Engineering Technology Open Access Journal

Juniper Publishers key to the Researchers

Opinion
Volume 5 Issue 3 - September 2023
DOI: 10.19080/ETOAJ.2023.05.555665

Eng Technol Open Acc


# Imagining African Agriculture

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**Submission**: September 12,2023; **Published:** September 22, 2023

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## Introduction

The Food and Agricultural Organization of the United Nations (FAO) estimates that Africa possesses around 60% of the world's uncultivated arable land, characterized by diverse agroecological and climatic zones ranging from tropical rainforests to arid regions [1]. This diversity offers promising opportunities to meet global food demands [2]. However, challenges like limited technology, policy constraints, human capital deficiencies, and climate change adaptation must be addressed. Integrating modern techniques with traditional practices into smart agriculture is crucial for enhancing production while safeguarding soil health and the environment. Hyper automation represents the future of agricultural technology, promising sustainable transformation through state-of-the-art automation methodologies and innovative technologies. Hyper automation is a true digital transformation in sustainable agriculture with the help of advanced techniques such as digital and robotic process automation, unmanned aerial vehicles, controlled-environment agriculture, remote sensing, Internet of Things (IoT), crop modeling, precision farming, sustainable yield, image analysis, machine learning, artificial intelligence, and deep learning. The environmental and economic importance of monitoring and mapping agricultural resources would allow the utilization of these modern technologies to make production more efficient and sustainable, responding to user needs.

Barriers to productivity growth in agriculture range from social, political, governance, cultural, and environmental factors to economic factors. Perhaps the most critical reasons for low productivity in Sub-Saharan African (SSA) agriculture are the generally low levels of technological inputs and the low usage of standard methodologies [3]. On average, about 70% of farm work is performed manually, 20% by draft animals, and only 10% by mechanical power[4]. The path to faster growth is increased productivity through improved input quality, of which technical inputs are a major part [5]. This calls for African innovative competence in technological and methodological applications and solutions as part of the most critical area of a holistic support infrastructure for social progress. Transforming agriculture on the African continent into an efficient, productive, agile, and resilient sector will provide opportunities for enhancing food security, stimulating economic growth, and improving quality of life sustainably, equitably, and responsibly. Integrating current digital agricultural technologies and methodologies with indigenous knowledge will bring the holistic complementary benefits of both worlds into optimally developing an African agriculture that is resilient, agile, adaptable, and regenerative, thus sustainable.

The backbone of digital agriculture is infrastructure for connectivity, power availability, technological know-how, and access to the market. The growth of telecommunications network and electrification on the African continent in the past decade has been trending upward, and so have professionals. The percentage of the population in lower-middle-income SSA countries that use the internet increased from less than 1% to over 30% between the early 2000s and 2018 [6]. By 2019, nearly 80% of SSA owned mobile cellphone subscriptions. Likewise, an increase was recorded in the percentage of rural SSA with access to electricity. This rose from 9% to 31% between 2000 and 2017 [7]. The rise of pioneering innovative financial technology solutions from the continent is evidence of these developments. Current efforts are underway on the continent to develop and expand the use of high bandwidth connectivity technologies such as 5G, Low-earth orbit (LEO) satellites, and Low power wide area network (LPWAN).

The level of mechanization is currently very low in Africa. Greater connectivity between farms would be essential in building resilience and agility [6,8]. Applications of intelligent, low-power-consuming interconnected sensing and robust communication systems offer means for efficient monitoring and control of farms

using IoT and Internet of Everything (IoE) remotely. For example, irrigation technologies are becoming more popular in Africa, and installing actuators would enable remote control of these systems using the IoT. The IoT and IoE also provide other opportunities, such as aggregating much needed data to shift from generalized management to highly optimized, individualized, real-time, and data-driven, continuous monitoring of crops, water, and livestock. Data analytics for process optimization, precise crop fertilization, irrigation, and pest and disease control, precise livestock feeding and medication, and prediction of machine and building failures are other ways agriculture can be transformed within the next decade [6,8].

The reconfiguration of farm layouts assumes pivotal importance in mechanization, primarily due to its facilitation of unimpeded access and seamless movement for farm machinery within and between farms. It serves as the transformative bridge that connects the divide between individual, fragmented small-scale farms and the realization of larger, commercially viable enterprises. Achieving this transition is contingent upon the implementation of government policies that streamline the process of land exchange among farmers, enabling them to consolidate irregularly shaped land parcels into configurations compatible with modern farm machinery, such as combines. These policy-driven advantages also extend to the establishment of cost-effective interconnected irrigation systems that span across multiple farms, thereby contributing significantly to a nation's broader irrigation expansion initiatives. Furthermore, this restructuring holds the potential to bolster flood control measures through the creation of integrated drainage systems, reinforcing the overall resilience of agricultural practices. Consequently, this land reform initiative serves as a critical enabler for the effective deployment of robotics in agriculture, especially in scenarios where precise path planning and navigational efficiency are of importance [9].

To transform African agriculture in a major way, novel pathways of production and post-production must be imagined that are fitting to the diversity of situations and contexts. These may include vertical agriculture in land-constrained regions to grow high value flowers, horticultural crops, spices, or livestock housing systems; ocean or sea farming in coastal regions (consisting more than 30 African countries) of seaweed for food, livestock feed, and energy; and development of perennial or multiple-harvesting crops to take advantage for the long growing seasons, and self-replicating plants. These could complement existing sustainable production systems.

In addition to the necessity of technological and methodological modernization, other equally critical measures that need to be implemented and integrated into a holistic approach to development are human technical and financial capacity through training farmers and growers by putting in place sustained extension and outreach programs (with translations into local languages), and curriculum changes that prepare youth to work on and own commercial farms [9-13]. The integration of technological innovations must be accompanied by creative knowledge transfer methods employing various digital tools, facilitating widespread and cost-effective dissemination. Governments should embrace fair land reforms and encourage farmers to form cooperative farming units suitable for mechanization and irrigation. Growers must gain access to markets, utilizing crop and grain stock exchanges and related services. The advancement of information technology has enhanced community access to shared information, experiences, and practices across the continent, with a focus on innovations that promote environmental sustainability, economic growth, and human capital development, particularly among women and youth. Engaging the youth is pivotal for transforming agri-food systems in SSA, as modern technology integration can render the agricultural sector more appealing to them, combating the perception of agriculture as an antiquated industry. This highlights the need for building regional capacity to grow strategically selected crops, thus protecting against supply chain disruptions. In fact, it has been reported that an investment of between $315 bn and $400 billion in transforming 18 agricultural value chains over a ten-year period will open markets worth $80 billion per annum for Africa [14].

## Conclusion

The transformation of African agriculture is not only a technological endeavor but also a societal and economic imperative. Leveraging modern technologies while addressing institutional and capacity constraints can unlock the continent's vast agricultural potential, improving food security, economic growth, and environmental sustainability. By embracing a holistic approach that includes innovation, education, equitable land reform, and youth engagement, Africa can build resilient and efficient agri-food systems, ultimately contributing to regional and global food security and economic prosperity.

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How to cite this article: Kifle G G, Daniel U. Imagining African Agriculture. Eng Technol Open Acc. 2023; 5(3): 555665.
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