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AGRO TECH AI: Agriculture with Artificial Intelligence

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Abstract - The evolving field of disruptive technologies has recently gained significant interest in various industries, including agriculture. The fourth industrial revolution has significantly impacted agriculture, with the application of artificial intelligence (AI) and machine learning (ML) reshaping the industry. This study reviews research advances in AI in the agricultural sector, focusing on its disruptive potential. The authors highlight the challenges urban populations face in developing countries during unpredictable global economic conditions. AI can optimize crop-related data, enhance crop production predictability, help farmers cultivate healthier crops, manage pests, monitor soil and growing conditions, analyse data, and manage food supply chain activities. AI can also help farmers choose the optimal time to plant seeds, offer weather forecasts, increase crop quality, and hasten product delivery. However, the use of AI in agriculture is limited due to its diverse impacts, ethical concerns, technological development, and ecological impacts. The research proposes adopting a differential approach to develop AI in agriculture, aiming for robustness, environmental value, and social desirableness, leading to greater acceptance and trust among farmers.

Keywords – Artificial Intelligence(AI), Machine Learning(ML), Agriculture, Disruptive Technologies, Crop Management , Soil Management.

1. Introduction

One of the oldest and most significant industries in the world is agriculture. The world's population is expanding quickly, which raises the need for jobs and food. Because traditional farming methods are not enough to meet food needs while also creating jobs for billions of people worldwide, new automated ways are being created to address these needs. Because of a lack of workers, more stringent laws, a growing world population, and a diminishing number of farms, farmers are compelled to look for new solutions. Nearly every industry is being impacted by technologies like the Internet of Things, Big Data & Analytics, Artificial Intelligence (AI), and Machine Learning (ML). Research and efforts are being made to make agricultural goods "intelligent" and "connected" through "smart farming," which will increase their quality and quantity.[8]

1.1. Progress of Agricultural Technology (AgriTech)

Reference [14] shows the study aims to categorize AgriTech types and techniques within the last decade and explore future research agendas *(Refer to Table 1.1)*. While numerous studies describe AgriTech from a solution- driven perspective, few provide a clear link between AI applications and business and operations. A systematic review and synthesis of existing literature will serve as a reference source for new insights into AI-driven AgriTech research and applications from an operations perspective.

Evolution	Properties	Technologies used
Neolithic Revolution (c.10,000 BCE)	Labour based	Manual process, animal based , f arming tools.
Agricultural Revolution (17th – 19th centuries)	Mechanization	Chemical fertilizers, harvesters, and tractors
Green Revolution (Mid – 20th century)	Data Based	Taking advantage of AI-powered multi-source data, sensors , satellite photos, weather tracking, and water and fertilizer usage monitoring

Table 1.1 Growth of Agriculture over centuries

1.2. Artificial Intelligence

Artificial intelligence (AI) is an interdisciplinary field that aims to replicate human intelligence in robots, including learning and problem-solving. Researchers and extension specialists are using AI technology to address issues in agriculture productivity, such as crop selection, improved soil and nutrient management, pest management, crop production estimation, and commodity price forecasting.

AI uses deep learning, robots, IoT, image processing, artificial neural networks, WSN, and machine learning to tackle agricultural challenges. AI helps farmers monitor farm items like weather, temperature, water usage, and soil conditions, reducing losses and achieving high yields. Agriculture is one of the oldest industries undergoing a digital transformation, with AI enabling precision agriculture, such as watering, crop rotation, harvesting, crop selection, planting, and pest control. The goal of a machine is to learn, reason, and perceive, and AI technology in agriculture has the potential to improve the world by performing tasks ranging from simple to complex.[8]

1.3 Need of Artificial Intelligence in Agriculture

Artificial Intelligence plays a vital role in the development of various sector , out of which one is agriculture. The Figure 1.3 shows us the major need of AI in Agriculture**.**

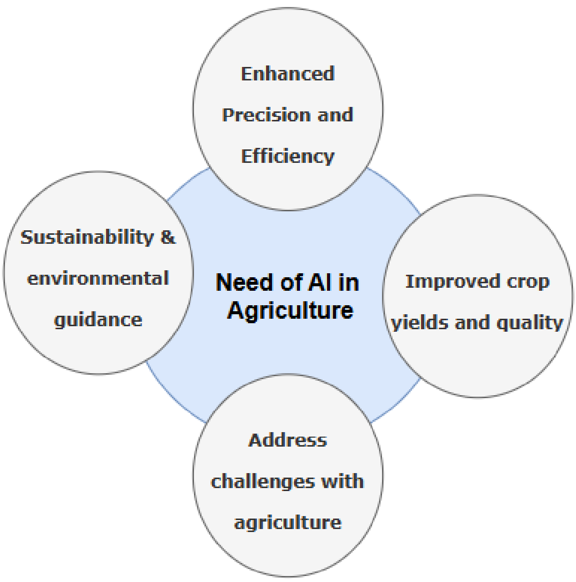

Figure 1.3 Need of Artificial Intelligence in Agriculture

1.4. Research Objectives

Agriculture technology vendors often struggle to explain the benefits and application of new technologies, leading to confusion and high costs. AI can enhance manual tasks and address labor shortages in the labor-intensive sector. Automation can help farmers with driverless tractors, intelligent irrigation systems, smart spraying, vertical farming software, and AI-based harvesting robots. AI-driven farm machinery is more efficient, productive, and quick than human workers.
The primary research objectives of this article are as under:

RO1: to study AI and its need in Agriculture;

RO2: to study the process of AI adoption in Agriculture;

RO3: to learn some Agriculture parameters as being monitored by AI;

RO4: to identify and discuss the major applications of AI in agriculture.[8]

1.5. Procedure of AI in Agriculture

AI technology is revolutionizing agricultural solutions by providing comprehensive monitoring at all stages of plant growth. By combining image classification techniques with distant and local sensing data, AI systems can continuously monitor nutrient levels in the soil and compare them to clerestories that have historically produced the highest yields on specific crops. AI can also examine the environmental implications of applying various dosages and types of fertilizers to find the dose that will have the least detrimental effect while maximizing production. AI has been used to address challenges faced by farmers due to climate change, such as identifying when to plant seeds. Remote sensing technologies can help farmers reduce waste, enhance product quality, and ensure quicker market access.

Automated tractors can run without a driver using GPS technology, gathering data, monitoring farm health from a distance, and relaying information. AI can also assist in pest control, predict precipitation and evapotranspiration, and train machine learning models to provide insights into soil moisture, temperature, and overall condition. Precision agriculture provides sustainability, environmental protection, and increased productivity and efficiency.[8]

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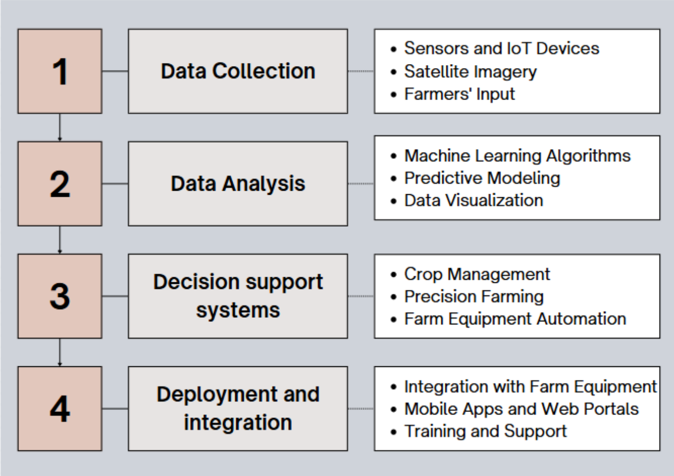

Figure 1.5 Process of AI in Agriculture

1.6. Applications of Artificial Intelligence in Agriculture

AI in agriculture can enhance consulting services, data analytics, and the internet of things. It can produce predictive insights by analyzing data sources like weather, soil, and crop performance. AI can improve crop management, identify plant illnesses, and efficiently administer agrochemicals. Farmers are increasingly adopting AI and IoT to increase land productivity. The significant applications of AI in agriculture are discussed in Table 1.6.

AI-powered technologies are revolutionizing the agriculture sector by improving decision-making, data processing, and efficiency. Advancements in technology and society's trust in machine learning have led to the adoption of AI for various reasons, including improved data accessibility, faster satellite image access, lower data logger costs, drone use, and access to government data repositories. AI also enhances transparency in the pre-disbursement process, allowing banks to offer loans with lower risk.

AI in agriculture is still in its early stages, with limited training data and varying lighting, angles, and background colors. However, AI models can learn from relevant data and images, supplementing farmers' knowledge for better decision-making. Water management in agriculture lacks reliable, timely, and sufficient data, which AI solutions can use. Crowd-sourced and participatory mechanisms can help collect richer contextual data, while remote-sensing technologies can provide hyper-local data on rainfall and other weather indicators.[8]

S No.	Applications	Description
1.	Precision Farming and Predictive Analytics	Precision agriculture is an integrated information and production-oriented farm system that improves site-specific, long-term farming production, effectiveness, and profitability while minimizing environmental and wildlife impacts. AI-enabled technologies help farmers with irrigation systems, harvest technologies, crop variety, insect and pest attacks, and nutrient administration. AI-driven solutions increase production and profits while meeting the world's need for more food sustainably, preventing resource depletion and enhancing yields.[5]
2.	Agricultural Robotics	Artificial intelligence (AI) companies are manufacturing robots for farming tasks, reducing weed management and harvesting faster than humans. These machines can operate in bulk quantities, reduce wastage, and improve productivity. AI techniques provide real-time data, reduce human error, and enhance decision-making skills. Farming is the second-largest industry using robots professionally.[5]
3.	Land and Plant fitness Monitoring System	Soil nutrition impacts crop variety and quality. German startup PEAT developed Plantix, an AI-based app that detects pests, diseases, and nutrient deficiencies in soil. Farmers can use this knowledge to recommend fertilizer applications. Trace Genomics and other AI apps help farmers

		monitor soil fertility, improve crop harvesting, and enhance profits.[5]
4.	Pest Detection	AI algorithms help farmers identify pests and send alarms to protect crops. This integration of environmental sensors and IoT reduces pesticide use and soil damage, allowing farmers to apply pesticides at the right time and place.[5]
5.	Weather Forecasting	Artificial intelligence can help farmers plan seed sowing due to climate change and pollution, using weather forecasting and machine learning techniques to predict future crop yields.[5]
6.	Price Forecasts and Crop Yield Predictions	Crop price fluctuations cause farmers concern, especially for short-lived crops like tomatoes. Climate and satellite data help assess crop health, while AI technology can forecast prices and predict crop yield. German start-up uses AI to detect diseases in crops, assisting over 7 million farmers.[5]
7.	Student studying regarding Agriculture	AI in agriculture should be integrated into undergraduate curriculums to promote interest and awareness of its rapid advancements. Collaboration among agricultural scientists, ML engineers, and data specialists is needed for developing relevant AI applications. Advanced remote sensing techniques and high-resolution multispectral imagery can monitor crop and soil health, detect soil flaws, and aid in disease prevention and crop production.[8]
8.	Detect anomalies and impurities	ML algorithms can accurately identify fruit and vegetable items, detect anomalies, and improve efficiency. AI aids in developing environmentally friendly packaging, precision farming, and ensuring high-quality food production, reducing food costs and addressing food insecurity.[8]
9.	Identify wasteful resource consumption patterns.	AI systems can optimize resource allocation, reduce costs, and increase profitability in agriculture. They help identify sustainable resource usage patterns, reduce costs, and promote sustainable agriculture, ensuring future generations have nothing.[8]
10.	Improve decision making	The agriculture industry is increasingly utilizing AI technology to improve decision-making, utilizing sensors, satellite photos, drones, and data archives. Precision farming uses precise techniques, advising on crop rotation, profitability, and long-term viability. AI can process large data for better agricultural decisions.[8]
11.	Achieve efficient results with lesser efforts	AI can revolutionize agricultural scenarios by reducing effort and providing benefits. However, farmers may struggle to understand its practical applications on physical land. Smart farming, combining traditional farms with IoT technologies, aims to improve product quality and reduce human intervention.[8]

Table 1.6 Applications of AI in Agriculture

2. Materials and Methodology

2.1. Research Methodology

For this study, we conducted a desk study on narrative. To conduct a thorough and organized assessment of existing literature on "Artificial Intelligence in Agriculture," the methodology used in this research is a Systematic Review. This literature review assessed the state of knowledge on agricultural AI by reviewing academic articles in discipline-specific areas such as economics, ethics, and computer science and engineering. The steps of methodology is shown in the Figure 2.1.

We employed the Scopus database and consistent search criteria for every discipline, but the results showed such a different number of publications (e.g. 204). Because of the wide spread number of publications across the various disciplines, we think a systematic review would be the best option because it would provide a completely balanced perspective of information. We limited each discipline using the following exclusion criteria: not focusing on agriculture, not focusing on AI technologies and their impact, not in English, not final and peer-reviewed, and no content pertaining to technical, social, environmental, economic, or ethical.

Utilizing these exclusion criteria, we examined the abstracts and the methodology section of the articles. To balance the evaluation, the exclusion and preliminary screen limited our searches to approximately six agricultural AI studies per discipline. To obtain the technological, environmental, social, economic and ethical challenges of the use and development of agricultural AI, we explored and reviewed the contexts of the selected studies and others.

Figure 2.1 Workflow of research methodology

2.2. Model Methods and Materials

The study suggests a thorough approach that includes gathering data, preprocessing it, creating a model, and deploying it. Important phases consist of:

Data collection : collecting data from dependable sources on weather, soil, agricultural yield, and Geographic Information System (GIS).

Data Preprocessing : Data integration, normalization, and cleaning are necessary for efficient analysis.

Model Development: Employing machine learning models (e.g., LSTM, ARIMA, SVM) for weather prediction, crop suitability classification, and yield estimation.

System Integration: creating an interface that is easy to use and implementing models on a cloud-based platform. Testing and Validation: To improve the system, field tests and performance monitoring are carried out.

2.2.1 Algorithm

This model seeks to suggest the best crop using the input parameters like :

- Nitrogen, Phosphorus, Potassium (NPK) levels
- Soil pH and moisture levels,

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- Temperature and rainfall data.

This paper uses the above input parameters for the following applications:

- Crop recommendation
- Crop price prediction
- Soil quality prediction
- Disease detection

And includes tools like:

- Plant task reminder
- Plant task reminder advanced
- Water management

It has more than 20 crops and fruits/vegetables such as : Arhar, Bajra, Barley, Copra, Urad, Gram , Groundnut, Jowar, Jute, Maize, Masoor, Moong, Niger, Paddy, Ragi, Rape, Pigeonpeas, Banana, Muskmelon, etc.

This system utilizes various Machine Learning algorithms such as:

- Logistic Regression : Logistic regression is a widely used algorithm for binary classification tasks, particularly in crop recommendation, providing probabilistic predictions and assisting farmers in selecting appropriate crops.

- Decision Trees : Decision trees are versatile algorithms for crop recommendation, capturing complex relationships between agricultural parameters and offering interpretability for farmers to understand the reasoning behind the recommended crop choice.

- Random Forest : Random forest enhances crop recommendation by selecting random features at nodes, improving predictive power and reducing correlation between trees, particularly in high-dimensional datasets with numerous features.[9]

Algorithms in our suggested AI-driven agricultural system will analyze weather and other data to generate precise recommendations. The algorithms involved the following process:-

i) The median is typically used to normalize soil and weather data for random machine learning models, addressing meteorological data and missing soil.
ii) Long short-term memory networks are weather prediction models that use satellite data to estimate temperature and humidity, with the baseline forecast derived from short-term models.
iii) Acceptability crop classification uses soil type, weather patterns, and geographical areas to group crops, determining
appropriate areas for each crop through a web-based portal or
application.
iv) Logical regression models will be utilized to estimate crop yields based on various input features like temperature, rainfall, soil moisture, and historical data.
v) The study aims to enhance planting schedules and resource allocation by simulating and selecting various scenarios and strategies for optimal scheduling.
vi) The Geographic Information System techniques will be utilized to predict geographic locations, map crop suitability, and provide visual insights and spatial analysis.
vii) LSTMs and CNNs are utilized for processing image and time data, aiding in deep data learning for further training.

2.2.2 System Workflow (UI) of the Targeted Program

Refer Figure 2.2.2 The AI-enabled crop recommendation system follows a robust process from data collection to recommendation generation. This includes phases in disease detection, crop price prediction, crop projection, and planting scheduling. The Agro Tech AI is designed with a user-friendly and intuitive interface that makes it easily accessible for farmers and other agricultural stakeholders to retrieve timely information and suggestions for optimal crop management decisions. The structure of the interface is designed to efficiently and clearly present relevant information, visual perspectives, and actionable recommendations.

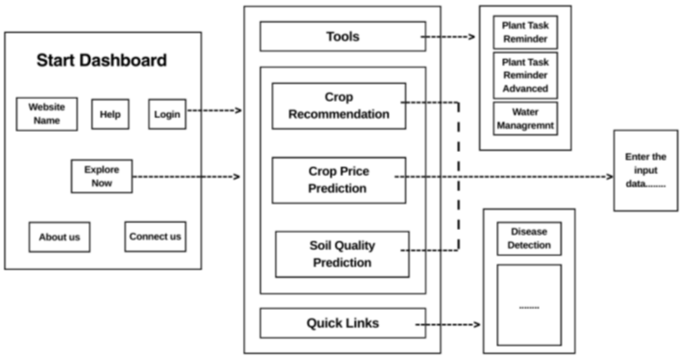

Figure 2.2.2 Workflow of Program

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3. Results and Discussions

3.1 Performance of AI in Various Disciplines

Although precision agriculture has existed for a few decades, artificial intelligence presents both opportunities and challenges. Some of the most significant economic, social and environmental effects of applying AI to the agriculture industry will be discussed in the sections that follow Figure3.1.1, Figure 3.1.2 and Figure 3.1.3 respectively.

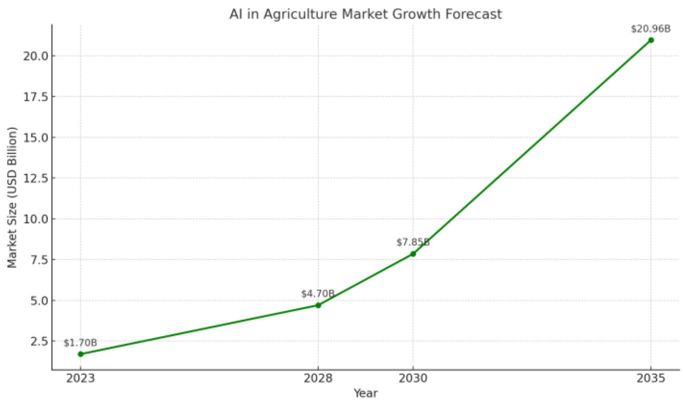

Figure 3.1.1 Economic Growth of AI in Agriculture
Here's a graph showing the projected growth of the AI in Agriculture market from 2023 to 2035 based on the data from internet.

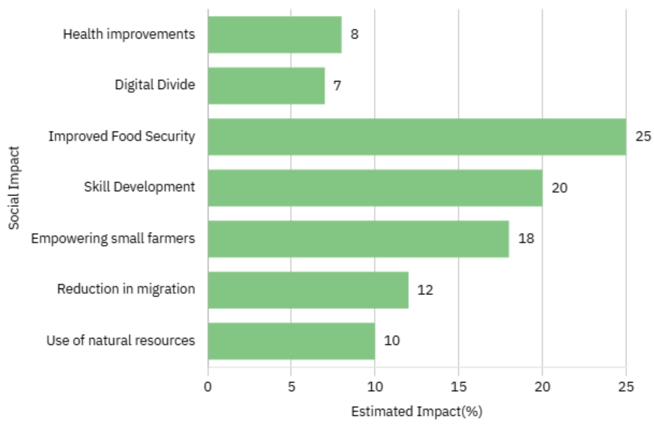

Figure 3.1.2 Social Impact of AI in Agriculture

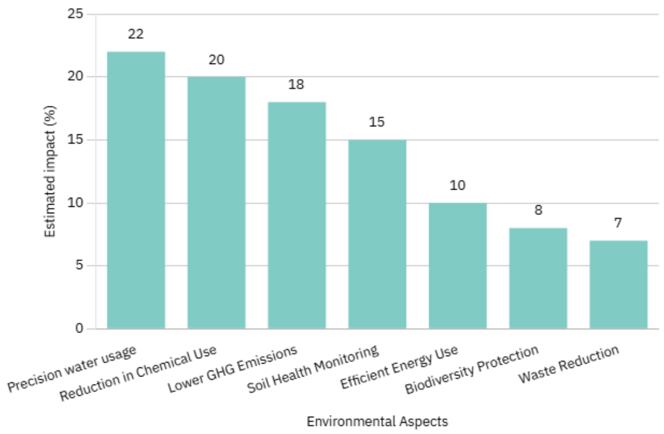

Figure 3.1.3 Environmental Aspect of AI in Agriculture

It will be important to incorporate farmer input to continue to improve the AI crop recommendation application, and keep it relevant to farmers and end users. Therefore, we can continue to utilize certain mechanisms. Methods to collect user input:
• Feedback Surveys via App: These surveys may be sent out via the app on a regular basis.
• Abstracts of interviews and groups: To provide deep qualitative input.
• Community (Online/ Forum): An area for farmers to ask questions, provide updates, provide feedback, and receive support.
By continually evaluating, designing, and harvesting farmer input, the application can grow and adapt to the end users and their changing needs.[4]

3.2 Experimental Result

Classifier	Accuracy
Logistic Regression	93.78
Decision Tree	95.12
Random Forest	96.36

Table 3.2 Classifier and its Accuracy result

It shows the related classifier's accuracy.

4. Conclusion

AI-related applications, which use data such as wind speed, temperature, solar radiation, and precipitation, can forecast weather, assess crop sustainability, identify pests and diseases, and monitor plant nutrition. Farmers can benefit from AI-driven strategies if they have access to internet-based AI applications. These programs provide accurate results, increase productivity, and meet global demands. AI-associated applications will play a vital role in agriculture, enhancing the entire agriculture system.

Some themes discussed are common to other fields and may be unique to agriculture, such as competitive advantage of profiting firms, equal access to information due to high investment costs, and data use privacy. Agriculture must look to other industries to gain insights, as AI in agriculture is relatively few compared to other fields like communication, infrastructure, manufacturing, and health.

A different approach is needed to develop agricultural AI, as agriculture provides food for humans to survive. Successful methods for producing more food for a growing population are a fundamental requirement, and the success or failure of AI may have significant implications for the place and future of the planet. Empirical studies in various agricultural areas using a different approach are recommended to study the ethical, environmental, and social impacts of agricultural AI.

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