THE DYNAMIC ROLE OF ARTIFICIAL INTELLIGENT (AI) IN MODERN AGRICULTURE

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INTRODUCTION

Agriculture has long been the foundation of human civilization, serving as the primary source of food and livelihood for the majority of the world's population. In the ancient time, Indian subcontinent was the largest producer of food grains in the world. However, in recent years, there has been no considerable increase in crop production in the agriculture sector. Furthermore, food prices are rapidly rising as crop production fails to meet the demand of accelerated population. One of the root causes of the drop in agricultural production is traditional way of cultivation. Such practices are time-consuming, labor-intensive and apply nutrients inappropriately, which leads to deterioration of soil health and decline in crop yield. Farmers of our country are not well aware of the advance technologies available for soil testing, crop monitoring, yield estimation and predicting the probability of weather phenomena throughout the cropping season. An interdisciplinary field of study called Artificial Intelligence (AI) aims to replicate human intelligence in robots that resemble human cognition and behaviors, including learning and problem-solving. Recently, AI technology has extensively been used by the research scientists and extension specialists to address problems in agriculture productivity. The introduction of AI in agriculture accompanied by other technological advances including data analytics, robotics, availability of cheap sensors and cameras, drone technology, and even wide-scale internet coverage on geographically dispersed fields will uplift the present day agriculture to a new height. By analyzing soil management data sources such as temperature, weather, soil analysis, moisture, and historic crop performance, AI systems will be able to provide predictive insights into selection of crop for a particular season, sowing time, inter-cultural operation, time of harvesting and forecasting commodity prices; thus improving crop yields, farmers income and increase the use efficiency of water, fertilizers, and pesticides.

APPLICATIONS OF AI IN AGRICULTURE

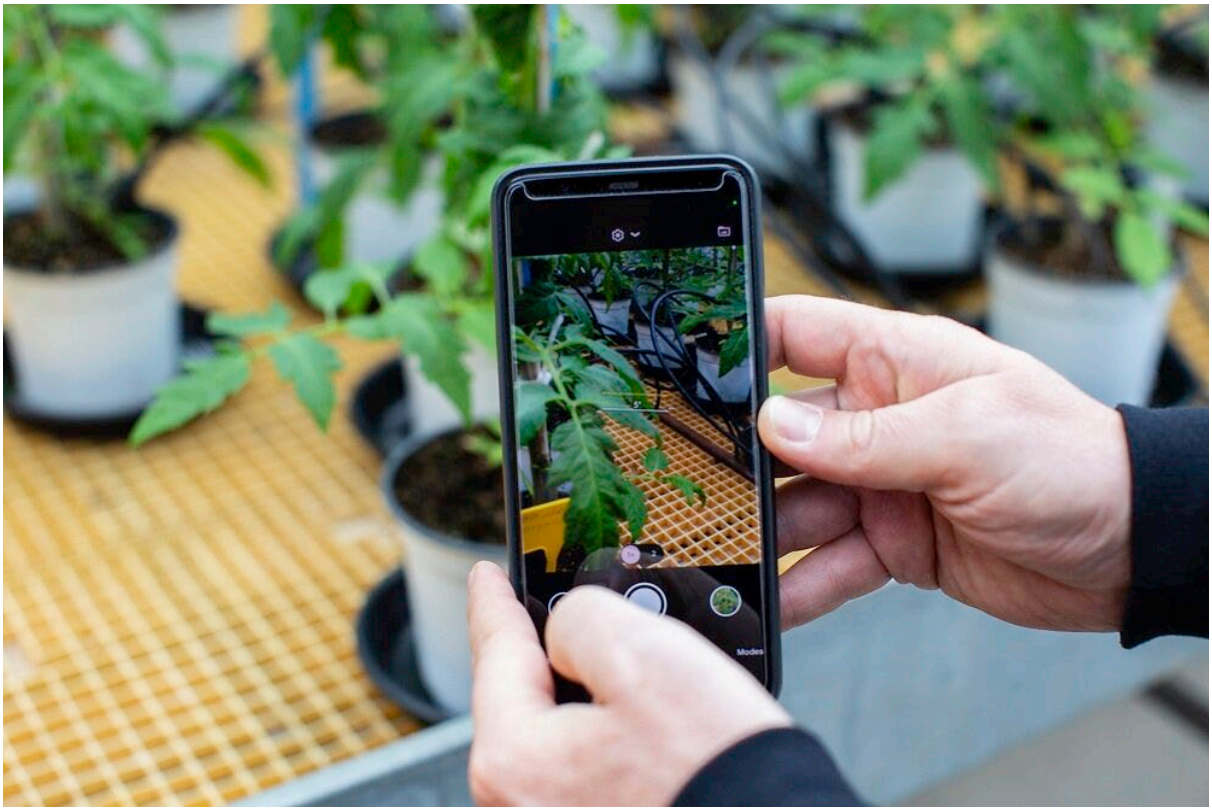
AI in agriculture will examine multiple data sources, including weather, soil, crop performance, and temperature to help with improved predictive insights (Fig 1). Quick plant phenotyping, agricultural monitoring, analysing soil composition, predicting weather and yield are made easier using machine learning.

Prediction of weather

Farmers can achieve great success with the AI-powered solution in reducing crop losses and helping them adjust to climate change. AI model uses diverse data sources for analysing temperature, humidity, wind speed, and atmospheric pressure in order to predict critical weather phenomena like rainfall, storm, cyclone etc. that provides advance weather information and warnings for farming activities such as sowing, irrigation, pesticide application and harvesting (Dewitte et al. 2021).

Soil management

One of the most vital components of a productive agricultural system is a healthy soil. Key soil parameters such as moisture content, nutrient levels, pH, and microbial activity can be continuously monitored by AI-powered devices, which can also offer real-time insights. This aids farmers in putting into practice sensible soil management techniques such as crop rotation, green manuring, in-situ residue management and cover crops to improve soil structure, fertility, and water retention. AI techniques like machine learning and remote sensing are also utilized



for soil mapping and classification, aiding in the identification of soil types, spatial variability, and land suitability assessment (Plaza et al. 2019).

Weed management

Utilising robots, computer vision, machine learning, and other technologies, AI detect, track, and manage weeds in agricultural fields. These systems have a high degree of precision in identifying weeds, which makes it possible to apply herbicides selectively or remove them mechanically. This minimises the need for large-scale chemical use and its negative effects on the environment (Gerhards et al. 2022).

Pest and disease management

Insect pests and diseases infestation is one of the most alarming problems in agriculture that leads to heavy economic losses. AI technologies used to detect serious pests and diseases of crop in advance, track them and helps early adopting treatment measures by utilising a variety of approaches, including machine learning, computer vision, and data analytics. This lessens the impact on the environment and raises agricultural productivity by enabling more accurate and effective pesticide application. AI also makes it possible to create intelligent monitoring systems that can continuously evaluate the risks posed by diseases and pests, giving farmers access to real-time information for preventative management plans (Demirel and Kumral 2021).

Decision making

AI algorithms helps farmers and stakeholders make informed decisions through predictive analysis of historical data, precision farming, crop monitoring, supply chain optimization, decision support systems and risk management. These systems assist farmers in optimizing agricultural practices, such as planting schedules, irrigation management, fertilization strategies, and pest control measures, to maximize crop productivity while minimizing resource inputs and environmental impacts.

Precision agriculture

Artificial Intelligence facilitates precision agriculture by evaluating information from satellites, drones, sensors and other available data sources to track weather patterns, crop health, and soil conditions. AI applications in agriculture, including irrigation, weed control, and spraying, aid in minimizing the overuse of water, pesticides, and herbicides. This not only conserves resources but also maintains soil fertility, ultimately enhancing both productivity and the quality of harvested goods (Bhat et al. 2021).

Yield prediction

AI algorithms analyse historical data, real-time data and multi-sensor data fusion from various sources, such as satellite imagery, weather data, and soil moisture sensors, to develop a comprehensive yield prediction model. This help farmers seasonal crop planning and predict yield in advance based on the local agro-climatic condition.

Aquaculture management

Artificial Intelligence is used in aquaculture to track fish behaviour, feed consumption, and water quality. AI-powered solutions can enhance general farm management procedures, identify symptoms of illness or stress in fish, and optimise feeding regimens.

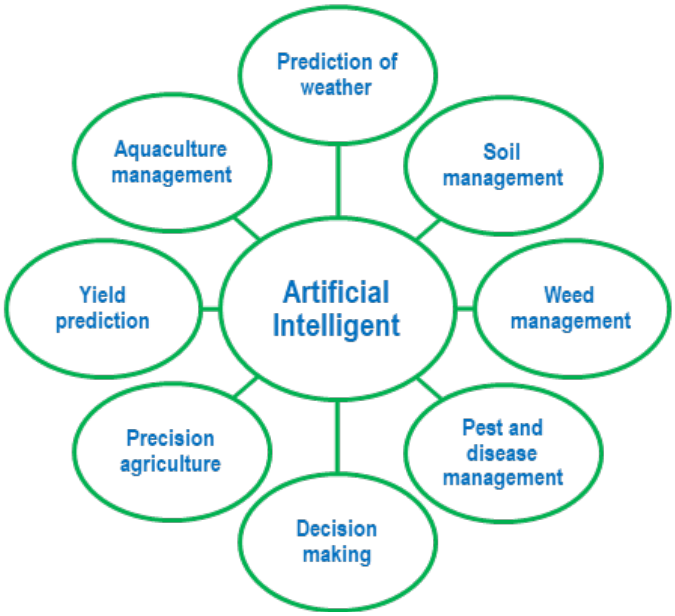
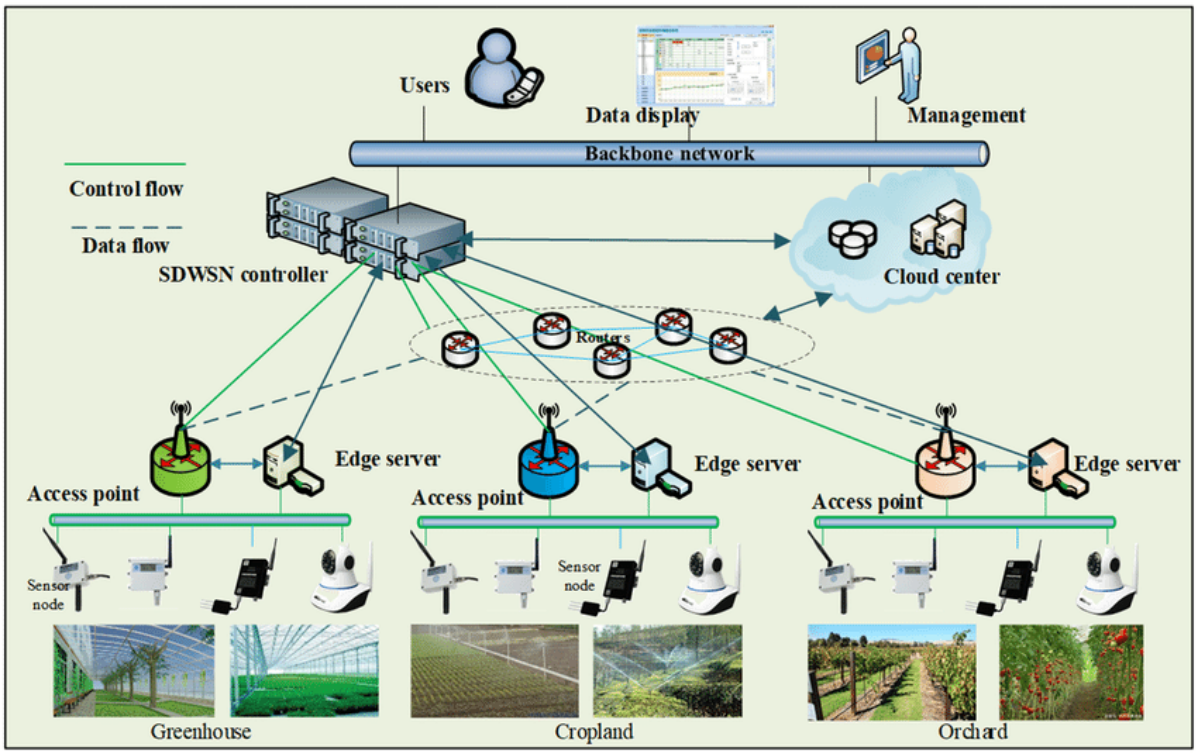


Fig 1. Various application of AI in agriculture

PROCESS OF ARTIFICIAL INTELLIGENCE IN AGRICULTURE



1. **Data collection:** Gathering data from various sources, such as weather stations, satellites, drones, sensors, and farm equipment, is the first step in the process (Fig 2).
2. **Data pre-processing:** The collected data needs to be cleaned up and pre-processed in order to remove errors, noise, and inconsistencies. This is done by filtering out of context data, addressing missing values, and normalising data for consistency.
3. **Feature engineering:** This involves extracting and modifying relevant variables (features) from the dataset in order to improve the performance of AI models.
4. **Model development:** Depending on the nature of the problem and the data available, machine learning or deep learning approaches are used to construct AI models.
5. **Model training:** This figure out the patterns and relationships in the data, the generated models are trained using either labelled (supervised learning) or unlabelled (unsupervised learning) data.
6. **Monitoring and maintenance:** This ensures the AI model keeps operating at its best, it must be routinely observed once it has been deployed. This could entail keeping an eye on end-user feedback, model performance, and data quality.

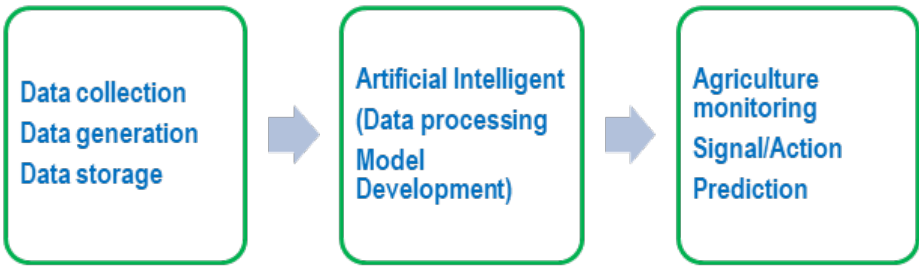
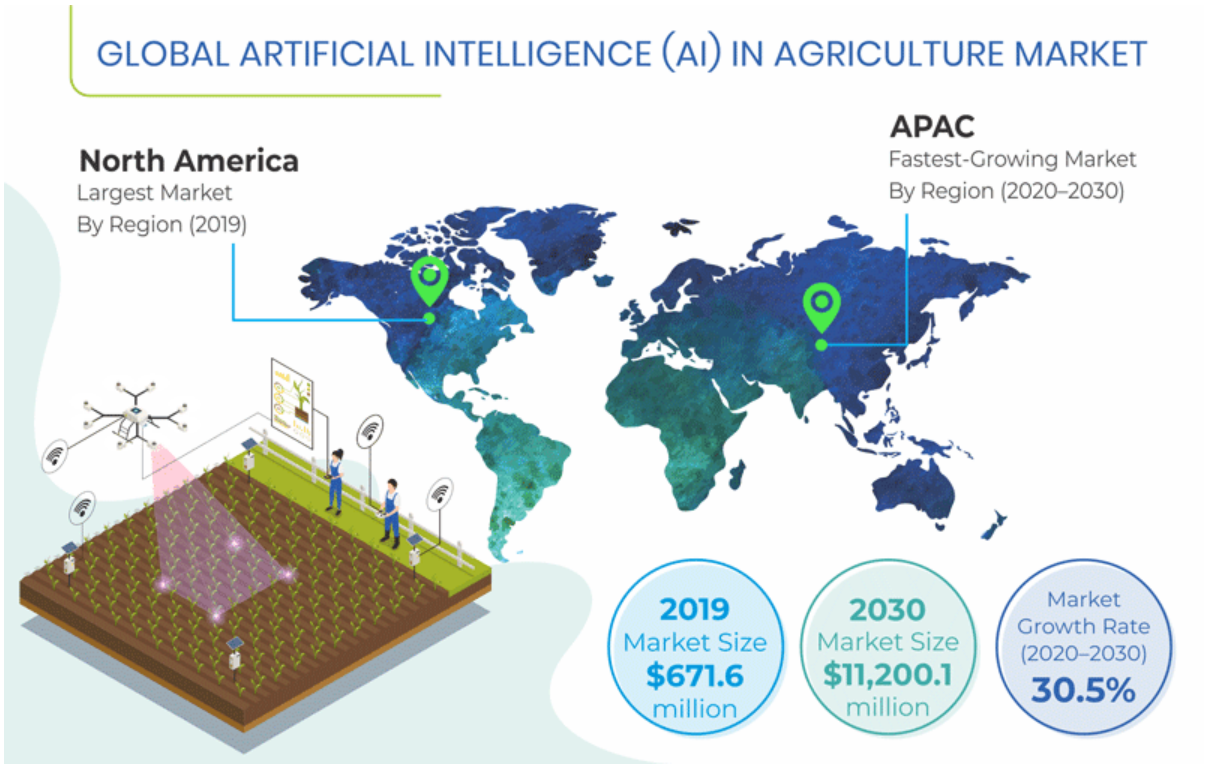


Fig 2: Process of Artificial Intelligence in agriculture

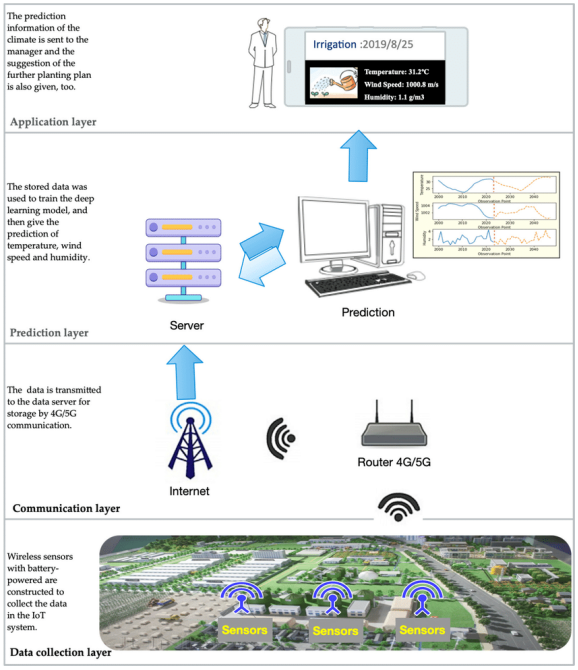
CHALLENGES IN AI ADOPTION IN AGRICULTURE



Although AI presents immense opportunities in agriculture application, there still prevails paucity in familiarity with advanced high tech machine learning solutions in farms around the world.

- **Response time and accuracy-** Artificial Intelligent not able to response in time or accuracy, or even both in some cases. The user's choice of task strategy is impacted by a system delay.

- **Big data required-** An enormous amount of data must be monitored by a real-time AI system. The bulk of the incoming data must be filtered away by the system.
- **Method of implementation-** As it uses big data, precise definition of the training and looking-up procedure is necessary to ensure accuracy and speed.
- **High data cost-** Because the majority of AI systems are internet-based, their use is limited, especially in rural or isolated places.
- **Flexibility-** AI shows narrow focus, data dependency it has difficulty with unforeseen situations, limited understanding of context, difficulty with abstraction and reasoning and vulnerability to adversarial attacks.



CONCLUSION

Artificial Intelligence will play a major role in farming in the future. The application of artificial intelligence in agriculture has the potential to revolutionise resource management, crop cultivation, and the sustainable provision of food for the world's expanding population. Agriculture may become more productive, robust to environmental difficulties, and efficient by utilising AI technologies. Precision agriculture methods that maximise resource allocation, minimise waste, and lessen environmental effect are made possible by AI-driven solutions. Artificial Intelligence (AI) improves every step of agriculture, from planting to harvesting and beyond, using data-driven decision support systems and autonomous robotic systems.