"Revolutionizing Agriculture with Artificial Intelligence"

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Abstract

Artificial intelligence (AI) is driving an incredible revolution in agriculture, one of the most important and ancient businesses. Farmers may maximise resource utilisation, cut expenses, and boost yields by implementing AI-driven technologies including precision farming, predictive analytics, automated equipment, and smart irrigation systems. The paper examines how artificial intelligence (AI) technology is changing agricultural methods, increasing production, and tackling some of the industry's most important problems. Artificial Intelligence is also used in agriculture to enhance supply chain management, identify plant diseases early, and facilitate improved decision-making through insights from data. This revolution intends to provide food security for an expanding global population and make farming more sustainable and efficient. This paper highlights how Artificial intelligence can transform agriculture, addressing issues related to global food security and providing predictions for the sector's future. Artificial intelligence can be used in agriculture more widely, the article highlights the significance, methods of AI, and several obstacles and issues. The outcomes provide the groundwork for future studies in this promising subject and advance our knowledge of AI's transformational potential in the area of agriculture.

Keywords- *Artificial Intelligence, Revolution, Transform agriculture*

Introduction

By 2050, it is predicted that there will be around 10 billion people on the planet, which will increase agricultural order in an environment of modest financial development by about 50% as compared to 2013. FAO (2017). Agriculture has played a significant role in the development of civilizations, although it has been a gradual one. Civilization acquired the skill of agriculture a very long time ago, which led to the establishment of farming as a settled way of life and development. Agriculture enabled them to produce and store excess food for use during the lean season, which finally made it easier for them to live near their property.[1]

One of the most important issues facing the globe today is still agriculture. The need for food has increased as a result of population growth. It is estimated that to meet these demands, 70% more food would need to be produced. Finding innovative solutions to increase agricultural productivity sustainably, fortify the global food supply chain, reduce food waste, and ensure that no one goes hungry or malnourished must thus be the top priority. [2]

To improve the sustainability, resilience, and inclusivity of our food and agricultural systems, technological interventions are now essential. It is now crucial to approach sustainable agricultural practices and food systems from an integrated, comprehensive perspective.

In places where food scarcity is already a problem, population growth is most noticeable. Food surpluses cannot be shipped as a long-term solution. As a outcome, it is crucial that technology progress and that this technology be applied

in all nations to maintain and ensure food security. Countries can produce food with improved quality and yields through agricultural technological advancements. [3]

Agriculture has been and will be the backbone of the Indian economy. Additionally, it makes for 11% of the country's exports and 18-19% of its GD& GVA 3.3 % as per the Ministry of Statistics & Programme Implementation (MoSPI). The country is one of the largest producers of agriculture and food products in the world. In India Agriculture industry growth rate was foreseen to be 3.5% in 2022–2023 after being 3% in 2021–2022.

For 2022–2023, the gross value added (GVA) in agricultural and related industries increased by the planned 4%. It is anticipated that the agriculture sector's first advance estimate of GVA for 2023–2024 would be 5.5%. [4]

The nation grows a wide variety of crops and food grains, including dairy products, fruits, rice, wheat, pulses, seeds, coffee, sugarcane, jute, tea, tobacco plant, and peanuts. In 2022–2023, 1,374.9 million tonnes of tea were produced in India. 352.0 million tonnes of coffee produced throughout the time. While the production of other goods, including sugarcane, wheat, rice, maize, legumes, and mustard, hit a record high. In Assam, Andhra Pradesh, Karnataka West Bengal, Uttar Pradesh, Punjab, Gujarat, Haryana, Madhya Pradesh, and Chhattisgarh these states produce the most crops. [5]

The states of Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, and Gujarat harvest most of the country's wheat. With almost 48% of the country's sugarcane produced, Uttar Pradesh leads the other two states in India, Maharashtra and Karnataka with 23% and 9% of the total, respectively. (Statistics by RBI & IBEF-2024)

Significance of AI in Agriculture

It would be logical and proper to place more of an emphasis on the agriculture sector. In countries like India, the agricultural sector employs half of the labour force and generates 18% of the country's GDP. Growth in the agriculture industry will encourage rural development, which will then result in rural transformation and, eventually, structural change. For all industries, including agriculture, NITI Aayog believes that Al solutions are essential.

Al machines can provide farmers with information about soil quality as well as other agricultural-related information, such as when to plant, where to use herbicide, and where to look for insect outbreaks. If Al systems can advise farmers on effective techniques, India could witness a revolution in farming. It is challenging to scale up such a potential scenario to include the entire value chain while considering cost and capacity reduction. [6]

A significant portion of the Indian economy 60% of families rely directly or indirectly on agriculture for their means of livelihood, making it a high-priority sector. The industry is currently at a critical crossroads due to a great deal of hardship facing it overall. The results attained in this field have been localised and have not been scaled up to an appropriate degree, even if the use of digital technology could potentially some of the issues. [7]

The business strategies of numerous agri-tech companies have used artificial intelligence (Al)-related technologies, including computer vision, robots, and machine learning, in the recent past. AI applications has the capability to lower costs for serving smallholder farmers through the agriculture ecosystem, improve the sustainable and efficient use of resources, and remove market inequalities that keep farmers from participating in regional and global value chains. Examples of these applications include "smart" farm equipment and alternative credit scoring systems.

Agri-tech companies are now able to use AI technologies in their products on a commercial scale and advancements in big-data analytics, increased computing power, cloud-based storage, and other related technologies. Additionally, costs associated with satellite imagery, remote sensors, and other related technologies have decreased. With the current state of society, which includes decreasing manual labour,

a shortage of arable land, and a growing disparity between the world's food production and population, scientists have been working for years to develop and enhance artificial intelligence as one of the most likely solutions to these problems. Al's social situation, which includes a decline in physical labour, a reduction in the amount of cultivated land available, and a wider disparity between the amount of food produced globally and the population of the planet, is the reason for this.

Applications of the Internet of Things (IoT) in Agriculture

According to the Economic Survey 2022–2023 agritech businesses raised over Rs 6,600cr. from private equity investors over the last four years, growing at a rate of more than 50% annually. As per the Survey, there are nearly more than 1,000 agritech businesses that help farmers enhance their farming methods. Farmers who use solar energy or other clean energy sources for irrigation are gradually coming around to the idea of climate-smart farming. Farmers have received incentives to feed electricity produced by solar power into the community grid. Drones and artificial intelligence have been used to start crop yield prediction models that monitor crop health and soil conditions, according to the Survey. Crop variety is another benefit of smart farming, which would lessen farmers' reliance on the monsoon for water. [8]

Innovative farming Practices with AI

1. Precision Agriculture

Precision agriculture is considered as a management technique that involves gathering, processing, and analysing time-based, spatial, and individual data by the International Association for Precision Agriculture, which claims to be the only international scientific association solely devoted to the field of precision agriculture. In order to support management decisions based on predicted variability and improve resource utilisation efficiency, productivity, quality, profitability, and sustainability in agricultural production, this data is then combined with additional data.

2. Agriculture Using Blockchain Technology

Blockchain technology is entering the agricultural industry by enhancing supply chain traceability and transparency. Blockchain technology can be used by farmers, distributors, and buyers to maintain an unchangeable, safe record of all agricultural commodity transactions. This reduces the risk of fraud, guarantees the authenticity of food goods, and empowers customers to make knowledgeable decisions about the source and quality of their food.

3. Smart Farming

This term describes a new approach to farm management that optimises the amount of labor needed for output while increasing productivity and quality through the use of loT, robotics, drones, and artificial intelligence (Al). A networked and automated agricultural ecosystem made up of sensors, actuators, and intelligent equipment that gathers and exchanges data in real time is formed through the combination of Internet of Things (IoT) devices and connections in smart farming.

4. Vertical Farming and Controlled-Environment Agriculture (CEA)

As urbanisation rises, vertical farming and controlled-environment agriculture (CEA) are gaining popularity. These cutting-edge techniques include cultivating crops in vertical stacks or in controlled environments like hydroponic systems or greenhouses.

It allows minimal land and water usage and provides a sustainable solution to urban regions and the environment.

CEA encompasses the techniques for controlling environment condition.

While limiting the negative effects of traditional agricultural operations on the environment, vertical farming maximises land use efficiency. With artificial lighting, climate control, and fertiliser solutions, farmers can create the perfect environment for plant growth throughout the year. [9]

Digital Farming Methods

1. Precision Agriculture Technologies:
GPS technology is essential to precision agriculture. Farmers can use it to accurately design their fields, which facilitates machine navigation and distributes resources appropriately.
2. Drones: Equipped with cameras and sensors for crop monitoring, drones capture high-resolution images of fields. Using this drone photography, farmers can identify areas of concern, such as pest infestations, fertiliser deficiencies, or water stress. Drones enable fast and efficient surveying of large areas.
***3. Smart Irrigation System*:** Smart irrigation systems employ soil moisture sensors to determine when and how much water crops need. This prevents over-irrigation, safeguarding water resources, and improving crop health. Automated irrigation systems can be remotely controlled through mobile or online applications.
4. Variable Rate Technology (VRT): This allows inputs to be applied to a field at various rates, including fertiliser, herbicides, and water. This approach considers the geographical variability of crop and soil conditions to ensure that resources are applied precisely where and when they are needed.[8]
***5. Automated Technology*:** Planting, harvesting, and plowing can be done by autonomous tractors and harvesters, which are equipped with GPS and sensor technology to do tasks without the need for direct human help. This reduces staff costs while also ensuring accuracy in farming operations.
***6. Machine Learning*:** Machine learning algorithms use historical and present data (crop prediction models) to estimate crop yields, disease outbreaks, and market trends. With these predictive analytics, farmers can now anticipate situations and adjust their strategies proactively.

***7. Data-driven Farm Management*:** Digital platforms and software tools help farmers handle various aspects of their operations. These devices often incorporate data from multiple sources, including weather forecasts, soil conditions, and crop health. Farmers may confidently plan their planting, irrigation, and harvesting activities by using farm management software.
***8.Robots for Agricultural Operations*:** More and more robots are being used for agricultural tasks. These self-driving cars can traverse fields, efficiently gathering crops or identifying and getting rid of weeds. Robotics increases efficiency while reducing the demand for manual labour.
***9. Digital Twins*:** These tools build digital copies of real farms. This enables farmers to test and refine different scenarios prior to putting changes into practice in the real world. Effective resource management and planning are made possible by digital twins.
***10. Blockchain*:** Blockchain technology has the potential to make supply networks safer and more transparent. From planting to distribution, every stage of the agricultural supply chain may be tracked via a blockchain. This encourages consumer confidence in the provenance and calibre of agricultural products in addition to guaranteeing traceability.

India is aiming to utilise technology to its full potential in order to gain benefits for society and the economy. It also recognises agriculture as a crucial industry for the application of Al-driven solutions. Over the past ten years, "Agriculture 4.0" has become more popular in the farming community. [10]

Challenges and barriers

Numerous obstacles and problems prevent artificial intelligence (AI) from being widely used and effectively integrated into agriculture. High costs are a major barrier because putting AI technologies into practice necessitates large investments in infrastructure, software, and hardware, which can be out of reach for small and medium-sized farms.
Furthermore, a significant skill gap exists between farmers and agricultural labourers, who frequently lack the technical know-how to run and maintain AI systems. This need for extensive training and educational

initiatives. The availability and quality of data provide additional difficulties.

Artificial intelligence (AI) systems require vast volumes of precise data, which can be hard to gather and guarantee, particularly in areas with poor access to technology.

Issues regarding compatibility and maintaining interoperability among various AI technologies can be difficult and expensive, which presents additional obstacle to integration with current systems.[11]

In addition, a lot of rural places don't have consistent internet access, which is necessary for AI technologies to perform at their best. The massive amount of data collecting mandated by AI raises ethical and privacy concerns, bringing up issues with data security and the possible effects on employment and social equity.

Barriers related to rules and policies also matter, strict regulations may hinder innovation, while the absence of encouraging policies and incentives from the government discourages adoption. The situation is further complicated by resistance to change within traditional farming communities, which is motivated by a preference for tried-and-true methods and a lack of knowledge about the advantages of artificial intelligence. [12]

It is also necessary to consider sustainability and environmental impact issues, so that AI technologies support resource conservation without having a negative long-term influence on the environment.

Ultimately, scalability and adaptation are serious issues because AI solutions need to

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be flexible enough to adjust to local climate and farming practices and scalable to larger enterprises. To fully achieve AI's potential to revolutionise agriculture, these complex difficulties have to be focus.

Conclusion

The integration of artificial intelligence into agriculture is a new era of efficiency, productivity, and sustainability. By adopting AI technologies, farmers can enhance crop yields, reduce waste, and make informed decisions that enhance their operations. This revolutionary approach not only addresses the challenges of modern agriculture but also paves the way for a more resilient and resource-efficient future. As AI continues to evolve, its impact on agriculture will undoubtedly grow, fostering innovation and driving progress in agripreneurship across the globe.

The acceptance of innovative digital farming techniques marks a significant turning point in the history of agriculture. Digital farming is the application of an all-encompassing strategy that combines many technologies to enhance productivity, sustainability, and efficiency in agriculture. Farmers can now meet the needs of a growing world population, produce more with fewer resources, and have a smaller environmental impact. As long as the agricultural industry takes these advancements and develops sustainable ways to feed the world in the years to come, farming seems to have a bright future.

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