14 Artificial Intelligence in Agriculture

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Abstract

In today's world changes of climate and rapidly growing population, our traditional methods of agriculture practices faced lots of difficulties regarding productivity and sustainability. Now times come to help of AI transformed agriculture, optimum uses of resources, improve quality of seeds and increased crop productivity. In this chapter, explored AI in modern agriculture, soil monitoring technology, automatic pest-controlled system and make hybrid seeds. By using AI machine learning and predictive analytics, farmers are getting informative decision that maximum output with minimum wastage. In further chapter examines, with influence of artificial intelligence (AI) on agricultural supply chain and market accessibility stroll with goals of sustainability in agro-economy.(Lal & Mishra, 2025) It talks about how artificial intelligence (AI) authorized tools helps better price discovered and demand forecast so that empowered farmers. However, the conversion to artificial intelligence (AI) driven farming is not possible without hurdles, high initial cost and artificial intelligence (AI)learning. This research provided a roadmap and suggestion that integrate artificial intelligence (AI) with sustainability for achieving long terms food security and economy spring in agricultural sector.

Keywords: Artificial Intelligence, Sustainable Agriculture, Productivity, AI in Marketing, Precision Agriculture, AI-Enabled Technology in agriculture.

Introduction

Artificial intelligence (AI) has emerged as a critical tool in agriculture, allowing farmers to analysis market demand, manage risk, breed seeds, monitor soil health, protect crops and track crop maturity.(Chandola & Sarma, 2026) Uses artificial intelligence to analysis fruits and vegetables, detect flaws and avoided crop failures. It aids seed breeding by gathering data on plant growth, identify best plant growth

varieties and crossbreeding them to produce superior hybrids.(Chandola & Sarma, 2026).(Chandola & Sarma, 2026)

Artificial intelligence (AI) describes programs that are able to think, learn new things and solve complicated problems. It differs from biological intelligence in that is digital, artificial and synthetics. By employing intelligent farming methods and decision-making tools, artificial intelligence (AI) in agriculture aids farmers in delivering exceptional value and guides society toward the "fourth industrial revolution." Precision agriculture (PA) is one such aspect that merges information technology with farming equipment and management. The four key functions of PA include detecting changes in the field, mapping and reporting data, autonomous navigation in fields, and recommending management zones for farms. PA has successfully minimized environmental impact while boosting agricultural profitability.(Tanna et al., 2024)

Precision Farming

Precision farming, an agricultural management strategy, is based on observing, measuring, and responding to variations in crops both within a single field and across different fields. This approach is also known by other terms such as site-specific crop management, satellite agriculture, precision farming, and as-needed farming. By utilizing information technology, precision farming ensures that soil and crops receive exactly what they need for optimal productivity and health, thereby ensuring profitability, sustainability, and environmental conservation. It considers various factors in crop management, including soil type, geography, weather conditions, plant growth, and yield data. (Sharma &Srushtideep, 2022)

What is the process of precision farming?

Precision farming depends on specialized tools, software and IT services of function. In addition to other pertinent data like hyperlocal weather forecasting, labor cost and equipment availability, this involve having access to real time data regarding the state of the crops, soil and ambient air.(Agrichain)

Sensors in fields that gauge the temperature and moisture content of the soil and surrounding air are used to gather the data in real time. Farmer can also obtain real time photos of individual plants via robotic drones and satellites.

What advantages can precision farming offer?

Following the data collection, farmers can receive advice on crop rotation, ideal planting and harvesting periods and soil management from predictive analytics software.(Agri India Today, 2025)(Sobti, 2025)

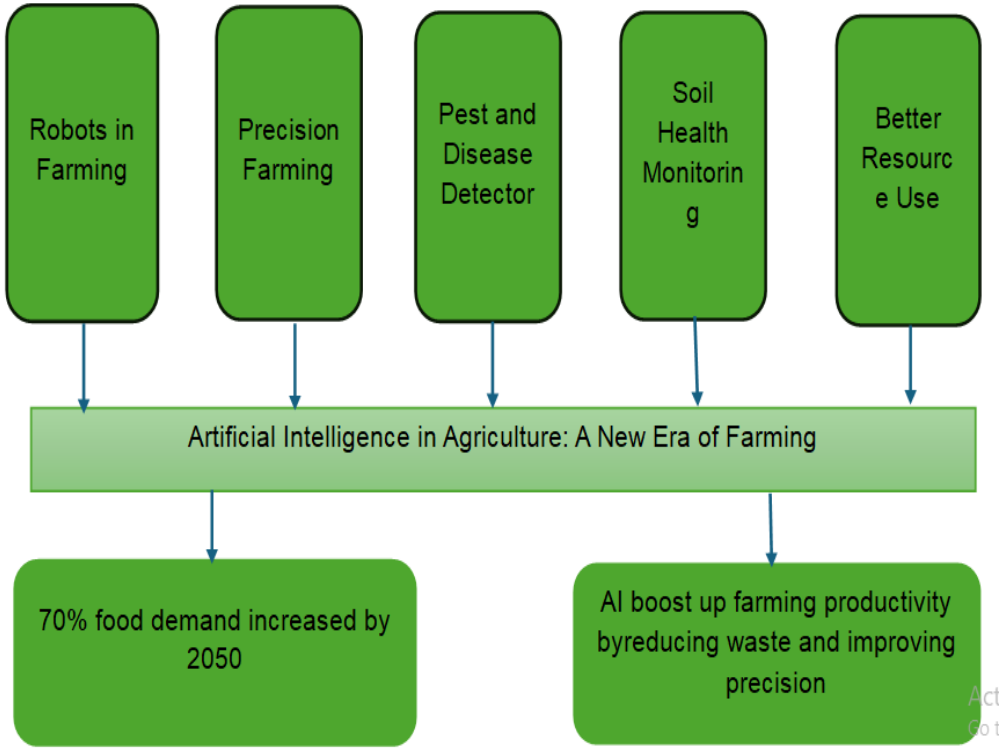
Farmers can identify crops that need treatment and calculate the best amount of water, fertilizer and pesticides to apply thanks to agricultural control centers capacity to integrate sensor data and imaging input with other data.

ISBN: 978-93-49468-10-8

In addition to lowering expenses and managing the farms environmental effects, it helps the farmers avoid wasting resources and stop runoff, ensuring that the soil has precisely the proper number of additives for optimal health.

Currently, some of the most widely used uses of precision farming are as follows:

- **Field reconnaissance and agricultural mapping:** High-resolution maps of fields can be produced using drones fitted with cameras. This information can be used to track crops, detect trouble spots, and evaluate yield potential.(S.K.Laha, 2025)
- **Sampling and analysis of soil:** Data on soil type, fertility, moisture content and other factor can be gathered via mobile apps. Fertilization, irrigation and other crop management decision can be made using this information.(Dipak A. Jadhav, 2025)
- **Tracking the weather:** farmers to choose when to planting plants, how much water provide to crops and when to harvesting with hyperlocal weather data.(Dipak A. Jadhav, 2025)
- **Management of labor:** Mobiles apps with GPS capability can monitor fields workers and work flows optimized with help of this data.



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AI-Powered Technologies in agriculture

- **Crop Monitoring**

Artificial intelligence (AI) powered crop monitoring system collect data in real time on crop health, growth trends and environmental variables using satellite imaging, drones and internet of things sensors(R.K.Gupta, 2026). Data analyzed by Machine Learning algorithms to find abnormality, forecast production results and spot possible hazards like insect infestation or nutrient storages(R.K.Gupta, 2026). AI-driven crop monitoring system enables farmers to take proactive steps to maximize crop productivity and reduce loss by giving them timely insights.(Sanket, 2024)

- **Soil Analysis**

Artificial intelligence in soil analysis converts labor-intensive, conventional lab testing into scalable, real time precision farming. Artificial intelligence provides highly localized, crop specific fertilizer recommendations by quickly measuring critical characteristics like pH, moisture and NPK (nitrogen, phosphorous and potassium) using a combination of internet of things (IoT) sensors, satellite images and machine learning(Lal & Mishra, 2025). AI-driven devices monitoring soil in the spot immediately.(Sanket, 2024)

- **Supply Chain**

AI-powered supply chain optimization is essential for agricultural supply chain optimization because its analysis enormous volumes of data on consumer preference, market trends and logistics. Predictive demand forecasting, dynamic pricing strategics and effective inventory management are made possible by Machine Learning algorithms which improve supply chain profitability and eliminate waste. Furthermore, the integration of block chain technology with artificial intelligence (AI) ensures the integrity of food by facilitating transparency, traceability and trust among stakeholders.(Sanket, 2024)

- **Crop Breeding System**

AI-driven crop breeding systems use genetic data, phenotypic attributes and environmental variables to speed up the production of new crop varieties with desired qualities. In order to enable focused breeding techniques, machine learning algorithm help breeding find genetic makers linked to qualities like yield potential, disease resistance and nutritional quality. Artificial intelligence (AI) helps create robust and high-yielding crop varieties that are necessary for guaranteeing food security in a fast-changing environment by reducing the breeding cycle and increasing breeding efficiency.(Sanket, 2024)

- **Agricultural Artificial intelligence (AI)Tools and Technologies**

The quick development of artificial intelligence (AI) has sparked the creation of several tools and technologies designed to meet the unique requirements of

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farmers(R.K.Gupta, 2026). AI-based decision support systems enable farmers to make well informed decisions by offering practical insights on resources allocation, pest control tactics and crop management techniques.(Sita Rani, 2025) Additionally, labor intensive jobs like planning, harvesting and spraying are automated by robots, drones and autonomous cars with artificial intelligence (AI) capabilities, improving operational efficiency and lowering labor costs.(Sanket, 2024)

- **Organic Farming**

Encouraging Organic farming with artificial intelligence (AI) Agroecology and sustainable development which place a high priority on soil health, biodiversity protection and environmental sustainability. Artificial intelligence (AI) technology provides organic farmers with useful tools and insight to help them optimize resource management, improve pest and disease control and encourage regeneration agricultural methods. Innovative technology designed to meet the demands of organic farming, such as autonomous weed control robots and AI-powered soil monitoring systems, have the potential to transform organic agriculture and promote its broader acceptance globally.(Sanket, 2024)

Why technology is important in Agriculture?

Technology plays a major role in modern agriculture. It assists farmers in increase productivity, reducing labor intensive tasks, saving time and improving crop quality. Growing population and increase demand for foods, traditional farming methods are inadequate. Therefore, employing cutting edge technology is now essential for the advancement of sustainable agriculture.

The benefits of technology are in agriculture a higher crops productivity.(Chen, 2026) Harvesting tractors and seed drills are examples of modern equipment that farmers help farmers complete agricultural task faster and more efficiently. Improved irrigation method like drip and sprinkler irrigation, also help reduce water waste and improve water management.

Technology also helps farmers make better decisions. Artificial Intelligence (AI), sensors, drones, satellite imaging and mobile applications allow farmers to predict weather conditions, crops growth, soil health and pest attacks in real time. They can response quickly and reduce crop losses.(Siddharth Singh Chouhan, 2025)

Smart farming and automated equipment minimize operating expenses and eliminating need of labors. In addition to saving money, farmers can apply pesticides and fertilizer more precisely, protecting the environment from overuse of chemicals. The three main issues facing agriculture today are water scarcity, soil degradation and climate change. In addition to encouraging ecologically friendly farming method, modern technology assist farmers in making effective use of natural resources.

Additionally, farmers can access market data, weather forecasting, government programs and improving selling opportunities through digital platform

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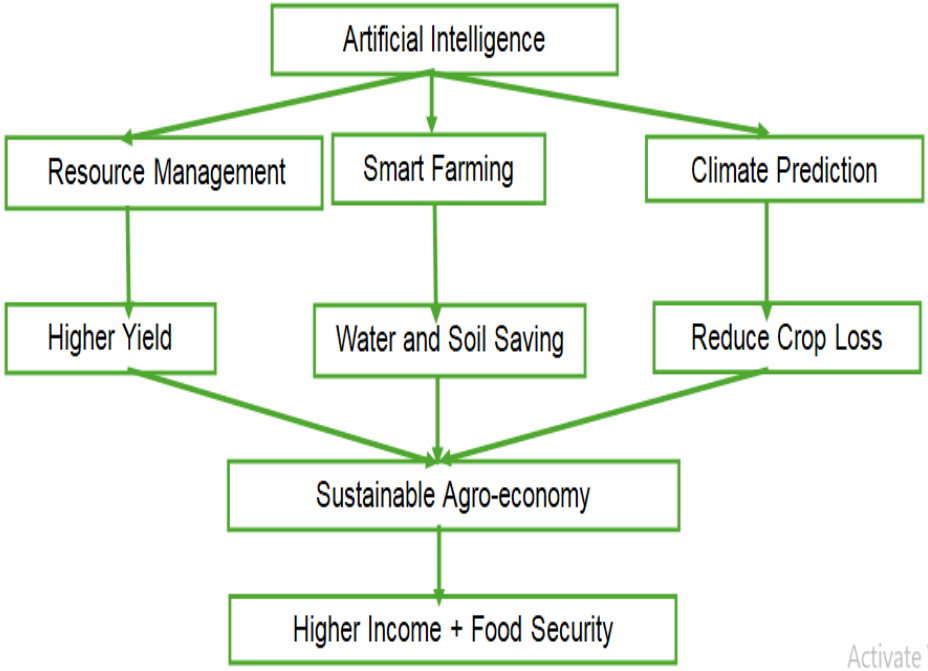
and online market places. This increases farmers earning and gives them direct access to buyers and consumers.

Artificial intelligence (AI) required to Sustainable Agro-Economy



Application of Artificial intelligence (AI) in Agriculture(Lal & Mishra, 2025)

AI Application	Purpose
Weather Forecasting	Predict climate condition
Soil Health Monitoring System	IOT based utilizing sensors to measuring key soil parameters
Analysis Crop Health	Evaluating plant vitality to detect disease, pests and nutrient deficiencies early
Precision Farming	Optimize resource use
Identifying Plant Disease	Analysis observable symptoms and signs
Detecting Pest Infestation	Identifying pests early to prevent yield loss
Agricultural Product Grading	Sorting product categories based on quality, size, color, moisture and ripeness
Alert on Crop Infestation	Krishi Vigyan Kendra (KVK) Haryana timely alert on crop infestation
Detecting Weeds	Uses computer vision, deep learning and AI to unwanted plants
Irrigation	Using drip and sprinkler to controlled water amount
Warehousing	Safely storing goods in designated places

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Artificial Intelligence (AI) in Marketing

Commodities from agriculture and horticulture, such vegetable and pluses, are essential to both economic stability and food security. However, farmers, traders and consumers face difficulties as a result of price fluctuation. Numerous factors, such as weather, marketing demand, supply chain problems and government restrictions affect these fluctuations. Artificial Intelligence (AI) and Machine learning (ML) have become potent tools that can analysis massive datasets and spot complex pattern in order to address these issues.(2021)

- **Demand Forecasting goes beyond conventional**

Forecasting attempts may be made more accurate and successful to use of machine intelligence technologies skill, are an artificial learning, algorithm, prediction analysis and automation.(R.K.Gupta, 2026) Artificial intelligence (AI) powered demand forecasting may help business make decision about production, pricing and strategic planning, optimum inventory level and enhanced supply chain management. By utilized large data sets and more sophisticated analytics to adjust to shifting market condition and customer behavior, this demand planning strategy goes beyond conventional forecasting technique. It helps businesses to keep a completive advantage, minimize stockouts, cut down on surplus inventory.

- **Price Optimization**

Artificial intelligence (AI) price optimization automatically modified product pricing to optimize profit margin and conversion rate by using machine learning to evaluate past sale, rival rates and current market trends. By anticipating demand and reacting quickly to change in the market, it removes the need of human guessing.

- **Supply Chain Efficiency**

Optimizes logistics networks, route optimization technologies leverage information from internet device, logistics providers to supplier networks spread across the supply chain. Artificial intelligence (AI) also used to market trends and inventory levels.(R.K.Gupta, 2026) Inventory management is one particular competency. Artificial intelligence (AI) can automate paperwork for tangible objects, improve supply chain visibility and automatic record data each time a data is transferred.

Uses and Advantages

There are several advantages to using artificial intelligence (AI) in agriculture, such as increased efficiency, sustainability and production.

- AI-driven crop monitoring allows for proactive decision making to reduce risk and increase yields, while precision farming methods improve resource allocation.

ISBN: 978-93-49468-10-8

- Predictive analytical and on-going monitoring enhances livestock management techniques, improve animal welfare and production. Artificial intelligence (AI) also speeds up the flow of agriculture products from farm to market by facilitating supply chain optimization.
- AI-driven breeding methods speedup agricultural hybridization attempts, help to hardly copy type that are crucial for food security.

The creation of artificial intelligence (AI) tools specifically designed to meet the demands of farmers improve decision making and operational effectiveness and making easy to farming to farmers.

Case Study and Success Studies

Artificial Intelligence (AI) has the potential to revolutionize agriculture. Crop varieties selection, soil and nutrient management, plant disease prevention, insects and weed control, community price forecasts and real time agriculture product marketing information are just a few of the ways artificial intelligence (AI) may boost agricultural yields. The section contains a few case studies and success stories related to the use of artificial intelligence (AI) in agriculture.(Lal & Mishra, 2025)

- **Saagu Baagu Project**

Without access of funding, farmers struggle with insects' infestation, unpredictable monsoon and diminishing yields. The artificial intelligence (AI) for Agriculture Innovation for the fourth industrial revolution was introduced in 2020 by the World Economic Forum India Center in partnership with the Union Ministry of Agriculture in India and state of Telangana. In Saagu Baagu project was tested among 7,000 chili producers in the Telangana region of Khammam.AI-based quality testing, bot advising services, soil testing technologies and a digital marketplace to connect buyers and sellers, has completely transformed the Khammam district chili production. Because of the digital advisory services their income more than doubled, yield increased by 21% per acre, pesticide uses dropped by 9%, fertilizer uses decreased by 5% and price per unit increased by 8% due to quality improvements.(Lal & Mishra, 2025)

- **Artificial Intelligence Prices Forecasting Model**

Due to price fluctuation, farmers are exposed to a high level of price risk, in this studies price forecasting might provide protection. Price forecasting depends on historical data which is quite costly to obtain accurately. The Karnataka Agriculture Price Commission (KAPC) and Microsoft using satellite imagery, cloud machine learning, artificial Intelligence and other cutting-edge technology to create a multi variate commodity price forecasting model. During the summer harvesting seasons of 2018, the model was first put the test. Three months in advance, local governments and farmers may forecast commodity prices for significant agricultural market, along with crop volume and arrival date forecasts. It also made it possible for the Karnataka

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government to anticipated ahead of time and establish the minimum support price.(Lal & Mishra, 2025)

- **Gobasco- The Intelligence Agri Supply Chain**

Gobasco assist farmers with quality control, agromapping and credit risk management. Fruits and vegetables are automatically evaluated and sorted using computer vision and artificial intelligence it preserves quality. The established a global standard for agro-commodity, facilitating trustworthy across bordered trading. Credit risk management was used to overcome the credit default problems- the most challenges issue facing the current supply chain by utilizing crowed sourced data, algorithm and analyzed to guarantee a very low risk operation. (Lal & Mishra, 2025)

- **Brijbot-Weeds Removing Robot for Indian Farmers**

Weeds are undesirable plants in the field that increase competition for light, nutrient, water and other resources, reducing the output of major crops. As a result, controlling weeds at the right time is quite important. Tartan Sense, an agrotech business located in Bengaluru, created a tiny, land based robot rover for pest and weeds management. The AI algorithm detects the weeds as the rover moves over the field and robot than sprays weedicide automatically. Brijbotfor eight hours a day during the pilots without any human supervision or interference. As a result, 50%-70% less pesticides were used, saving money and safeguarding the crops. The robot increased weeding efficiency by 700% by removing weeds from a full acre in an hour, compared to alternatives that needs at least half a day each acre.(Lal & Mishra, 2025)

- **Fasal Software: AN Artificial intelligence (AI) and Internet of things (IOT)**

For horticulture crop growers, determining the precise timing and amount of irrigation is quite challenges. A team of employees at Wolkus Technology develop Fasal software.

Maharashtra, received immediate financial advantages of Rs. 78000 by lowering the frequency of irrigation by 30%through the uses of Fasal software. In one season, almost 8.5 lakh liters of water were saved. Hariom Mukati, a farmer from Nagal wadi, Madhya Pradesh, also saved 50% of water by using the program. This increases the productivity of the chili crop and reduce the incidence of root borne illness.(Lal & Mishra, 2025)

- **TCS: Intelligence Diary Farm Assistance**

6% of the nation gross value added (GAV) come from the cattle industry. Breeding determines the quality of animal product like milk and AI based dairy farm assistance can solve this scientifically. It combines motor sensors with artificial intelligence (AI). An Artificial intelligence (AI)interprets the data that is transmitted by

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sensors attached to the cow's neck. TCS matches current livestock with sustainable partners for cross-breeding using the artificial intelligence (AI) system. During artificial insemination, it guarantees superior breeding.(Lal & Mishra, 2025)

Challenges

The fundamental issue with promoting machine learning and artificial intelligence in agriculture is not a lack of expertise among agricultural scientists, but rather the difference in physical surroundings that make testing, validating and implementing technology more challenging. In practical terms, a man can handle a situation better than Artificial intelligence. However, since eliminating drudgery is the main objective, artificial intelligence (AI) and machine learning has a wide range of applications, from post – harvest technology to tillage.(Mohan et al., 2021)

According to farmers, artificial intelligence (AI) is limited to the digital realm and may not be useful to them in the field. Unreasonable cost and a lack of comprehension are evident neglect to describe their benefits and the best ways to put them into practice. The use of precision agriculture tools is restricted by small land holdings and uneven field elevations. Because they cannot afford an AI-drones or unmanned arial vehicle (UAV) a modest farmer engages in conventional farming. As a result, community farmers who own more the 5 hectares of land can readily engages in precision agriculture and rent is out for bespoke hiring.(Mohan et al., 2021)

In that time, Traditional farming is adopting some challenges and artificial intelligence (AI)or modern technology are overcome these challenges:(Mohan et al., 2021)

- Soil moisture, fertilizers level and weed and insect infestation may all we checked with the use of soil and crop monitoring systems.
- Cutting edge method to level or grade the field for uniform eater distribution and soil moisture such as laser land leveler and automated depth regulating systems.
- The use of precision seeders and planters, which can conserve seeds and maintain consistent seeds spacing, must increase.
- Autonomous robotic weed control devices can increase agriculture sustainability and lessen its impact on the environment by replacing labor and reducing the existing reliance on chemicals.
- When a crop is understress, unmanned arial vehicle (UAV) technology can locate it and if needed, apply chemical sprays.
- By delivering optimum rates based on crop requirements and soil conditions, variable rate technology (VRT) improves input uses efficiency, the likelihood that site specific input management will be(Mohan et al., 2021) required increases with yield variability within a field.

ISBN: 978-93-49468-10-8

- Robotic harvesting will be an emerging technology in a near future due to growing concerns about raising labor costs and unpredictability among seasonal agricultural laborers.(Mohan et al., 2021)

Future

Artificial intelligence (AI) in agriculture has a bright future ahead of it,(Akhouri Nishant Bhanu, 2026)with continued developments expected to significantly alter farming methods. More efficiency and sustainability in agriculture will result from ongoing(Dipak A. Jadhav, 2025) advancement in artificial intelligence (AI)technology, such as improved sensing capability and predictive analytics.

Building on the fundamental results of AI enabled agricultural systems, future research may investigate a number of important avenues to strengthen institutional sustainability and contextual relevance.

First, integrating indigenous knowledge systems with artificial intelligence (AI) models provides a technique to improve contextual subtlety, guaranteeing that algorithmic outputs take into account cultural distinctiveness and ecological wisdom. Long term continuity and practitioner credibility will be ensured by institutionally integrating these technologies into agricultural extension programs, academic publishing and credentialing system alignment across sectors, including water governance, health infrastructure and smart city planning will further establish artificial intelligence (AI) as a crucial facilitator in larger development ecosystems(R.K.Gupta, 2026). In the end, artificial intelligence (AI) in agriculture must continue to be a tool, not a goal, for reestablishing structural autonomy and narrative dignity in the face of ecological unpredictability.

Conclusion

In this study we explore that how artificial intelligence (AI) are important in agriculture. Today's needs of farmers are more sustainable and prosperous farming. We clearly notice that the integration of technologies with artificial intelligence (AI) and internet of things are reshaped the traditional agriculture into a modern agriculture(Dipak A. Jadhav, 2025). Modern agriculture enhances crops yields, crops productivity, better decision making, decreased environmental impact, less uses of pesticide and harmful chemical, unnecessary weeds control and better supply chain to liked up the marketers. Farmers faced some of problems or challenges to adoption of technology and implemented this technology in fields. Advanced technology reduced the needs of manual labor that's why employment impacted.

At the end, the fields of artificial intelligence (AI) and internet of things (IoT) in agriculture hold immense potential of future growth and innovation(Sita Rani, 2025). Emerged technology such as robotics, satellite imaginary, soil monitoring and irrigation system further revolution in agriculture.

ISBN: 978-93-49468-10-8

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ISBN: 978-93-49468-10-8