HP
JAESR2024
*Hummingbird Publications*
**Journal of Agricultural & Env. Sci. Research**
www.hummingbirdjournals.com
***© May, 2024***
***Vol. 4 No. 1***

# Reengineering Agricultural Land System for Food Security in a Depressed Economy

**Ikugbe Cyril E.[1]; and Hassan Shehu T.[2]**
School of Environmental Studies, Gateway (ICT) Polytechnic, Saapade, Ogun State.
*sevs@gaposa.edu.ng*

**Keywords:** Food, Food Security, Agricultural Productivity, Land and Agricultural Land System, Depressed Economies; and Sustainable Food Production

## Abstract
Food security remains a critical challenge, particularly in depressed economies where agricultural productivity is hindered by environmental degradation, limited technological advancement, and inadequate investment. This study examines the urgent need to reengineer agricultural land systems as a means of enhancing food security in these economies. Reengineering involves redesigning and optimizing agricultural systems by integrating modern technologies, sustainable practices, efficient resource management, and robust policy interventions. Key strategies include adopting precision agriculture, biotechnology, and advanced irrigation systems, alongside sustainable techniques like crop rotation, agroforestry, and integrated resource management. Overcoming socioeconomic barriers, building capacity through knowledge exchange, and fostering community engagement are also crucial components. By radically transforming agricultural land systems through a comprehensive, interdisciplinary approach, it is possible to increase productivity, build resilience against environmental stressors, and ultimately ensure sustainable food production amid economic challenges.

## Introduction

Agricultural land systems are the backbone of food security worldwide, playing a crucial role in producing the food necessary to sustain populations. As the global population continues to rise, the demand for food increases, placing unprecedented pressure on agricultural systems to enhance productivity and efficiency. This pressure is particularly acute in depressed economies, where the intersection of poverty, environmental degradation, and limited technological advancement can hinder agricultural productivity (Godfray et al., 2010). In many developing and depressed economies, traditional agricultural practices are insufficient to meet the growing demand for food. This inadequacy is exacerbated by factors such as climate change, land degradation, and resource depletion (United Nations, 2021). As economies experience downturns, the agricultural sector often suffers from reduced investment, leading to diminished productivity and heightened food insecurity (FAO, 2019). Climate change also poses a significant threat to agricultural productivity and food security, particularly in vulnerable regions (Vermeulen et al., 2012). Depressed economies often faced challenges exacerbated by environmental issues such as soil degradation, water scarcity, and climate change, these factors contribute to low agricultural productivity and threaten food security. Addressing these issues requires innovative approaches and reengineering of agricultural land systems to build resilience and improve productivity (FAO, 2017).

According to Tilman et al. (2011) reengineering agricultural land systems involves redesigning and optimizing these systems to better meet current and future food security needs. This process includes the adoption of new technologies, sustainable practices, and efficient resource management techniques, by integrating modern agricultural practices with traditional knowledge, reengineering can help create more resilient and productive agricultural systems capable of supporting food security in depressed economies. Innovations such as precision farming, genetically modified crops, and advanced irrigation systems can significantly improve agricultural outputs (Bongiovanni & Lowenberg-DeBoer, 2004). In depressed economies, the adoption of such technologies can bridge productivity gaps and contribute to food security. However, the implementation of these technologies must be tailored to the specific conditions and constraints of these economies. In addition to technological innovations, sustainable agricultural practices play a critical role in reengineering agricultural land systems. Practices such as crop rotation, agroforestry, and organic farming can improve soil health, increase biodiversity, and enhance resilience to climate change. These practices not only boost productivity but also ensure long-term sustainability, which is essential for maintaining food security in the face of environmental and economic challenges (Altieri, 2002).

In the work of Pretty (2008) in depressed economies, where resources are often scarce, adopting integrated resource management strategies can maximize the efficient use of available resources and support sustainable agricultural practices. Additionally, governments and international organizations play a key role in creating an enabling environment for agricultural innovation and sustainability. This includes investing in infrastructure, providing financial incentives for sustainable practices, and ensuring access to markets. In depressed economies, targeted policies and support can help overcome barriers to agricultural productivity and contribute to food security (Paarlberg, 2009). Moreso, involving local communities in the planning and implementation of agricultural projects ensures that interventions are contextually relevant and culturally appropriate (Pretty & Ward, 2001). Also, capacity building efforts, such as training programs and knowledge exchange initiatives, can empower farmers with the skills and knowledge needed to adopt new practices and technologies (Pretty, 2008). Reengineering agricultural land systems through the integration of advanced technologies, sustainable practices, and effective resource management, supported by robust policy frameworks and community engagement, is essential for enhancing food security in depressed economies by increasing productivity, resilience, and sustainability amidst environmental and economic challenges. Thus, this study focuses on reengineering these systems to ensure a reliable food supply and enhance food security in Nigeria.

## Overview of Agricultural Land Systems

The current agricultural land systems are the product of 19th century economic and land market paradigms and have failed to properly support sustainable agricultural development and food security. The need for urgent reform is accepted, but the way forward unclear in many jurisdictions (Williamson, 2001).

Agricultural land system refers to the organization and management of agricultural lands, including the spatial arrangement of crops, livestock, and other components within a given area or region. It encompasses the interrelationships between various biophysical and socioeconomic factors that shape agricultural practices and land use patterns. According to Netting (1993), an agricultural land system is the ordered combination of appropriate technical and institutional means to control energy, water, and vegetation for the direct acquisition of those ecological goods and services that satisfy human needs. Agricultural land systems are dynamic and evolve over time in response to various drivers, such as population growth, technological advancements, market forces, policy changes, and environmental factors (Lambin et al., 2003). Understanding agricultural land systems is crucial for sustainable land management, food security, and rural development initiatives. Key components of an agricultural land system include:

- **Land use patterns:** The spatial distribution of different agricultural activities within a given area.
- **Farming systems:** The specific combinations of crops, livestock, and management practices employed by farmers within a particular ecological and socioeconomic context.
- **Infrastructure and markets:** The availability and accessibility of infrastructure such as roads, irrigation systems, storage facilities and markets for agricultural inputs and outputs.
- **Socioeconomic factors:** The influence of factors such as population density, cultural traditions and labor availability on agricultural land use decisions.
- **Environmental conditions:** The biophysical characteristics of the land such as soil quality, climate, topography, and water resources.

## Reengineering Agricultural Land System for Food Security

In depressed economies, agricultural land systems are often plagued by inefficiencies and vulnerabilities that severely impede food security. These systems frequently suffer from poor infrastructure, limited access to advanced agricultural technologies, and inadequate financial resources, which collectively hinder productivity and sustainability. Moreover, environmental challenges such as soil degradation, water scarcity, and the adverse effects of climate change exacerbate these issues, making traditional farming methods increasingly unsustainable. As a result, the agricultural sector in these economies struggles to meet the food demands of growing populations, leading to persistent food insecurity and malnutrition. The urgent need to reengineer agricultural land systems in depressed economies is further highlighted by the socio-economic barriers that limit farmers' capacity to adopt innovative practices. Lack of education, insufficient government support, and weak institutional frameworks contribute to the perpetuation of outdated and inefficient agricultural practices. This creates a vicious cycle of low productivity, poverty, and food insecurity. Addressing these complex challenges requires a comprehensive approach that integrates technological innovation, sustainable resource management, and robust policy interventions. By reengineering these systems, it is possible to enhance agricultural productivity, build resilience against environmental and economic shocks, and ultimately achieve sustainable food security in depressed economies.

The need to adopt an innovative approach to agricultural land systems that ensures security of food for the growing populace is as important as the need for agricultural practices in the first place. Rethinking existing practices will give rise to better ways of food production. The emergence of technological advancement in the fields of machine learning, data analytic, robotics and precision farming provide opportunity for leverage within the traditional agricultural practices giving rise to increase yield in farms and ensuring food security. Re-engineering is geared towards the achievement of improved business processes so that product and service costs are lowered and the quality of products and services improved. In effect, therefore, re-engineering involves a fundamental rethinking and radical redesign of business processes (Hammer and Champy, 1993) that results in a better way of doing work. Re-engineering is a relatively new concept and while some proponents suggest incremental re-engineering (Morris and Brandon, 1993), others advocate nothing less than revolutionary change (Hammer and Champy, 1993). What is clear with regards to agricultural land re-engineering is that the application of change as a tool for improvement of performance is the basic and underlying theme.

**Effect of Reengineering Agricultural Land System and Land Use Patterns**

Land in Africa is broadly used for agricultural activities which include food and cash crops, live stocks, pastures, forest and game reserves, fallow land and waste land (Iwena, 2008). There are also small areas which are being developed for fisheries. Therefore, the type and intensity of land use patterns varies from place to place since there are considerable differences in population density and customary beliefs (Akinyosoye, 1986).Agricultural production in Nigeria is centered around food crops such as yam, cassava, maize, millet, beans, rice, guinea corn and cash crops such as cocoa, oil palm, cotton, rubber, coffee, bananas and groundnut. These arable crops occupy over 15% of the cultivated land areas of West Africa and of this land; over 80% is fully developed for food crops (Akinyosoye, 1986). The bush fallow is an important aspect of agricultural land use patterns; this pattern is used to describe land system which is left to revert to bush after some period of cultivation.

Consequently, the bush fallow is use for preservation of games, increasing oil fertility and ensuring the utility of land. Forest reserves may also be developed for aesthetic purposes(Uguru, 1983). Effective land allocation and use focuses on re-distributing land to reduce waste of land and achieve the well-intended land policy objectives of which one of them is increased food crop production. In recent times, there have been global food crises. This maybe associated with the forms of land use patterns practiced. Most agricultural lands are being used for non-agricultural purposes such as land use for construction of bridges, roads, railway, airports and seaports, as well as land use for residential buildings, banks, offices, shops/stalls. Lands are also used for commercial, social, religious, industrial and recreational purposes which adversely affect agricultural productivity at large (Ezeogwu, 2006). Others are the Influence of bad Cultural/farming systemssuch as continuous cropping on a piece of farmland. In the words of Williamson, (2001) reengineering agricultural land systems and land use patterns can have significant effects on both the environment and socio-economic aspects. Here are some potential impacts:

Increased Productivity: By reengineering agricultural land systems, such as implementing precision agriculture techniques, optimizing crop rotations, or introducing more efficient irrigation methods, productivity can increase. This can lead to higher yields per unit area of land, thereby enhancing food security and farmer incomes.

Resource Efficiency: Adopting sustainable land use patterns can help in the efficient utilization of resources such as water, soil, and nutrients. Practices like agroforestry, contour farming, and organic farming can improve soil health, reduce erosion, and minimize water usage, thus contributing to long-term agricultural sustainability.

Biodiversity Conservation: Reengineering land use patterns to incorporate buffer zones, conservation areas, or wildlife corridors within agricultural landscapes can promote biodiversity conservation. This helps in preserving native flora and fauna, maintaining ecological balance, and enhancing ecosystem services such as pollination and pest control.

Climate Change Mitigation and Adaptation: Altering land use patterns to include climate-smart agriculture practices, such as carbon sequestration through afforestation, agroforestry, or conservation agriculture, can contribute to mitigating climate change. Additionally, adopting resilient cropping systems and water management strategies can help farmers adapt to changing climatic conditions.

## Impact of Food Security in Depressed Economies

Food security is the condition of having reliable access to a sufficient quantity of affordable and nutritious food, it is a critical issue in depressed economies where economic challenges exacerbate food scarcity. In these regions, several interconnected factors contribute to the precarious state of food security, including poverty, unemployment, and lack of infrastructure. These factors not only limit food availability but also hinder access to and utilization of food, posing a significant threat to the well-being of vulnerable populations (FAO, 020; WFP, 2020; WFP, 2021). According to FAO (2019), over 690 million people worldwide were undernourished in 2019, with the highest prevalence in regions struggling with economic hardships. In these areas, poverty rates are often high, and economic instability further aggravates the situation, making it difficult for households to secure consistent and nutritious food supplies. According to UNDP (2020) unemployment and underemployment aggravate food insecurity in depressed economies. Without stable employment, individuals and families have reduced purchasing power, limiting their ability to buy food. The World Bank notes that in many low-income countries, unemployment rates are significantly higher than in more prosperous nations, which directly impacts food security. Job scarcity and low wages mean that even employed individuals may struggle to meet their nutritional needs, leading to a cycle of poverty and hunger. Additionally, WFP (2020) highlighted that in regions with poor infrastructure, food distribution networks are often disrupted, which can severely limit food availability, especially in rural areas. Improving infrastructure is essential for enhancing food security by ensuring that food can reach those who need it most. The FAO and WFP have documented numerous cases where conflict has led to severe food crises, particularly in countries like Yemen, South Sudan, and Syria (FAO, 2020; WFP, 2020). According to the WHO (2021), malnutrition is a significant public health issue in many low-income countries, contributing to high rates of morbidity and mortality. Ensuring access to nutritious food is crucial for improving overall health outcomes and breaking the cycle of food insecurity. In depressed economies, food security is often significantly impacted due to various factors:

1. Decreased Purchasing Power: Economic downturns typically result in increased unemployment, reduced wages, and overall decreased purchasing power among the population. This makes it challenging for households to afford an adequate quantity and quality of food, leading to food insecurity.
2. Rising Food Prices: Inflationary pressures during economic depressions can lead to higher food prices, further exacerbating food insecurity. As the cost of living rises, households may struggle to afford nutritious food items, resorting to cheaper, less nutritious alternatives or reducing their food intake.
3. Disruption of Agricultural Production: Economic downturns can disrupt agricultural production due to reduced investment, limited access to credit, and a decline in demand for agricultural products. This can lead to decreased yields, loss of income for farmers, and food shortages in local markets.
4. Reduced Access to Inputs and Resources: Farmers in depressed economies may face challenges in accessing essential inputs such as seeds, fertilizers, and equipment due to supply chain disruptions, high costs, or limited availability. This can further hinder agricultural productivity and contribute to food insecurity.

Food security in depressed economies requires comprehensive strategies that address underlying economic challenges, strengthen agricultural systems, improve access to resources and social safety nets, and build resilience to shocks. Investments in agriculture, social protection programs, and emergency food assistance can help mitigate the impacts of economic downturns on food security and support vulnerable populations during times of crisis. Efforts to improve food security in depressed economies must include agricultural development. Investing in agriculture can enhance food production, create jobs, and boost economic growth.

The International Fund for Agricultural Development (IFAD, 2021) emphasizes that smallholder farmers, who make up a large portion of the population in many low-income countries, need support to increase productivity and access markets. By providing resources, training, and infrastructure, these farmers can contribute significantly to national food security. Furthermore, organizations like the WFP, FAO and various non-governmental organizations (NGOs) provide emergency food assistance, support agricultural development, and implement programs aimed at improving food access and nutrition. However, sustainable solutions require long-term investments and policies that promote economic stability and resilience (WFP, 2021; FAO; 2021). However, the knowledge about nutrition, sustainable farming practices, and resource management can help communities become more self-sufficient and resilient to economic shocks. Moreover, the United Nations Development Programme (UNDP, 2020) advocated for community-based approaches that involve local populations in decision-making processes and capacity-building initiatives. Empowered communities are better equipped to address their food security challenges and improve their overall quality of life.

## Traditional Agricultural Practices and their Limitations

Traditionally, agricultural practices have been carried out using crude tools coupled with basic technique. For centuries communities have fed and sustained food production through this basic means. However, has things changed and society evolve especially with population explosion the need for sustainable practices has become necessary to ensure food security. Traditional agricultural practices are often characterized by their reliance on locally available resources, indigenous knowledge, and low-input farming methods. Some examples of the basic techniques applied in traditional farm practice include shifting cultivation, traditional irrigation system and reliance on human and animal power for plowing and transportation. While these practices have been adapted to local conditions and have contributed to food security, they face dire and several limitations. It is important to recognize that traditional agricultural practices have evolved over time and have contributed to the resilience and diversity of agricultural systems. However, addressing the limitations of these practices through appropriate interventions, such as improved access to resources, technology transfer, and policy support, can help enhance productivity, sustainability, and the livelihoods of smallholder farmers (Pretty et al., 2003).

**Limitations of Traditional Farm Practice**

- Traditional practices may result in lower yields compared to modern, input-intensive agriculture (Tilman et al., 2002).
- Many traditional practices are labor-intensive, which can be a constraint in areas with limited labor availability or competing demands for labor (Pingali et al., 1987).
- Traditional practices may not be well-suited to cope with rapid environmental changes, such as climate variability, soil degradation, or pest outbreaks (Altieri & Nicholls, 2017).
- Smallholder farmers practicing traditional agriculture often face challenges in accessing markets, credit, and modern agricultural inputs (Barrett, 2008).
- Insecure land tenure rights can discourage long-term investments in sustainable land management practices and limit the adoption of new technologies (Holden & Ghebru, 2016).

**Modern Agricultural Technologies and Innovations**

Modern agricultural technologies and innovations have changed the way we produce food and manage agricultural systems. These advancements aim to enhance productivity, efficiency, and sustainability while addressing challenges such as population growth, environmental degradation, and climate change. However, the adoption and implementation of these technologies and innovations have sparked debates and raised concerns regarding their potential impacts on various aspects of agriculture and society. These innovations hold in one hand the potentials to significant impact on the quantity of food produced given the ever-growing population. On the other hand, there are fears and concerns about the quality and safety of these genetically enhance foods to the human body. However, there is need to strike a balance between quantity and quality in technological advancement in the agricultural landscape. The following are modern agricultural technologies and innovations:

- **Biotechnology and Genetic Engineering**: Biotechnology has enabled the development of genetically modified organisms (GMOs), including crops engineered for improved traits such as pest resistance, herbicide tolerance, and enhanced nutritional value. While proponents argue that GMOs can increase yields, reduce pesticide use, and improve food security (Qaim, 2009), critics raise concerns about potential risks to human health, biodiversity, and the dominance of large agribusinesses (Stiglitz, 2006).
- **Precision Agriculture and Smart Farming:** Precision agriculture involves the integration of various technologies, such as GPS, remote sensing, and data analytics, to optimize resource use and management practices. Smart farming techniques, including precision irrigation, variable rate fertilizer application, and automated monitoring systems, aim to improve efficiency and reduce environmental impacts (Gebbers & Adamchuk, 2010).
- **Vertical Farming and Controlled Environment Agriculture:** Vertical farming and controlled environment agriculture (CEA) systems, such as hydroponics and aquaponics, offer the potential to produce food in urban areas or in regions with limited arable land. These systems optimize resource use, minimize environmental impacts, and reduce transportation costs (Kozai et al., 2016). However, concerns have been raised about the energy demands and economic viability of these technologies (Banerjee & Adenaeuer, 2014).

As technology advancement marches on in the field of agricultural production, it is pivotal to consider the complex interplay between technological advancements, socioeconomic factors, environmental concerns, and ethical considerations when evaluating the impacts of modern agricultural technologies and innovations. Inclusive and context-specific approaches that involve stakeholders, policymakers, and local communities are essential for responsible and sustainable adoption of these technologies (Azadi et al., 2020; Mwombe et al., 2017).

**Need for Efficient Land Use Development in a Depressed Economy**

Economic development essentially means a process of upward change whereby the real pr capita income of a country increases over a period of time. Agriculture has an important role to play in the development of a country. It is one of the most important inputs in economic development. The number and competence of Agricultural activities affect the food security of the country. The economic history of the presently advanced countries like USA, Russia and Japan supports the fact that economic development is the outcome for which agriprenurs is an inevitable cause. The crucial and significant role played by the entrepreneurs in the economic development of advanced countries has made the people of developing and under developed countries conscious of the importance of agriculture for economic development. It is now a widely accepted fact that active and enthusiastic entrepreneurs can only explore the potentials of the countries availability of resources such as labour, capital and technology. Efficient land use development becomes even more crucial in a depressed economy for several reasons:

1. Maximizing Resources: With limited financial resources available, it's essential to make the most of existing land assets. Efficient land use ensures that every inch of available land contributes to economic growth and community development.
2. Cost Reduction: Developing infrastructure and services for sprawling, inefficient land use patterns can be prohibitively expensive. Concentrating development in already developed areas or areas with existing infrastructure reduces the cost of providing essential services like water, electricity, and transportation.
3. Economic Stimulus: Optimizing land use can stimulate economic activity by creating opportunities for investment and development. Concentrating

development in urban areas, for example, can attract businesses, create jobs, and drive economic growth.

4. Environmental Sustainability: Efficient land use reduces urban sprawl, which helps preserve natural habitats, protect agricultural land, and minimize environmental degradation. Compact, mixed-use development encourages walking, cycling, and the use of public transportation, reducing carbon emissions and promoting sustainability.
5. Social Equity: Concentrating development in existing urban areas can improve access to essential services and amenities for all residents, including those in underserved communities. Efficient land use planning can promote social equity by reducing disparities in access to healthcare, education, and employment opportunities.

Efficient land use planning enables local governments to optimize the allocation of resources and streamline regulatory processes. By reducing bureaucracy and promoting collaboration between public and private stakeholders, governments can foster a more responsive and efficient development environment. Land use development is essential for maximizing resources, reducing costs, stimulating economic activity, promoting environmental sustainability and social equity, building resilience to economic shocks, and improving government efficiency—especially in a depressed economy.

## Conclusion

Reengineering agricultural land systems is a pivotal endeavor in the quest to achieve sustainable food security, particularly in depressed economies. By integrating modern technologies, sustainable practices, and effective resource management strategies, we can unlock the potential for increased productivity, resilience, and long-term sustainability. This transformation requires a multilayered approach that accounts for the unique challenges and constraints faced by these economies. There is need consider the establish long-term monitoring and evaluation frameworks to assess the effectiveness and impacts of implemented interventions over time, allowing for continuous improvement and adaptation based on empirical evidences. By so doing allowing for a seamless and widespread adoption of radical rethinking and redesigning of agricultural land system.

The road to radically rethink and redesign agricultural land system is not without obstacles, as socioeconomic barriers, environmental degradation, and limited institutional capacity pose significant hurdles. Overcoming these challenges demands collaborative efforts involving governments, research institutions, local communities, and international organizations. By fostering knowledge exchange, capacity building, and policy reforms, we can create an enabling environment that empowers farmers, promotes innovation, and supports the adoption of reengineered agricultural land systems. Ultimately, reengineering agricultural land systems is not merely a technical endeavor but a holistic pursuit that encompasses social, economic, and environmental dimensions. It requires a fundamental shift in our approach to food production, one that prioritizes sustainability, resilience, and equity. By embracing this transformative vision, we can pave the way for a future where depressed economies can achieve lasting food security, ensuring that no person goes hungry and that the fundamental human right to food is upheld for all.

## Recommendations

To attain food security through reengineering of agricultural land system the following recommendations are underlisted.

Promote sustainable agricultural practices through the encouragement of practices like crop rotation, agroforestry, and organic farming to improve soil health, increase biodiversity, and enhance resilience to climate change.

Adopt integrated resource management strategies to maximize the efficient use of available resources, such as water and nutrients.

Develop policies and regulations that incentivize the adoption of sustainable agricultural practices and technologies.

Involve local communities in the planning and implementation of agricultural projects to ensure contextual relevance and cultural appropriateness.

## References

Altieri, M. A. (2002). Agroecology: The science of natural resource management for poor farmers in marginal environments. Agriculture, Ecosystems & Environment, 93(1-3), 1-24.

Azadi, H., Schoonbeek, S., Mahmoudi, H., Derudder, B., De Maeyer, P., & Witlox, F. (2020). Organic agriculture and sustainable food production system: Main potentials. Agriculture, Ecosystems & Environment, 292, 106821.
Banerjee, C., & Adenaeuer, L. (2014). Up, up and away! The economics of vertical farming. Journal of Agricultural Studies, 2(1), 40-60.
Barrett, C. B. (2008). Smallholder market participation: Concepts and evidence from eastern and southern Africa. Food Policy, 33(4), 299-317.
Bergerman, M., Billingsley, J., Reid, J., & van Henten, E. (2015). Robotics in agriculture and forestry. In Springer Handbook of Robotics (pp. 1463-1492). Springer, Cham.
Bongiovanni, R., & Lowenberg-DeBoer, J. (2004). Precision agriculture and sustainability. Precision Agriculture, 5(4), 359-387.
Critchley, W., & Siegert, K. (1991). Water harvesting: A manual for the design and construction of water harvesting schemes for plant production. Food and Agriculture Organization of the United Nations.
FAO. (2017). The future of food and agriculture – Trends and challenges. Food and Agriculture Organization of the United Nations.
Food and Agriculture Organization (FAO) & World Food Programme (WFP). (2020). Hunger Hotspots.
Food and Agriculture Organization (FAO). (2019). The State of Food Security and Nutrition in the World 2019.
Food and Agriculture Organization (FAO). (2021). Sustainable Food and Agriculture.
Gebbers, R., & Adamchuk, V. I. (2010). Precision agriculture and food security. Science, 327(5967), 828-831.
Godfray, H. C. J., Beddington, J. R., Crute, I. R., Haddad, L., Lawrence, D., Muir, J. F., ... & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people. Science, 327(5967), 812-818.
Holden, S. T., & Ghebru, H. (2016). Land tenure reforms, tenure security and food security in poor agrarian economies: Causal linkages and research gaps. Global Food Security, 10, 21-28.
Ingram, J. (2020). Sustainable agriculture: Transitioning from contemporary to modern systems. In Sustainable Food Systems from Agriculture to Industry (pp. 1-24). Academic Press.
Intergovernmental Panel on Climate Change (IPCC). (2019). Climate Change and Land
International Fund for Agricultural Development (IFAD). (2021). Rural Development Report.
Kozai, T., Niu, G., & Takagaki, M. (2016). Plant factory: An indoor vertical farming system for efficient quality food production. Academic Press.
Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. Annual review of environment and resources, 28(1), 205-241.
Lowenberg-DeBoer, J., & Erickson, B. (2019). Setting the record straight on precision agriculture adoption. Agronomy Journal, 111(4), 1552-1569.
Mertz, O., Padoch, C., Fox, J., Cramb, R. A., Leisz, S. J., Lam, N. T., & Vien, T. D. (2009). Swidden change in Southeast Asia: Understanding causes and consequences. Human Ecology, 37(3), 259-264.
Mwombe, S. O., Mugivah, M. J., Otieno, D. J., & Asienyo, B. O. (2017). Adoption of Biotechnology in Agriculture: A Case Study of Tisssue Culture Banana Production in Kenya. Journal of Biosafety, 15(1), 1-14.
Netting, R. M. (1993). Smallholders, householders: Farm families and the ecology of intensive, sustainable agriculture. Stanford University Press.
Paarlberg, R. (2009). Starved for science: How biotechnology is being kept out of Africa. Harvard University Press.
Pingali, P. L., Bigot, Y., & Binswanger, H. P. (1987). Agricultural mechanization and the evolution of farming systems in sub-Saharan Africa. The World Bank.
Pretty, J., Morison, J. I., & Hine, R. E. (2003). Reducing food poverty by increasing agricultural sustainability in developing countries. Agriculture, Ecosystems & Environment, 95(1), 217-234.
Qaim, M. (2009). The economics of genetically modified crops. Annual Review of Resource Economics, 1(1), 665-694.
Rotz, S., Gravely, E., Mosby, I., Duncan, E., Finnis, E., Horgan, M., ... & Worsick, V. (2019). Automated pastures and the digital disruption of dairy farms. Journal of Rural Studies, 68, 25-37.
Starkey, P. (1998). Integrating animal traction into conservation agriculture systems. GTZ.
Stiglitz, J. E. (2006). Making globalization work. WW Norton & Company.
Struik, P. C., & Kuyper, T. W. (2017). Sustainable intensification in agriculture: The richer shade of green. A review. Agronomy for Sustainable Development, 37(5), 1-15.
Tilman, D., Cassman, K. G., Matson, P. A., Naylor, R., & Polasky, S. (2002). Agricultural sustainability and intensive production practices. Nature, 418(6898), 671-677.
United Nations Development Programme (UNDP). (2020). Human Development Report.
United Nations World Food Programme (WFP). (2020). Annual Performance Report.
United Nations World Food Programme (WFP). (2021). Global Report on Food Crises.
Vermeulen, S. J., Campbell, B. M., & Ingram, J. S. I. (2012). Climate change and food systems. Annual Review of Environment and Resources, 37, 195-222.

Williamson, Ian. (2001). Re-engineering land administration systems for sustainable development - From rhetoric to reality. International Journal of Applied Earth Observation and Geoinformation. 3. 278-289. 10.1016/S0303-2434(01)85034-0.

World Bank. (2020). World Development Indicators.

World Health Organization (WHO). (2021). Nutrition Landscape Information System (NLIS).