TRANSFORMING AGRICULTURE WITH ARTIFICIAL INTELLIGENCE (AI): A PROMISING FUTURE

ABHISHEK PATEL[1*], SHILPA S SELVAN[2], ASEEYA WAHID[1], D K YADAV[3], RAJESHWAR SANODIYA[1]

[1]ICAR-Central Institute of Agricultural Engineering, Bhopal Madhya Pradesh; [2]ICAR-Central Institute of Post-Harvest Engineering &Technology, RS Abohar, Punjab; [3]ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh

*Corresponding Author, E-mail: abhishekpatel2910@gmail.com

Agriculture plays a vital role in the economic sector of every country. The growing demand for food due to the global population increase poses a challenge to world agriculture since, traditional farming practices alone are not sufficient to meet the food demand in future. Consequently, new techniques have emerged to support the agri-food system, generating lucrative job opportunities in the agricultural sector. Artificial intelligence (AI) is one among those technologies that has transformed world agriculture. AI addresses many factors that affect agricultural sector, including climate change, population growth, employment issues, and food security. AI enables efficient crop production and real-time monitoring, empowering farmers with valuable insights and decision-making support (Barriguinha and Moysiadis, 2021).

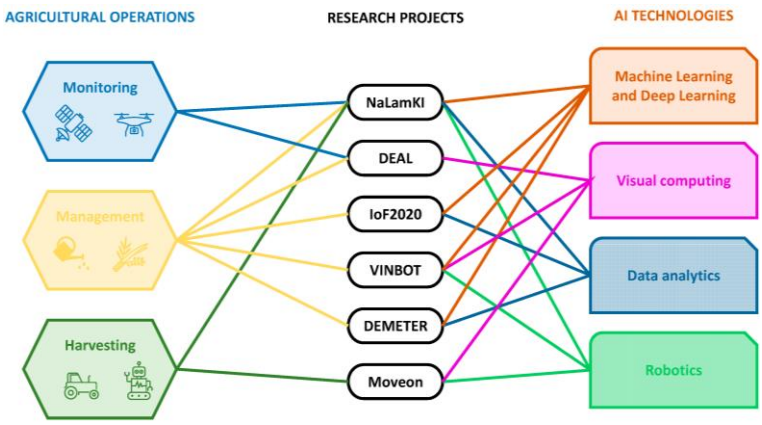

Figure 1. AI related technologies in research projects (Linaza et al., 2021)

The future of Indian agricultural sector relies on innovative ideas and technologies that increase yields with optimize resource use. Crop models and decision-making tools incorporating AI techniques are progressively being used in agricultural field to fulfil this target. AI provides tremendous scope to reform agriculture by integrating advanced technologies to forecast agricultural productivity and streamlining various aspects of crop management. The idea of AI techniques in crop management was first proposed in 1985 by McKinion and Lemmon in their paper 'Expert Systems for Agriculture'. Since then, the world has witnessed a steady development of agro-intelligent systems over the past four decades.

AI refers to the simulation of human intelligence in machines to think and imitate human behaviours such as learning and problem-solving. Machine learning, a subset of AI, is an outstanding tool for analysing, understanding, and identifying data patterns. It enables computers to automate tasks that are exhaustive or impossible for a human being. Machine learning algorithms leverage data to learn input-output relationships and make predictions or generate new datasets with least human intervention.

Deep learning, another subset of machine learning, involves the use of computer software that mimics the network of neurons in a human brain. It utilizes deep neural networks composed of multiple layers to learn from data, enabling machines to extract complex patterns and insights. Artificial Neural Network (ANN) and Fuzzy logic are examples of AI techniques based on the principles of deep learning. In this rapidly evolving era of AI in agriculture, machine learning, deep learning, and other AI techniques hold great promise to transform farming practices, enhance productivity, and optimize resource management. This article aims to explore the applications, benefits, and challenges of AI in agriculture, with a focus on its potential to improve crop management, disease and pest control, weed management, commodity price predictions, and real-time marketing information for agricultural products.

STRUCTURE OF ARTIFICIAL I IN AGRICULTURE

Through the means of precision agriculture (PA), information technology, robotics, and data integration play a vital role in crop management. They provide farmers with information on where, how much, how, and when to cultivate. These technologies optimize crop production and reduce environmental pollution.

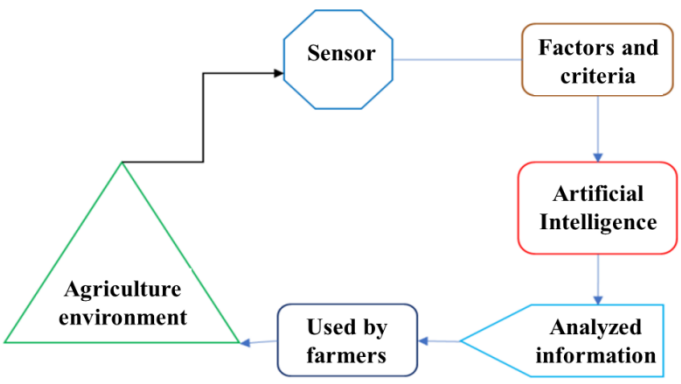

Figure 2. Illustration of significance of AI in agriculture

Sensors and wireless connectivity play a crucial role in collecting data, such as soil and environmental parameters, moisture, rainfall, irrigation, soil conductivity and pH, soil frequency, quality of rainfall, etc. These data can be transmitted wirelessly using communication devices (Wi-Fi, Bluetooth, and Internet). Software is used to analyze the data. Results of their analysis are utilized through agricultural management.

AI in agriculture is a computational brain that can be used to provide validation or mimicry of animal behavior. AI easily adopts things that are given by animals through computer logic. It helps in understanding the technical processes experienced by humans. Through the adoption of automation and robotics by worm science, AI can perform physical tasks based on features & knowledge perspective. Worm science has to perform many ambitious and long-term agricultural tasks such as coordinating disease management, crop harvesting, chemical usage, water management, etc. To understand these tasks, it is necessary to assist in human analysis of crops, soil, environment, and other factors. Based on these tasks, the following information can be obtained:"

AGRUCLTURE DEVELOPMENT IN INDIA THROUGH AI

According to estimates, investments in AI applications in agriculture reached nearly one billion US dollars globally in 2019. It is projected that by 2030, with a growth rate of 30%, this investment could reach up to eight billion US dollars. However, despite its potential, the Indian agricultural technology market is significantly behind, currently accounting for only 1% compared to the United States. The vastness, geographical diversity, and different types of farming in India make it a unique platform for opportunities in agricultural AI. Indian agriculture and farmers can not only contribute to the development of AI solutions in India but also on a global scale, providing extensive and rich data.

The diversity in size of farmlands, soil, and varied climates in India can provide valuable data to scientists for developing AI tools and other agricultural solutions.

Efforts from the Indian Government and its agencies in utilizing AI in agriculture sector (Moret al., 2021)

- Government and industrial sectors jointly working to develop AI-powered crop yield prediction model to provide better advice to farmers.
- AI-based tools are used to improve soil fertility and crop yield, prevent agricultural investment wastage, and predict pest or disease outbreaks.
- This system utilizes remote sensing data provided by ISRO, soil health card data, weather forecasting by India Meteorological Department, and soil moisture and temperature data analysis.
- This project is implemented in ten districts of Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh.

With increasing world population, scarcity of land for agriculture has emerged as a significant problem, which highlights the need for people with more creativity and skills in the agricultural sector. Despite many significant efforts in India since independence, agricultural sector still challenged with climate related uncertainties and lack of effective technologies. In this context, AI can be instrumental in increasing crop productivity through the efficient use of land resources amidst climate change and food security issues. Recently, 'Responsible Artificial Intelligence Summit 2020' (RAISE 2020), inaugurated by the Indian Prime Minister emphasized the vital role of AI in empowering agriculture, healthcare, education, and developing of foundational urban infrastructure for the next generation.

Applications of artificial intelligence (AI) in agriculture include automated farming, collection and processing of produce, seed and crop management systems, natural resource management, industrial agriculture, and more. Data obtained through AI helps in analyzing agricultural science, predicting production capacity, meeting documentation requirements, and making informed decisions regarding increased productivity, minimal air pollution, optimal use of water resources, appropriate farming techniques, disease prevention, and more.

APPLICATIONS OF AI IN INDIAN FARMING

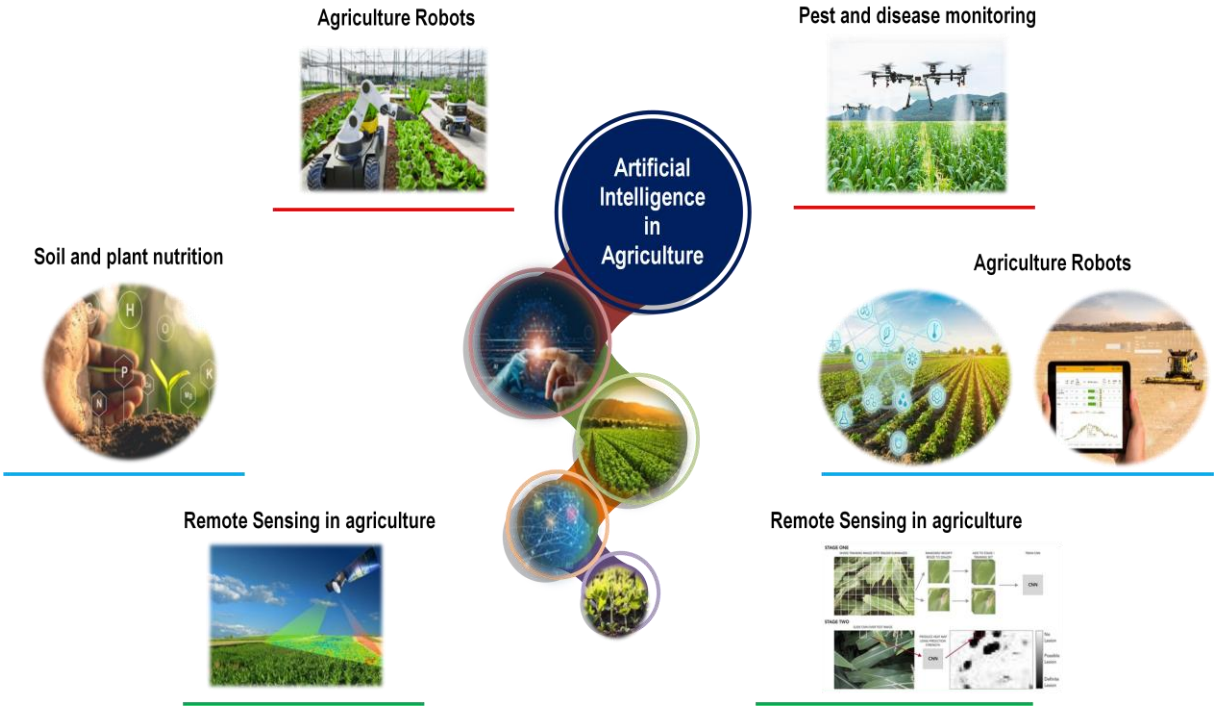

Figure 3. Applications of Artificial Intelligence in Agriculture (Eli, 2019)

AI-powered Crop Yield Prediction Models and Government Initiatives: To provide better guidance to farmers in India, work has begun on developing AI-powered crop yield prediction models. The Indian government has sought assistance from Indian Space Research Organisation (ISRO) for this purpose. The government, in collaboration with the industrial sector, has initiated the deployment of AI-powered crop yield prediction models in some districts of Assam, Bihar, Jharkhand, Madhya Pradesh, Maharashtra, Rajasthan, and Uttar Pradesh. This system uses data from remote sensing provided by ISRO, along with soil health card data, weather information from the India Meteorological Department, soil moisture and temperature data. Data collection part consists of pooling of information regarding crop phenotype or environmental factors such as weather, soil, crop management and yield data from various sources of different location (Figure 3). Proper feature engineering and selection techniques are also involved in the process of feature selection or extraction, then modelling is done with proposed crop yield prediction model and final predicted crop yield values are analysed with various machine learning techniques (Figure 4).

AI helps to conquer the challenges Indian farmers face in achieving accuracy in agriculture mainly due to the lack of information availability about weather, water, and soil moisture. This technology enables soil analysis to address nutrient deficiencies, crop monitoring and identification of water stress, infestation of pests and diseases etc. to ensure optimal crop productivity.

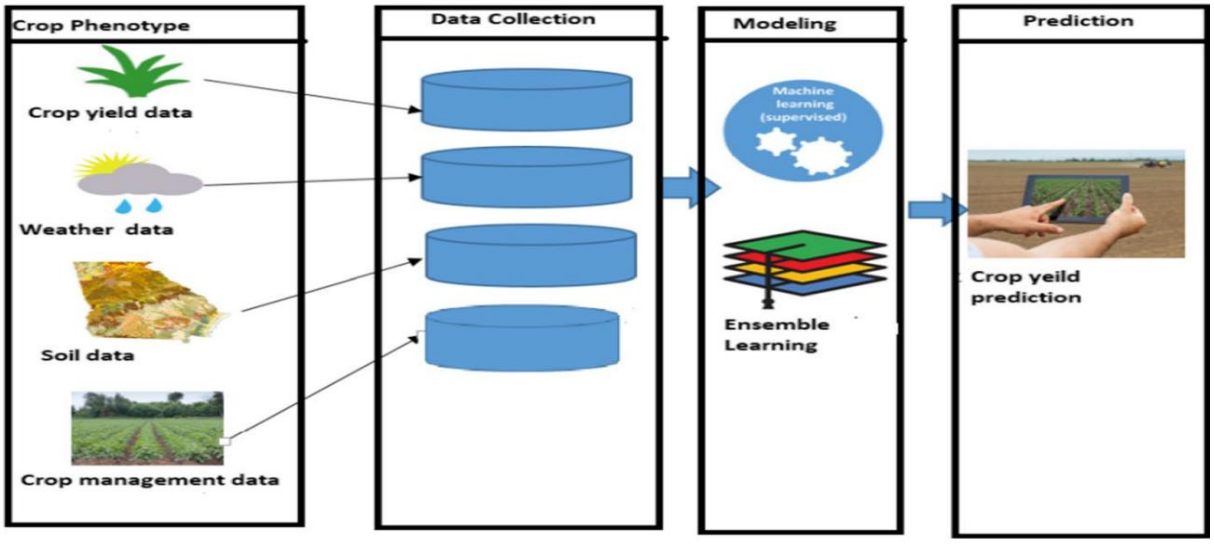

Figure 4. Architecture of crop yield prediction (Source: Inian and Jebakumar, 2021).

Crop Protection: AI sensors precisely identify pests, diseases and other indicators in growing crops through communication signals and data analysis. It ensures farmer's timely action to protect the crop. Here, reduced use of agricultural chemicals helps minimizing their adverse effects on environment and human health.

In diagnosing plant diseases using AI predictions, first, pre-processing of plant images is done using computer vision techniques. This ensures that the plant images are properly segmented into diseased and non-diseased parts. After detection, the diseased portion is cropped and sent to laboratories for further diagnosis. This technique can also help identify pests, nutrient deficiencies, and various other problems. Figure 5 depicts the general steps involved in AI based plant disease identification.

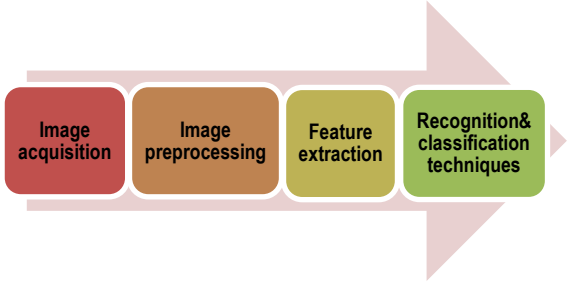

Figure 5. Steps involved in plant disease identification using Artificial Intelligence

Automated Farming: Integration of AI and robotics in automated farming enhances efficiency and assist safe working of machines in the field. Automated system helps achieving higher yields saving time and labor.

Quality Monitoring of Products: AI and analytical tools can be used to determine the quality of products, leading to improvements in their sales. Additionally, it aids in setting appropriate prices for products.

Efficient Water Management: AI ensures timely availability of water to the crop in specific quantity after analysing the water requirement of the crop at specific growth stages. This promotes conservation of water and reduces water wastage.

Market Analysis: AI can be utilized for the market analysis and marketing, providing farmers with valuable information for better sales of their products.

CONCLUSION

Overall, future progress of AI in agricultural machinery will depend largely on the adoption of AI solutions in a significant portion of agricultural practices. While some research advancements have been made at a larger scale, and some applications are already available in the market, the agriculture industry is still largely dependent on traditional expectations. Additionally, the process of developing predictive solutions to address real challenges faced by farmers in agriculture is still in its early stages.

REFERENCES

Barriguinha, A. and Moysiadis, T. 2021. Data-Driven Artificial Intelligence Applications for Sustainable Precision Agriculture. Agronomy 2021, 11, 1227.

Selvaraj, M. G., Vergara, A., Ruiz, H., Safari, N., Elayabalan, S., Ocimati, W. And Blomme, G. 2019. AI-powered banana diseases and pest detection. *Plant methods*, *15*, 1-11.

Eli Chukwu, N. C. 2019. Applications of artificial intelligence in agriculture: A review. *Engineering, Technology & Applied Science Research*, *9*(4).

Mor, S., Madan, S. and Prasad, K. D. 2021. Artificial intelligence and carbon footprints: Roadmap for Indian agriculture. *Strategic Change*, *30*(3), 269-280.

McKinion, J.M. and Lemmon, H. E. 1985. Expert systems for agriculture. *Computers and Electronics in Agriculture* 1(1), 31-4

Linaza, M. T., Posada, J., Bund, J., Eisert, P., Quartulli, M., Döllner, J. and Lucat, L. (2021). Data-driven artificial intelligence applications for sustainable precision agriculture. *Agronomy*, *11*(6), 1227.

***