NEW ERA AGRICULTURE MAGAZINE

Agriculture 4.0: Fourth Agricultural Revolution

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Abstract: -

Agriculture 4.0, referred to as the Fourth Agricultural Revolution, is a transformative period in farming that is powered by a suite of digital and data-centric advancements that allow for increased accuracy, automation, and sustainability in agricultural practices. The Internet of Things (IoT), artificial intelligence (AI), big data analytics, robotics, drones, autonomous vehicles, and enhanced environmental sensors are among the key technologies that support Agriculture 4.0. These advances enable real-time data gathering and analysis, optimize resource allocation such as water and fertilizers, automate labor-intensive operations, and improve crop monitoring, thus boosting productivity and sustainability. Agriculture 4.0 applications include crop management, precision irrigation, livestock monitoring, pest and disease control, supply chain traceability, and vertical farming. Farmers may make informed decisions using real-time analytics, resulting in better yields, decreased input waste, improved food security, and a smaller environmental imprint. Despite its potential, Agriculture 4.0 faces numerous hurdles, including technological complexity, high adoption costs, data security and privacy concerns, insufficient infrastructure, digital literacy gaps, and ethical questions about automation and data ownership. Overcoming these challenges through collaborative stakeholder involvement and policy support is critical to ensuring equitable, responsible, and meaningful deployment of fourth-generation technology in global agriculture.

KEY WORDS: Agriculture 4.0, Agricultural revolution, IoT, Challenges

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INTRODUCTION:

The Internet of Things, artificial intelligence, and nanotechnology are all becoming more popular as part of Agriculture 4.0. In addition to having a major effect on value chains and agriculture, it has altered the industrial process. To improve output quality and create pest-resistant seeds, the farming sector is implementing genome editing, smart breeding technology, and digital AI-based approaches in conjunction with microbial soil mapping. To protect important data, one of the core IoT security principles is to monitor data flow using encryption techniques. This is accomplished by using AI-based security tools to identify warning signs of questionable activity instantly and by encrypting data on the blockchain to guarantee its accuracy (Abbasi, R. et al., 2022).

Over the past few decades, farming has experienced numerous technological advancements, becoming more industrialized and reliant on technology. By using intelligent agricultural technologies, farmers have increased their control over crop growth and animal production, making these processes more efficient and predictable. This has helped smart farming technology proliferate over the world, along with the growing demand for farm products from consumers. One revolutionary force that will have a big impact on the sector is the sector 4.0 movement. The campaign is built around a number of digital technologies, including as artificial intelligence, big data, and the Internet of Things, as well as digital behaviors like open innovation, mobility, and teamwork. The ability to collect, use, and share data remotely is where Agriculture 4.0's real potential for higher productivity lies, beyond the introduction of new tools and processes (Araújo, S. O.et al., 2021).

AGRICULTURE 4.0

Robots, cloud computing, artificial intelligence, and the Internet of Things are few examples of emerging technologies that have the potential to completely change farming and make the shift to Agriculture 4.0 seamless. These technologies have a wide range of uses; smart farming techniques are being used to increase the efficiency of herbicide, pesticide, and fertilizer applications. While farmers are using robots to help milk their animals and remove weeds, drones are being used to help detect weeds. In order to cultivate more efficiently and accurately predict the results, farmers employ agriculture 4.0 technologies. Technology can benefit nearly every aspect of agriculture, including planting, seeding, and harvesting (Abbasi, R. et al., 2022).

1. AGRICULTURE 4.0 CORE TECHNOLOGIES

Although the use of data in agriculture is not a new notion, the uniqueness is the

possibility of sector digitization. Another consideration is the quality of information obtained at the farm level, as well as the technology utilized to gather, store, process, manage, and communicate that data. Sensor technology advancements have enabled farmers to monitor certain factors in real time, while robotics have helped to automate procedures more effectively. Furthermore, computational power has become more accessible and affordable, facilitating the development of new decision-support technologies for improved agricultural management. For example, big data supports large amounts of real-time and historical data, and AI-based approaches translate this data into added value and actionable knowledge (Weltzien, C., 2016).

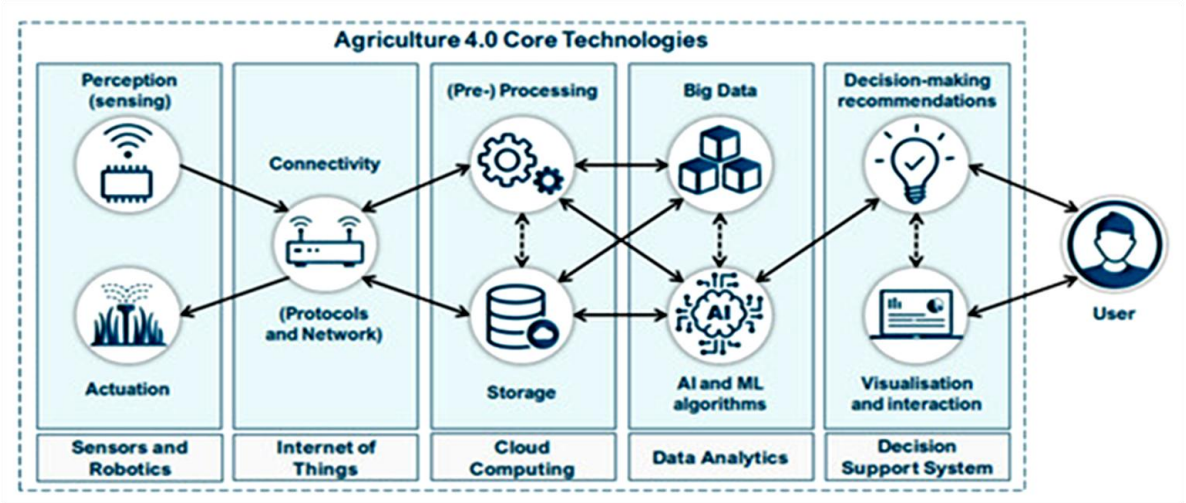

Figure 1: Data flow between the core technologies of the Agriculture 4.0 paradigm

A. SENSORS

Sensors are one of the primary drivers of the Internet of Things concept, thanks to technological advancements that allow them to be smaller, more intelligent, and less expensive. They serve an essential role in agricultural activities by collecting plant, animal, and environmental data, and they are a critical technology for IoT adoption in agriculture (Araújo, S. O.et al., 2021).

- **Remote Sensing**
- **Wireless sensor networks**

B. ROBOTICS

Robots have been used to automate some agricultural practices, including crop scouting (plant monitoring and phenotyping), planting and harvesting, water supply, target spraying, environmental monitoring, weed and pest control, disease detection, pruning, milking, and sorting (Ozdogan, B. et al., 2017).

C. INTERNET OF THINGS

IoT-designated devices have been used in agriculture for a number of years. The

majority of proprietary solutions involve devices that are integrated into agricultural machinery; as a result, the machine manufacturer has a direct influence on how these devices are used. Due to numerous initiatives aimed at open solutions that would resolve proprietary device compatibility difficulties, significant advancements in this field are anticipated soon.

D. CLOUD COMPUTING

A commercial Internet-based infrastructure, cloud computing offers a range of IoT applications hardware, infrastructure, platform, software, and storage services. Cloud computing has attracted a lot of attention in the agricultural industry in recent decades because it offers: (a) low-cost data storage services for text, images, videos, and other agricultural information, which significantly lowers storage costs for agricultural enterprises; (b) intelligent large-scale computing systems, which convert these raw data, which farmers' technical level makes it difficult to use and make decisions on into knowledge, from which they can then make decisions based on quantitative analysis; and (c) a secure platform for the development of various agricultural Internet of Things applications.

AGRICULTURE 4.0 APPLICATIONS:

Several innovation opportunities brought by Agriculture 4.0 can be observed in heterogeneous domains across the entire AFSC. These application domains can be classified into four main categories, as illustrated in Figure 2: (a) monitoring (Section 5.1); (b) control (Section 5.2); (c) prediction (Section 5.3); and (d) logistics (Section 5.4). Despite this variety, one common characteristic is that this innovation stems from the recent developments in disruptive technologies such as IoT, sensors technology, robotics, cloud computing and AI. Additionally, while these domains appear separately, in fact they are closely linked. For

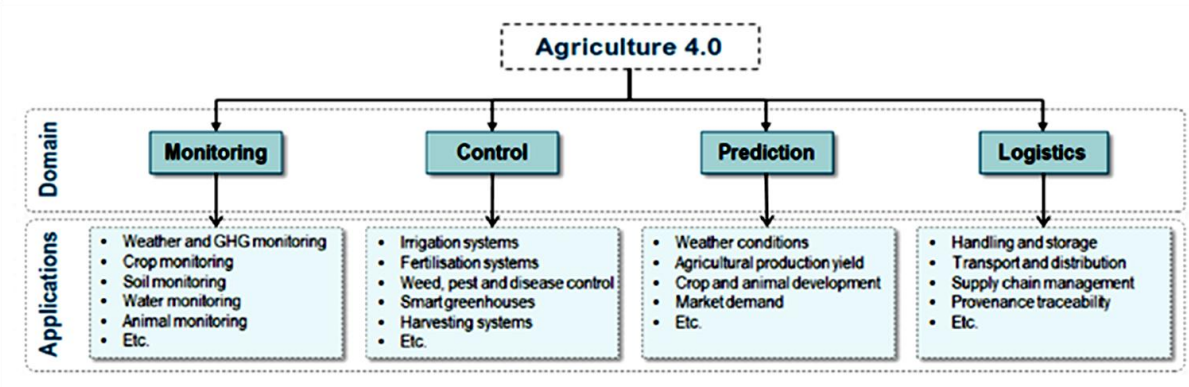

Figure 2: Distribution of Agriculture 4.0 applications domains and respective examples of applications (Sub-Domains)

instance, a smart control system actually requires monitoring and possibly forecasting functionalities to fully leverage the potential of data-driven support systems (Rose, D. C. et al., 2021).

CHALLENGES AGRICULTURE 4.0

Despite the many advantages that the realisation of Agriculture 4.0 could bring, there are still several open issues and challenges (Araújo, S. O.et al., 2021).

making. These technologies have a wide range of applications, including precision irrigation and soil monitoring, automated harvesting, supply chain traceability, and predictive yield modeling, all of which contribute to increased productivity, sustainability, and resilience in food systems.

Despite its potential, Agriculture 4.0 faces many hurdles, including high implementation costs, low digital literacy

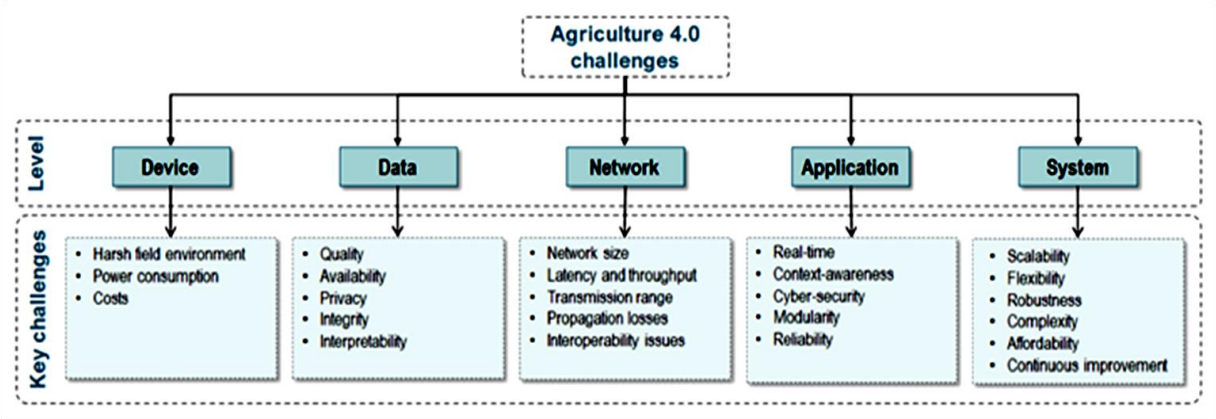

Figure 3: Some of the key challenges to be addressed in Agriculture 4.0 divided into five levels

CONCLUSION:

Agriculture 4.0 is a watershed moment in farming, with digitization, smart technologies, and data-driven breakthroughs reshaping the entire agricultural ecosystem. Agriculture 4.0 is powered by technologies such as the Internet of Things (IoT), artificial intelligence, drones, robotics, geographic information systems (GIS), sensors, blockchain, and big data analytics, which allow for precision farming, resource optimization, and climate-smart decision-

among farmers, insufficient rural infrastructure, data privacy concerns, and the risk of expanding the divide between smallholders and large-scale farmers. Addressing these limits is critical to ensuring that technological developments result in inclusive, egalitarian, and sustainable growth. Ultimately, Agriculture 4.0 has the potential to revolutionize global agriculture, but its success is dependent on balancing technical innovation with accessibility, affordability, and farmer empowerment.

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