–30%**. Digital marketplaces and mechanization services have produced documented **income gains ranging from 15% to 227%** for participating farmers. Employment projections from the Agentic AI-Powered Agriculture Network estimate **over 730,000 jobs** across digital services, learning, and enterprise channels. Viable business models emerging in the field include **subscription services, pay-as-you-go, commission-based platforms, and data monetization.**

Security and conflict dynamics intersect directly with agricultural resilience. AI applications such as **predictive analytics** that fuse conflict trends, environmental indicators, and social media signals can forecast hotspots and enable early interventions. **Surveillance and threat detection** using drones, sensor arrays, and automated recognition systems provide situational awareness for rapid response. Digital conflict-management tools such as the **FUNAAB– Peace Eye Farmer–Herder App** leverage geospatial intelligence and AI to map grazing routes, mediate disputes, and reduce friction. Policy integration should align AI-driven security capabilities with community-based and military responses, subject to robust ethical oversight and investments in rural digital infrastructure.


8.11 Monitoring Evaluation Roadmap and Policy Recommendations

Robust monitoring and evaluation are prerequisites for scaling effective AI interventions. Mixedmethods evaluation frameworks that combine quantitative metrics with qualitative insights incorporating **gender-disaggregated indicators** are essential to measure adoption, yield impacts, and empowerment outcomes.


Geospatial and remote sensing data provide scalable monitoring of land use, crop performance, and environmental externalities. A pragmatic roadmap for scale comprises seven priorities:

1. **Invest in rural connectivity and power** by prioritizing broadband and solar infrastructure in underserved areas.
2. **Build human capital** through expanded AI and digital literacy programs focused on women, youth, and extension agents.
3. **Strengthen data governance** by developing localized, high-quality datasets and enforcing data protection and algorithmic accountability.
4. **Foster inclusive innovation** via co-design with farmers, women, and marginalized groups to ensure relevance and uptake.
5. **Scale proven models** through public-private partnerships and blended finance to move pilots into sustainable operations.
6. **Enhance policy and regulation** by enacting a comprehensive, risk-based AI Act, establishing an AI Ethics Commission, and aligning with international best practices.
7. **Monitor and evaluate impact** by institutionalizing rigorous, gender-sensitive evaluation frameworks.

The integration of AI with targeted infrastructure investments, human capital development, robust data governance, and inclusive design practices, can materially strengthen Nigeria's food system. Centering women, smallholders, and marginalized communities in both policy and practice will be decisive for equitable outcomes. With coordinated policy action, strategic partnerships, and sustained investment, Nigeria can transition to a **digital, data-driven, and resilient agricultural system** that scales proven innovations while safeguarding equity and security.



Chapter 9: CASE STUDIES AND MODELS THAT WORK



9. Case Studies and Models That Work

Some **leading African AI–Agriculture startups and initiatives** are actively shaping the continent's AI-enabled agricultural transformation.

Aerobotics (South Africa): Aerobotics is one of Africa's most prominent precision agriculture technology firms. Based in Cape Town, it uses **drone and satellite imagery fused with machine-learning algorithms** to provide early detection of crop stress, pest pressure, and water deficiency. Its AI-driven insights enable farmers and agribusinesses to optimise inputs and forecast yields more accurately, enhancing decision analytics across production systems.

FarmCrowdy AI (Nigeria): FarmCrowdy has extended its digital platform into AI-driven agricultural services that support smallholders with **predictive analytics, weather forecasting, and disease detection**. The company's multilingual AI advisory and market linkage systems help bridge information asymmetries and connect producers to buyers and logistics partners, reducing inefficiencies in value chains.

Winich Farms (Nigeria): Winich Farms digitises agricultural supply chains and builds **farmer digital identities** using smart cards tied to official financial identifiers. By doing so, it improves traceability, enables access to credit and insurance, and embeds digital financial services into rural economies, benefiting smallholders who traditionally face barriers to formal finance.

RoboCare (Tunisia): RoboCare deploys high-resolution imaging and machine learning for **early plant stress and disease detection**, particularly in greenhouse and controlled environment agriculture. Its AI models analyse data from various imaging sources to inform management actions before visible symptoms appear on crops.

AgriPredict (Zambia): AgriPredict offers an AI-powered decision support platform that synthesises soil, climate, and market data to generate **hyper-localised agronomic advice**, including pest predictions, tailored weather forecasts, and actionable crop plans. Its design emphasises accessibility for smallholders with limited data connectivity.

Farmerline and Darli (Ghana): The Ghana-based Farmerline Group has pioneered AI-enabled agricultural advisory services tailored for smallholders. Notably, **Darli**, an AI chatbot available via WhatsApp, supports farmers in **27 languages** with regenerative farming guidance, pest diagnosis from images, and general agronomic information — dramatically expanding access to digital knowledge among underserved farmers.

MazaoHub (Tanzania): MazaoHub blends an **offline-first, AI-powered farm management platform** with in-person agronomy support. The system uses low-cost soil sensors and portable testing kits to deliver soil nutrient data and crop recommendations even in low-connectivity settings. Through “Farmer Excellence Centres,” the startup couples’ digital insights with agronomic coaching on the ground.

AirSmat Inc (Nigeria): AirSmat develops AI-enabled agtech platforms that integrate **remote sensing, IoT, and predictive analytics** to support farmers in optimizing water use, input application, and yield forecasting. Its systems synthesise diverse farm data streams into actionable recommendations.

Other Notable Initiatives

- **AkoFresh (Ghana):** While not strictly AI-centric, it complements agritech ecosystems by integrating **solar-powered smart cold storage systems** to reduce post-harvest losses in rural communities.
- **Ulangizi (Malawi):** A generative AI advisor pilot accessible via WhatsApp that provides smallholders with rapid responses to agronomic queries in local languages.
- **VunaPay (Kenya):** Combines agri-fintech and AI for **produce quality assessment and cooperative payment systems**, integrating digital records and payment automation to improve cash flow for farmers and cooperatives.

Table 16: Leading African AI–Agriculture Startups and Initiatives

Startup / Initiative	Country / Region	Funding Stage*	Key AI / Digital Technologies	Primary Application Areas	Reach Metrics (Approx.)
Aerobotics	South Africa (pan-African operations)	Growth / Series B	Machine learning, satellite imagery, drone analytics, computer vision	Precision farming, crop health monitoring, yield forecasting	3,000+ commercial farms; millions of hectares analyzed globally
FarmCrowdy (AI services)	Nigeria	Growth / Late Seed–Series A	Predictive analytics, weather AI models, data-driven advisory systems	Smallholder advisory, market linkage, production planning	500,000+ farmers onboarded across Nigeria
Winich Farms	Nigeria	Series A	Data analytics, digital identity systems, algorithmic credit profiling	Supply-chain digitization, farmer profiling, access to finance	120,000+ farmers; operations in 25+ states
AgriPredict	Zambia (Southern Africa)	Early Growth / Seed	AI-based predictive models, climate and pest analytics	Weather forecasting, pest/disease early warning	100,000+ farmers reached across Southern Africa
Farmerline / Darli AI	Ghana (multi-country)	Growth / Series A	Natural language processing, AI chatbots, image-based diagnostics	Advisory services, regenerative agriculture guidance	1,000,000+ farmers; support in 27 local languages
MazaoHub	Tanzania	Seed–Early Growth	AI-assisted soil analytics, sensor data fusion, offline-first platforms	Soil health diagnostics, farm management	20,000+ smallholders via Farmer Excellence Centers
RoboCare	Tunisia	Early Stage / Seed	Computer vision, plant imaging AI, machine learning	Early disease and stress detection (greenhouses)	Dozens of commercial farms; pilot-scale deployments
AirSmat	Nigeria	Seed–Early Growth	AI analytics, IoT integration, remote sensing	Input optimization, water management, yield prediction	Pilots and SME farms; regional scaling underway
VunaPay	Kenya	Early Growth	AI-based quality assessment, digital payments automation	Market access, cooperative payments, produce grading	Thousands of cooperative farmers in East Africa
Ulangizi (AI Advisory Pilot)	Malawi	Pilot / Pre-Seed	Generative AI, WhatsApp-based NLP interfaces	Farmer advisory, agronomic Q&A	Pilot users in rural districts;

9.1 Interpretive Notes from the Table

1. **Most AI–agriculture ventures remain at seed to early growth stages**, which explains why pilots dominate and national-scale integration is still rare. This is not a failure of technology, more a reflection of financing structures that favour experimentation over long-term public infrastructure alignment.

2. **The core technologies are less about cutting-edge robotics and more about applied analytics.** Machine learning on satellite data, natural language interfaces, and predictive models show up repeatedly. These are practical choices, shaped by Africa's connectivity constraints and the realities of smallholder farming.

3. Reach metrics reveal something important, and a little uncomfortable. Platforms serving **smallholders at scale often rely on low-cost, low-bandwidth channels** such as SMS, voice, and messaging apps. High-resolution drone and imaging solutions tend to concentrate on commercial farms unless subsidized or bundled into public programmes.

For governments and agricultural agencies, this table underscores a strategic lesson. Scaling AI in agriculture is less about importing sophisticated tools and more about **embedding proven, context-aware technologies into extension systems, credit schemes, and climate services.** Without this institutional bridge, even well-funded startups struggle to move beyond islands of success.

10. Policy Roadmap for Inclusive, Sustainable, and Youth Driven AI Adoption

A Human-Centered Food System

The convergence of Artificial Intelligence and global food security represents one of the most significant opportunities and challenges of the 21st century. While the biological and demographic pressures of 2050 are immense, the emergence of precision nutrition, smart food safety systems, and AI-enabled extension services offers a path toward a more resilient and equitable food system. However, the success of this transformation hinges on the proactive resolution of the governance and infrastructure gaps that currently define the "digital divide."

In Nigeria and across sub-Saharan Africa, the transition to AI must be youth-driven and policy led. By moving beyond "technological solutionism" and embracing a holistic roadmap that prioritizes data sovereignty, ethical accountability, and inclusive capacity building, governments can ensure that AI serves as a bridge to a food-secure future. The ultimate metric of success for these technologies will not be the sophistication of their algorithms, but their ability to improve the productivity, resilience, and dignity of the billions of

individuals who constitute the global food system. The imperative to act is immediate; as the global population continues its ascent toward the 9.7 billion marks, the integration of responsible AI into the heart of agriculture is no longer an option, but a necessity for the survival and prosperity of humanity.



Chapter 10: TECH-TO-TABLE



10.1 Tech-to-Table

AI as the Engine of Resilience

The imperative for AI adoption in food security is rooted in its capacity to manage multidimensional complexity at a scale beyond human cognition. The socio-economic environment of 2050 will be defined by rising incomes and a subsequent "nutrition transition" in developing countries. As populations grow wealthier, dietary patterns shift away from vegetal staples toward animal-source foods, vegetable oils, and dairy. This shift places immense pressure on cereal production, as a significant portion of crops must be diverted to livestock feed; currently, only 55 percent of global crop calories directly feed humans. AI-driven precision agriculture mitigates these pressures by enhancing feed-to-meat conversion ratios and optimizing the cultivation of high-value, nutrient-dense crops.

Table 17: Investment in AI

Key Demographic and Prod (2050)	Estimated Value / Requirement
	9.1 - 9.7 Billion
Required Increase in Net Food Pr	70%
Required Increase in Developing	~100%
Population Growth in Sub-Sahara	+114%
Proportion of Production from Yie	80% - 90%
Projected Annual Cereal Yield Gro	0.7% - 0.8%
Investment Needed in Developing	USD 83 Billion

AI and the Frontier of Personalized Nutrition

A transformative application of AI within the food security nexus is the rise of hyper-personalized nutrition. Modern science increasingly recognizes that "one-size-fits-all" dietary guidelines are biologically inadequate. Personalized nutrition (PN) adapts dietary recommendations based on individual-level variability in biology, behavior, and environmental context. This paradigm shift is essential for addressing the dual burden of malnutrition: the persistence of undernutrition alongside the rapid rise of obesity and chronic metabolic diseases in both developed and developing regions.

(a) The Microbiome Paradigm: ZOE and Day Two

At the center of the personalized nutrition revolution are platforms like ZOE and DayTwo, which leverage machine learning to decode the human gut microbiome. ZOE's PREDICT studies, the world's largest in-depth nutritional research program, have utilized clinical trials involving over 1,000 to 100,000 participants to map personalized metabolic responses to food. These studies use deep metagenomic sequencing to identify specific microbial species, often categorized as "good" or "bad" bugs that are consistently linked to cardiometabolic biomarkers and dietary patterns.

Technically, ZOE integrates data from Continuous Glucose Monitors (CGM), Nuclear Magnetic Resonance (NMR) spectroscopy for metabolite characterization, and metagenomic taxonomic profiling. Their algorithms demonstrate that individual responses to identical meals can vary by as much as 103 percent in triglyceride levels and 68 percent in glucose levels. By using machine learning regression and classification models, ZOE generates "ZOE Scores" that predict how a specific individual will respond to certain foods, thereby helping to avoid postprandial glucose "crashes" that trigger hunger and excessive calorie consumption.

Similarly, DayTwo combines microbiome profiling with AI to manage metabolic diseases such as type 2 diabetes. Their platform analyzes an individual's gut microbiome composition to provide precise dietary recommendations that maintain stable blood glucose levels. These interventions are grounded in "nutrigenomics," a field that explores gene-nutrient interactions to uncover how genetic profiles and metabolic phenotypes influence nutritional needs. The application of Deep Learning architectures, particularly Convolutional Neural Networks (CNNs), allows these platforms to extract actionable insights from the vast, non-linear complexity of microbiome data.

(b) AI-Driven Nutritional Surveillance and Public Health

Beyond individualized care, AI enhances the capacity for population-level

nutritional surveillance. Traditional methods of monitoring nutritional health are often slow, expensive, and reactive. AI-driven innovations enable real-time tracking of dietary intake and nutritional deficiencies through computer vision and predictive modeling. For example, AI platforms have demonstrated the potential to reduce childhood anemia rates by 25 percent in vulnerable populations by providing equitable, localized nutrition advice.

The integration of AI with remote sensing and electronic health records (EHRs) allows for the early identification of at-risk regions. Predictive models can assess the risk of deficiencies in micronutrients such as Vitamin D and Calcium by analyzing diverse datasets including genomic data and lifestyle surveys. This capability is vital for designing effective safety net programs and social interventions that are targeted rather than generalized, ensuring that limited public health resources are deployed where they can have the greatest impact.

10.2 Strengthening Food Safety and Supply Chain Integrity

Food safety and the prevention of post-harvest loss are critical pillars of global food security. It is estimated that a significant portion of produced food never reaches a human stomach due to spoilage, contamination, or logistical inefficiencies. AI, in combination with smart packaging and blockchain technology, offers a robust framework for creating transparent, efficient, and safe food supply chains.

a). Smart Packaging and Intelligent Monitoring

The transition from passive containment to smart, active, and intelligent packaging is facilitated by AI-driven sensors. These technologies monitor the environment around the packed food, providing real-time data on gas emissions (such as CO₂ and ethylene), pH changes, and microbial activity. A prominent commercial application is Timestrip, which utilizes smart labels and indicators to monitor time and temperature thresholds during transport. These sensors ensure that perishable goods, such as meat and dairy, remain within safe temperature ranges, thereby preventing the proliferation of pathogens like Salmonella.

AI systems analyze these sensor data points to predict shelf-life with over 90 percent accuracy, allowing for "dynamic expiration" labels that adjust based on actual storage conditions rather than static estimates. For businesses, this

translates to fewer recalls and higher profitability, while for consumers, it ensures the consumption of safe, high-quality products. In the context of the COVID-19 pandemic, AI-enabled supply chains have also been used to monitor environmental conditions in frozen meat packages to minimize the risk of virus transmission.

b). Blockchain and Immutable Traceability

Blockchain technology provides a decentralized, tamper-proof ledger that records every transaction and movement within the supply chain. By 2025, it is estimated that over 60 percent of global food supply chains will utilize blockchain-based smart contracts for traceability. These self-executing contracts automate agreements between farmers, suppliers, and retailers, triggered by predefined conditions such as delivery confirmation or quality verification.

The integration of blockchain with GS1 standards for barcode communication allows for a "single version of the digital truth," reducing error rates in agribusiness shipments by 80 percent and increasing transaction speeds by 70 percent. For smallholder farmers, this technology reduces fraud and ensures fair compensation for high-quality produce. Consumers can instantly verify the origin, handling, and carbon footprint of their food by scanning a QR code, which fosters profound confidence in the agricultural ecosystem.

10.3 Addressing the Policy and Governance Gap in Nigeria

Despite the clear benefits of AI, its deployment in the Global South, particularly in Nigeria, is hindered by a fragmented policy landscape and significant structural hurdles. Nigeria is a leader in AI adoption in Africa, with 93 percent of companies reporting some level of AI integration. However, this rapid adoption is outpacing the government's capacity for comprehensive governance and policy enforcement.

a) Governance Fragmentation and Regulatory Lag

The primary legal instrument currently governing AI in Nigeria is the Nigeria Data Protection Act (NDPA) 2023. While the NDPA provides critical safeguards, such as

Section 37, which grants data subjects the "right to a human" in significant automated decisions, it remains an ancillary tool rather than a comprehensive AI law. Nigeria lacks dedicated legislation that defines algorithmic transparency, accountability for AI-induced harm, and liability for malfunctioning autonomous systems.

The National Artificial Intelligence Strategy (NAIS) outlines a strategic vision, but its implementation is constrained by limited institutional authority, inadequate funding, and a technical skills deficit among regulators and the judiciary. This regulatory lag creates risks such as algorithmic bias and the misuse of AI-generated content. Without a risk-based AI Act that mandates stricter compliance for "high-risk" sectors like healthcare and finance, the sustainable deployment of AI remains vulnerable to ethical breaches.

b) The Infrastructure and Data Deficit

A fundamental barrier to inclusive AI in Nigeria is the acute shortage of high-performance computing (HPC) resources and localized data. AI innovation is currently concentrated in high-income countries, which also draw nearly all global investment. For AI to be relevant in the Nigerian context, it must be trained on localized datasets that reflect the country's linguistic and cultural diversity. Currently, less than 0.02% of internet content exists in African languages, and only 2.8% of computer vision data is representative of African demographics.

This "data colonialism" occurs when proprietary AI ecosystems from the Global North are imported wholesale without contextual adaptation, leading to technological lock-in and the marginalization of local knowledge systems. Furthermore, the lack of digital infrastructure, characterized by low internet usage rates (37%) and limited access to electricity (40%) prevents AI tools from reaching the rural smallholders who could benefit most.

c) Investment Hurdles and Economic Barriers

The financial requirements for a continental AI transformation are staggering. Full implementation of the African Union (AU) Continental AI Strategy is

estimated to cost between USD 250 billion and 500 billion. However, current continental commitments amount to only USD 100 million to 150 million, leaving a massive funding gap. In Nigeria, while large organizations allocate significant budgets to privacy protection, smallholder farmers and small-to-medium enterprises (SMEs) struggle to access the capital needed to adopt even basic digital tools.

Fig. 18: Challenges to AI Adoption in Nigeria

Barrier Type	Key Challenge in the Nigerian Context
Regulatory	Lack of AI-specific legislation; fragmented enforcement power.
Technical	Acute deficit in HPC; reliance on unrepresentative datasets.
Infrastructure	Low internet penetration (37%); unreliable rural electricity.
Human Capital	Only 3% of global AI talent in Africa; skills deficit in regulators.
Financial	83% of AI funding concentrated in just four African countries.

10.3 Youth-Driven Innovation and the DAES Case Study

The future of African food systems is intrinsically linked to its youth. Africa possesses the world's youngest population, a demographic asset that, if empowered with digital tools, can serve as the architects of a sustainable food future. Youth are "co-creators" of digital solutions, utilizing AI to optimize harvests and create new market linkages.

10.3.1 Strategies for Youth Engagement

To unlock this potential, African governments must act as "system stewards," creating an enabling environment for youth-led innovation. This involves reforming education systems to integrate AI, data science, and agri-entrepreneurship into the national curriculum. Initiatives like AGRA's Youth Agripreneurs Platform provide a continental hub for e-learning and mentorship, while national food systems strategies in countries like Ethiopia are setting

specific youth employment targets. In India, the National Agricultural Higher Education Project (NAHEP), a collaboration between the government and the World Bank, has modernized 74 agricultural universities. The project has developed 600 new market-oriented courses covering AI, robotics, and precision agriculture, significantly improving graduate placement rates (up to 67%) and changing students' perceptions of agriculture as a high-tech sector. Similar models are being explored in Nigeria to reskill the agricultural workforce and attract tech-savvy youth to the sector.

10.4 Case Study: Nigeria's Digital Agricultural Extension System (DAES)

Nigeria's agricultural sector faces a critical "extension gap," where one agent serves an estimated 10,000 farmers, far exceeding the recommended ratios for effective farm advisory. In response, a public-private partnership (PPP) has validated an AI-enabled Digital Agricultural Extension System (DAES) designed to scale advisory services to millions of smallholders.

The DAES platform is engineered to support rather than replace human extension agents, using digital tools to extend their reach into remote areas. Key technical features include:

- **Voice-Based Interfaces:** Designed for farmers with limited literacy, the system utilizes speech-to-speech interaction and USSD channels to deliver real-time advisory in local languages.
- **Bundled Service Model:** Integrates agronomic advice with direct links to input markets and financial services, ensuring that knowledge is coupled with the means to act on it.
- **Tiered Pricing Approach:** Balances affordability for vulnerable farmers with the longterm sustainability of the platform by differentiating between "ability to pay" and "willingness to pay".

The pilot implementations in Gombe, Kaduna, and Oyo states provide a testing ground across diverse agro-ecological and cultural contexts. Early feedback from similar digital farmer services in Nigeria indicates that younger farmers (under 35) are the most likely to adopt these tools, and 64 percent of users access these services exclusively through their mobile phones. The DAES initiative represents a paradigm shift, moving away from grant-dependent donor projects toward a self-sustaining digital ecosystem that aims to bring 80 percent of Nigeria's smallholder farmers into the formal economy.

10.5 Policy Roadmap for Inclusive AI Adoption

Achieving the transformative potential of AI in food security requires a

coordinated, multistakeholder roadmap that addresses the "Four Cs" of the digital divide: Connectivity, Compute, Context, and Competency. This roadmap must be grounded in principles of responsibility, equity, and inclusion (GEDI) to ensure that the benefits of technology are distributed fairly among all demographic groups.

Phase 1: Establishing the Governance Foundation (2025-2026)

The initial phase of the roadmap focuses on creating a robust and principled regulatory environment.

- **Enact Risk-Based AI Legislation:** Moving beyond the NDPA, governments should establish a comprehensive AI Act that defines accountability, transparency, and liability for high-risk applications in food and health systems.
- **Establish Regulatory Sandboxes:** Create supervised environments where innovators can test AI-driven agricultural solutions under oversight, ensuring they meet ethical and privacy standards before full-scale release.
- **Institutionalize Coordination Units:** Form dedicated AI advisory boards and national AI councils to align food system strategies with broader digital transformation goals.

Phase 2: Infrastructure Development and Data Sovereignty (2027 - 2028)

The second phase prioritizes the structural foundations necessary for AI to thrive in the Global South.


- **Invest in Local AI Infrastructure:** Establish a "Digital Sovereignty Fund" to finance the development of regional data centers and high-performance computing (HPC) resources.
- **Create Open Data Ecosystems:** Incentivize the sharing of non-personal data among public and private stakeholders to build standardized, high-quality repositories for AI training.
- **Develop Local Language Models:** Prioritize the creation of datasets and AI tools in African and regional languages to ensure inclusivity and cultural relevance for rural populations.

Phase 3: Inclusive Capacity Building and Scaling (2029-2030)


The final phase aims for the saturation of AI benefits across the entire agricultural value chain.

- **Transform Agricultural Education:** Integrate digital skills, AI ethics, and data science into the national curriculum at all levels, modeled on successful programs like India's NAHEP.

- **Support Youth-Led Agripreneurs:** Implement tax incentives, grants, and work-based learning opportunities to foster a vibrant startup ecosystem focused on solving local development challenges.
- **Scale Participatory AI Design:** Ensure that AI solutions are co-designed with smallholder farmers, youth, and women, integrating indigenous knowledge with algorithmic insights.



Chapter 11: **CONCLUSION: THE FUTURE TABLE: AI-ENABLED FOOD SYSTEM**



Conclusion

11. The Future Table: AI-Enabled Food Systems

AI-enabled food systems seem futuristic when you stand in a market or watch a farmer bend over a field. AI has been slipping into this space, not as a spectacle but as an infrastructure. The most honest way to think about the future of AI-enabled food systems is not robots replacing farmers or algorithms cooking meals **but decision-making**, once intuitive and local, becoming computational, distributed, and increasingly abstracted from the soil itself. Artificial intelligence (AI) is increasingly recognized as a transformative force in global food systems. It is reshaping how food is produced, distributed, consumed, and monitored, offering solutions to persistent challenges such as food insecurity, climate change, supply chain inefficiencies, and nutritional imbalances. For farmers, engineers, policymakers, researchers, and cross-disciplinary professionals, AI represents both a technical frontier and a governance challenge.

At its core, an AI-enabled food system is about sensing, predicting, and coordinating. Sensors capture what the human eye cannot. Models project what tomorrow may look like under uncertainty. Platforms coordinate actors who may never meet: farmers, traders, processors, regulators, humanitarian agencies. The technology is impressive, but the real shift is epistemic. Who knows what, when, and with what authority. **The basis for decision has shifted from experience alone to experience augmented by probabilistic inference.**

In regions like Nigeria, where farms are fragmented and extension services overstretched, AI tools embedded in mobile platforms can function as a surrogate extension agent. Yield prediction models tied to seasonal climate forecasts allow farmers to adjust planting dates or crop choice. Credit scoring algorithms, trained on nontraditional data such as transaction histories or satellitederived productivity proxies, unlock finance for farmers previously deemed unbankable. Models can encode bias, or fail spectacularly under novel climate conditions but the alternative is often no decision support at all.

Beyond the farm gate, AI reshapes aggregation, storage, and logistics. Post-harvest loss remains one of the quiet scandals of global food systems. Food grown but never eaten. AI-enabled demand forecasting helps align production with consumption, especially in urban markets. Algorithms optimize routing for transport fleets, reducing spoilage and emissions. In grain storage, computer vision and predictive maintenance systems monitor silos for spoilage risk or structural failure. These are not glamorous applications, they do not make headlines, but they save food, which is arguably the point

Food manufacturing and processing add another layer. AI-driven quality control systems now inspect raw materials and finished products in real time, identifying contamination risks or deviations from standards. In food safety, pattern recognition models analyze streams of data from laboratories, hospitals, and even social media to detect outbreaks earlier than traditional surveillance. This is where AI begins to act as a public health instrument, not just an efficiency tool.

The table, after all, is where nutrition meets safety.

Nutrition itself is becoming algorithmic. Personalized nutrition platforms promise diets tailored to individual metabolic responses, preferences, and health conditions. The science here is still uneven, and the hype sometimes outpaces evidence, but at a population level, **AI-enabled analysis of dietary intake data, price trends, and health outcomes can inform policy in more grounded ways.** Governments can simulate the nutritional impact of food subsidies, fortification programs, or import restrictions before implementing them. It is policy by sandbox, which feels prudent in a world where mistakes cost lives.

Perhaps the most consequential role of AI lies in forecasting and early warning. Food crises are rarely sudden. They are slow-moving, layered failures of climate, markets, conflict, and governance. AI systems that integrate weather anomalies, crop conditions, price volatility, and displacement data can flag emerging risks months in advance. In theory, this enables anticipatory action. In practice, the

bottleneck is not prediction but response. Knowing a crisis is coming does not guarantee political will, funding, or logistical capacity to prevent it. **The future food system**

will certainly rely on AI as its nervous system for risk perception.

Data ownership: Who owns the data generated by a farmer's field, a trader's transactions, or a consumer's diet? In many cases, it is not the person producing the data but the platform capturing it. For countries in the Global South, this becomes an issue of data sovereignty. If models trained on local data are owned and operated elsewhere, decision-making power migrates outward. The food system becomes digitally dependent in the same way it once became input-dependent. Despite these concerns, it is hard to argue for a future without AI in food systems. Climate volatility alone makes purely reactive, experience-based decision-making untenable. **The scale**

of urbanization, the complexity of global supply chains, and the urgency of nutrition challenges demand tools that can operate across space and time in ways humans cannot.

There is also the issue of automation of judgment. When an algorithm recommends which regions should receive food aid first, or which farmers qualify for credit, it is embedding values, whether acknowledged or not. Efficiency competes with equity. Accuracy competes with transparency. The future of AI-enabled food systems will be shaped as much by governance frameworks as by technical capability. Without clear accountability, AI risks becoming a technocratic shield behind which responsibility dissolves.

Bringing tech to table, then, is not about replacing the human element. It is about reconfiguring it. Humans set goals, define constraints, and bear responsibility. AI processes signals, explores scenarios, and surfaces options. When it works well, it expands the space of possible good decisions. When it fails, it reminds us that food systems are not engineering problems alone. They are social systems, political systems, moral systems.

The future will be like a revolution. Another dashboard. Another model. Another alert. Over time, though, these layers will change how food is grown, moved, regulated, and eaten. Quietly, persistently, the TABLE will be set by CODE. **Whether that TABLE is more equitable, resilient, and nourishing will depend on choices made now, often far from the fields and kitchens they eventually affect.**

11.1: Tech Meets Table: Bridging Tech and Tradition

Global examples include **John Deere's See & Spray technology**, which uses computer vision to distinguish crops from weeds, and **IBM's Watson Decision**

Platform for Agriculture, which integrates multisource data for farm-level decision support. In Africa, platforms such as **PlantVillage Nuru** in Kenya provide AI-powered crop disease diagnosis, accessible even offline.

Nigeria offers a compelling case: **Apollo Agriculture** uses AI to assess creditworthiness and deliver tailored inputs and advice to smallholders, while **Hello Tractor** connects farmers to mechanization services through AI-enabled booking platforms. These innovations demonstrate how AI can address structural constraints in smallholder farming, including limited access to finance and machinery.

Demand, Supply, and Price Factors: On the demand side, consumption per capita is expected to be an important determinant of food security. For the population to be adequately nourished, it is important to be able to demand food in sufficient quantities, for food to be supplied, and for the price to be kept at an affordable level. Previous work on the determinants of the demand for food have highlighted the role of consumption/GDP per capita in PPP terms since, by definition, higher consumption per capita should lead to greater food security because of its role in increasing calories.

Consumption Per Capita and Food Security

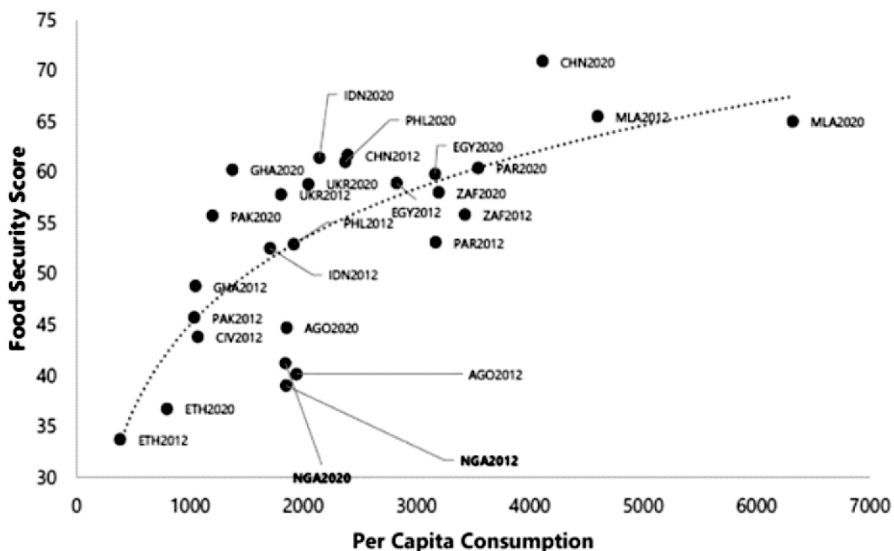


Fig. 21: The tight relationship between per capita consumption and the EIU food security index (the initial and most recent matched datapoints are shown for the sample of countries).

Globally, AI-enabled climate-smart agriculture is aligned with the **UN Sustainable Development Goals (SDGs)**, particularly Zero Hunger and Climate Action. In Nigeria, AI-driven irrigation systems powered by solar energy are being piloted to optimize water use and reduce vulnerability to erratic rainfall.



Fig. 22: Bridging Tech and Tradition



Fig. 23: Digital Connectivity Gap in Africa

FINAL TRIBUTE



PROF. S . O. AWOKOYA - The Architect of Tomorrow's Prosperity

Distinguished guests, colleagues, and friends. We gather today to honour a vision that was as expansive as it was enduring “the legacy of Chief Stephen Awokoya”. It is often said that a pioneer plants trees under whose shade they will never sit; Chief Awokoya did more than plant trees, he cultivated the very soil of our national intellect. His journey was one of constant evolution. He understood that the tools of progress would change, but the necessity of knowledge would not. He took us

from classrooms to farmlands, recognizing that a nation that cannot feed itself cannot lead itself. He transitioned us **from chalkboards to code**, anticipating a world where digital literacy would become the new universal language of opportunity. Chief Awokoya's brilliance lay in his refusal to see education as a static ivory tower. To him, education was a bridge to industry, **a tool for the farmer**, and a blueprint for the engineer. By laying the groundwork for technical and scientific education, he ensured that our youth would not just be spectators of the future, but its primary architects.

Today, as we navigate an era of unprecedented technological change, we realize that we are still walking the path he cleared. His legacy does more than sit in history books; it **feeds the future**. It fuels our innovation, sustains our industries, and inspires every student who picks up a stylus or a shovel. **We honour him best by continuing to build upon the foundation of excellence he so masterfully laid.** “From classrooms to farmlands, from chalkboards to code, his legacy feeds the future.”



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ABRIDGED PROFILE OF GUEST LECTURER



PROF. CHRISTIANAH OLAKITAN IJAGBEMI, FNSE
Engr. Prof. Mrs. Christianah Olakitan Ijagbemi is a distinguished scholar, pioneering engineer, and celebrated academic leader. Born in Akure, Ondo State, she earned her degrees in Mechanical Engineering from the Federal University of Technology, Akure (FUTA) and in Environmental Engineering from Ewha Womans University, Seoul, Korea.

Professor Ijagbemi holds the historic distinction of being the first female Professor of Mechanical Engineering at FUTA, also, the first, in southwest Nigeria, placing her the second female Mechanical Engineering Professor in Nigeria. She has served the nation as a Member of the Board of Technical Directors of NASENI and currently directs the Centre for Gender Issues in Science and Technology (CEGIST), FUTA. She also chairs the Steering Committee on Responsible Artificial Intelligence for Climate Action in Africa, another first for a Nigerian woman. In recognition of her expertise, she was appointed to the Ondo State Government Committee on the upgrade of Rufus Giwa Polytechnic to a university.

A leading Energy and Environment scholar, Professor Ijagbemi has made groundbreaking contributions to sustainable engineering, including the development of a titanium-based lightweight automotive suspension system that reduces CO₂ emissions. Her research spans green energy, remediation engineering, climate change, and sustainable manufacturing, with publications widely cited globally.

Her international engagements include a merSETA Research Fellowship at Tshwane University of Technology, South Africa, global collaborations with institutions in the USA and UK, and participation in the EU Programme for Developing Female University Leaders.

A Fellow of the Nigerian Society of Engineers and the Nigerian Institution of Mechanical Engineers, she has held several pioneering leadership roles within the profession. She recently delivered FUTA's 183rd Inaugural Lecture titled "Waste Engineering and Climate Change – An Ingenious Alliance to the Drawdown."

Professor Christianah Olakitan Ijagbemi is celebrated for her excellence in research, leadership, mentorship, and service to humanity.