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Sustainable development, agricultural innovation, and food security: Pathways to strengthening global competitiveness and socio-economic resilience

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Abstract

The global agrifood system stands at a critical juncture: while agricultural value and food production have grown substantially over the past decades, food insecurity, undernourishment, and environmental pressures persist. According to the 2024 edition of the Food and Agriculture Organization of the United Nations (FAO) Statistical Yearbook, global agricultural value reached US\$ 3.8 trillion in 2022 an 89% real-terms increase over two decades. Despite this, between 638 and 720 million people about 8.2% of the global population experienced hunger in 2024, a slight decline from previous years, but still unacceptably high.

This paper argues that bridging the gap between increased agrifood output and persistent food insecurity demands a paradigm shift: from conventional agriculture toward sustainable agricultural innovation (e.g. diversification, precision farming, soilless agriculture), supported by institutional reforms and investments. Drawing on recent global data and empirical studies, the paper explores how such a shift can simultaneously promote food security, environmental sustainability, and socio-economic resilience thereby enhancing global competitiveness. Finally, policy recommendations are offered for governments, institutions, and stakeholders involved in transforming agrifood systems.

Keywords: Sustainable development, agricultural innovation, food security, global competitiveness, socio-economic resilience, diversified farming, precision agriculture, soilless agriculture, climate-resilient agriculture

Introduction

Over the past two decades, global agriculture has undergone dramatic transformation. The 2024 FAO Statistical Yearbook reports that global agricultural value rose by 89% in real terms, reaching US\$ 3.8 trillion in 2022. However, this growth has not translated into universal food security. As of 2024, an estimated 673 million people faced hunger globally (about 8.2% of the global population), according to the latest The State of Food Security and Nutrition in the World (SOFI) 2025. Meanwhile, food insecurity remains widespread: about 2.33 billion people experienced moderate or severe food insecurity in 2023, and over 2.8 billion people could not afford a healthy diet in 2022.

This paper examines how sustainable agricultural innovations including diversification, precision farming, and soilless agriculture can contribute to improved food security, socio-economic resilience, and global competitiveness. It also analyses barriers (technological, institutional, financial) and proposes policy pathways for scalable, equitable agrifood transformation.

The State of Global Food Security & Agriculture: Data & Trends Growth in Agriculture and Agrifood Systems

- According to FAO data, global agricultural value reached US\$ 3.8 trillion in 2022 (real terms), up 89% compared to two decades earlier.
- Global primary crop production in 2022 was 9.6 billion tonnes a 56% increase relative to 2000 with staple crops (sugarcane, maize, wheat, rice) accounting for nearly half of global crop production.
- Nevertheless, the share of global workforce employed in agriculture declined from ~40% in 2000 to ~26% in 2022.

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Food Insecurity, Undernourishment, and Diet Affordability

- In 2024, approximately 673 million people globally were hungry (8.2% of population). In 2023, around 733 million people were undernourished about one in eleven globally showing little progress toward ending hunger. More than one third of the global population cannot afford a healthy diet; in low-income countries, over 70% often lack the income for balanced diets.
- Over 2.33 billion people experienced moderate or severe food insecurity in 2023.

Environmental and Systemic Pressures

- **Agriculture remains a major user of natural resources:** for example, globally, agriculture accounts for about 72% of freshwater withdrawals.
- Traditional, resource-intensive agriculture faces increasing pressure due to climate change, land degradation, water scarcity, and rising demand from growing populations.

Agricultural Innovation & Sustainable Practices: Evidence and Potential

This section explores innovative practices and their potential to reconcile food production, sustainability, and resilience.

Diversified & Sustainable Farming

A recent meta-analysis synthesizing 50 years of data (4,260 effect sizes) shows that diversified agriculture (intercropping, organic amendments, non-crop diversification) leads to substantial long-term benefits: increased biodiversity, improved soil quality, enhanced carbon sequestration, and increased economic profitability. Over 20 years, benefits increased by up to 2,823%; over 50 years, non-yield benefits rose up to 2,000%.

When yield neutrality or modest yield gains are acceptable, diversification yields "win-win" outcomes for ecological services and socio-economic returns making it a viable strategy for sustainable agrifood transformation.

Precision Farming & Soilless Agriculture

Emerging research points to the potential of soilless agriculture (hydroponics, aeroponics, aquaponics) paired with smart technologies like Internet of Things (IoT) enabling resource-efficient, high-yield, climate-resilient cultivation even in urban or degraded environments.

Such innovations are especially promising for regions facing land scarcity, degraded soils, or unpredictable climate offering stable yields, reduced dependency on conventional arable land, and lower environmental footprint.

Finance, Institutions & Access to Capital

Sustainable agribusiness and innovations require access to timely, adequate, and affordable finance, especially for smallholder farmers. A very recent study (2025) found a strong positive relationship between access to finance and food security outcomes among smallholder farmers.

Without enabling institutional and financial frameworks, technological innovations may remain confined to large-scale farms undermining equity, rural livelihoods, and broader socio-economic resilience.

Linking Sustainable Agriculture, Food Security & Global Competitiveness

This section argues that promoting agricultural innovation and sustainable agrifood systems can drive socio-economic resilience and global competitiveness.

- **Food Security as a Stability Foundation:** Ensuring universal access to nutritious food, reducing undernourishment, and stabilizing food supply chains helps avoid social unrest, health crises, and economic shocks. Given that hundreds of millions still suffer hunger or food insecurity globally despite high agricultural output, reforming agrifood systems is essential.
- **Sustainable Agriculture and Environmental Resilience:** Diversification, sustainable practices, and precision/soilless farming reduce pressure on natural resources (land, water), lower carbon footprint, and buffer against climate-change-driven risks helping countries build long-term resilience.
- **Economic Competitiveness & Value Addition:** Innovation in agrifood systems sustainable farming, high-value crops, processing, agribusiness can increase profitability, create rural employment, and integrate agriculture into global value chains, boosting countries' economic competitiveness.
- **Social Equity and Rural Livelihoods:** By improving access to finance, technologies, and markets for smallholder and marginal farmers, agrifood transformation can reduce rural poverty, curb rural-urban migration, and improve socio-economic inclusion.

Thus, sustainable agriculture and food security are not just social or environmental goals they are central to economic development, stability, and global competitiveness.

Challenges, Gaps & Risks

While the potential is large, there are significant obstacles:

- **Investment and Financial Barriers:** Smallholders often lack access to credit, insurance, modern inputs limiting adoption of innovations. Institutional reforms and supportive policies are needed.
- **Technological Dependence & Inequality:** Advanced methods (IoT-based precision farming, soilless agriculture) may be capital-intensive and benefit only larger farms risking widening inequality unless mechanisms for equitable access are ensured.
- **Need for Long-Term Commitment:** Benefits of diversification and sustainable agriculture often accrue over decades requires long-term policy consistency, incentives, and capacity building.
- **Environmental and Resource Limitations:** Despite innovations, constraints like water scarcity, degraded soils, climate change remain requiring integrated resource management, adaptation strategies.
- **Food Distribution, Pricing & Access:** Increasing production alone doesn't guarantee food security distribution networks, affordability, social protection, and inclusive policies remain crucial.

Policy Recommendations and Pathways Forward

Based on the analysis, the following policy pathways are proposed:

1. **Promote Sustainable & Diversified Farming:** Encourage practices such as intercropping, organic

- farming, crop diversification through subsidies, training, extension services, and long-term incentives.
2. **Support Agricultural Innovation & Technology Adoption:** Facilitate access to precision farming, soilless farming, IoT-based agriculture including grants, low-interest credit, public-private partnerships, and demonstration farms.
 3. **Strengthen Financial Inclusion for Smallholders:** Expand institutional financing, microcredit, crop insurance, input support; design financial products tailored for small and marginal farmers to adopt sustainable farming.
 4. **Invest in Agrifood Value Chains and Infrastructure:** Improve storage, cold-chain, transport, processing, market access reducing post-harvest losses, improving profitability, and ensuring fair prices.
 5. **Ensure Social Protection & Inclusive Food Access:** Policies for affordable access to healthy diets, social safety nets, subsidies for vulnerable populations to ensure food security along with production.
 6. **Adopt Integrated Resource Management & Climate Adaptation:** Water conservation, soil health, sustainable land use, climate-resilient crops to sustain agriculture under changing environmental conditions.
 7. **Monitoring, Data & Research:** Strengthen data collection, monitoring systems, research on sustainable agriculture, nutrition, agrifood systems, to guide evidence-based policy.
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Conclusion

Agriculture today stands at the crossroads of opportunity and challenge. While global agrifood output and value have grown markedly, hunger, undernourishment, and food insecurity persist at unacceptably high levels. The disconnect underscores the need for transformation not just more production, but smarter, sustainable, inclusive agriculture rooted in innovation, equity, and long-term vision.

By embracing diversified farming, precision and soilless agriculture, enhancing financial inclusion, building robust agrifood value chains, and ensuring equitable access to healthy diets, nations can achieve food security, socio-economic resilience, and improved global competitiveness fulfilling both social justice and economic development goals.

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