TRANSFORMING AGRICULTURE WITH THE POWER OF ARTIFICIAL INTELLIGENCE

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Agriculture is a fundamental pillar supporting the sustainability of any economy and facilitating structural transformation. Earlier agricultural activities used to focus on food and crop production but in the past two decades, they have expanded to include processing, manufacturing, marketing, and distributing both crop and livestock products. In light of the ongoing global population growth, it is crucial to reassess agricultural practices with the goal of offering innovative approaches to sustain and enhance agricultural activities. The integration of artificial intelligence into agriculture is made possible by various technological advancements, such as big data analytics, robotics, the Internet of Things, the availability of affordable sensors and cameras, drone technology, and widespread internet coverage across geographically dispersed fields.

The application of AI technologies in agriculture has the potential to mitigate the impact on natural ecosystems, leading to a reduction in environmental harm. Moreover, it can contribute to the improvement of worker safety conditions, ultimately resulting in stabilized or decreased food prices. This, in turn, ensures that food production remains aligned with the ever-increasing global population demands. The application of computers in agriculture was initially documented in 1983. Various strategies have been proposed to address agricultural challenges, ranging from database utilization to the implementation of decision support systems. Among these solutions, AI-based systems have consistently demonstrated superior performance in terms of accuracy and resilience. Agriculture is a dynamic field where no one-size-fits-all solution applies. AI techniques have empowered us to capture the intricate specifics of each unique situation and provide a tailored solution that best suits the particular problem at hand. Over time, the development of various AI techniques has facilitated the resolution of increasingly intricate and complex problems.

Fig 1. Plant regulation using AI technology

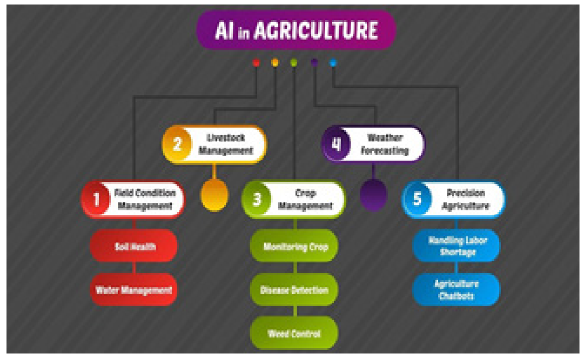


Fig 2. Flowchart illustrating use of AI in agriculture

USE OF AI IN VARIOUS DOMAINS OF AGRICULTURE:

(A) Soil Management

Soil management is an integral part of agricultural activities. A sound knowledge of various soil types and conditions will enhance crop yield and conserve soil resources. Various techniques like Management-oriented modeling (MOM) minimizes nitrate leaching as it consists of a set of generated plausible management alternatives and the dynamics of soil moisture are characterized and estimated by a remote sensing device embedded in a higher-order neural network (HONN). Some more examples of AI techniques are:

S. No.	Technique	Strength	Limitations
1.	MOM	Minimize nitrate leaching, maximize production	Takes time, only limited to nitrogen
2.	DSS	Reduce erosion and sedimentary yield.	Only measures a few soil enzymes
3.	ANN	Can estimate soil nutrients after erosion	Its estimate is restricted to NH4 only

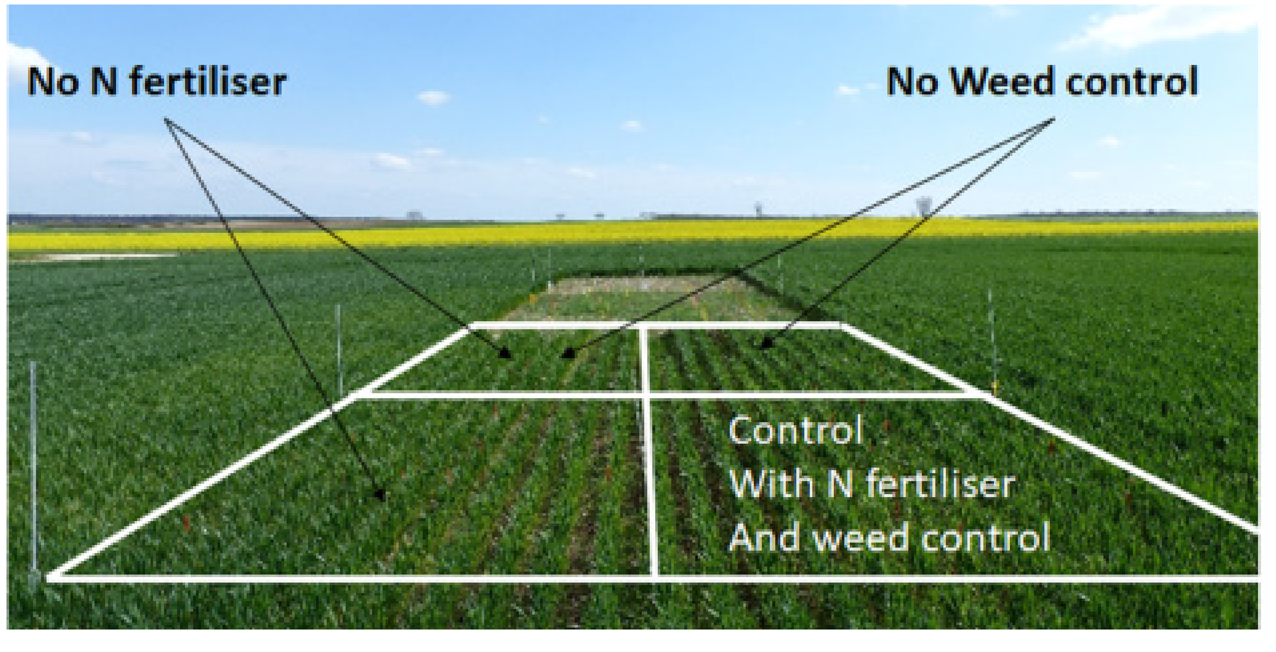
(B) Weed control

Persistent weed growth can consistently lower farmers' anticipated profits and crop yields. Research has indicated that uncontrolled weed infestations can lead to a significant 50% reduction in the yield of dried beans and corn crops. According to the Weed Science Society of America (WSSA) report, weeds have diverse effects. Some weeds can endure flooding during hurricanes and certain weed species can thrive even after wildfires.

S. No.	Technique	Strength	Limitations
1.	ANN, GA	High performance, reduce trial and errors	Require big data
2.	UAV, GA	Can quickly and efficiently measure weeds	Has little or no control on weeds
3.	Support vector machine (SVM)	Quickly detect stress in crops	Only detect low-level of nitrogen

(C) Disease Management

For efficient disease control and loss reduction, a farmer should implement an all-encompassing disease management system, which involves utilizing physical, chemical, and biological methods. However, this process is time-consuming and not particularly cost-effective, hence the necessity for applying artificial intelligence (AI) approaches in disease control and management. The Explanation Block (EB) provides a clear insight into the expert system's logic. This system employs a unique approach that utilizes fuzzy logic for rule promotion,



enabling intelligent inferences in crop disease management. Additionally, a text-to-speech (TTS) converter is integrated to offer a text-to-speech user interface.

(D) Pest Management

In agriculture, combating insect pest infestations is a pressing concern due to significant economic losses. Researchers have been working for decades to address this issue by developing computerized systems capable of identifying active pests and suggesting control methods.

S. No.	Technique	Strength	Limitations
1.	Rule based expert, Data base (DB)	Accurate results in tested environment	Inefficiency in large data base
2.	Fuzzy logic (FL), web GIS	Cost effective, eco friendly	Ineffective due to scattered data

FUTURE TRENDS OF AI IN AGRICULTURE:

The world's population is projected to exceed nine billion by 2050, necessitating a 70% increase in agricultural production to meet the growing demand. Approximately 10% of this increased production may come from untapped lands, while the remainder must be achieved through intensification of current production. To address this challenge, the adoption of advanced technological solutions to enhance farming efficiency is crucial. Current strategies for intensifying agricultural production often demand substantial energy inputs and aim for high-quality food to meet market requirements. Robotics and autonomous systems (RAS) are poised to revolutionize various global industries, including sectors with comparatively lower productivity like the agro-food chain (from farm to retail).