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APPLYING ARTIFICIAL INTELLIGENCE (AI) TO AGRICULTURE

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Abstract
Artificial intelligence (AI) is transforming agriculture by making farming more efficient and productive. This technology helps farmers meet the growing global demand for food without relying solely on traditional, labor-intensive methods. AI applications in farming include using robots and drones equipped with sensors to perform tasks like weeding, spraying pesticides, and monitoring crop health. These automated systems help to reduce waste by precisely applying water and chemicals, which not only saves money but also promotes healthier soil. By analyzing data on crops and environmental conditions, AI helps farmers make better decisions, leading to increased yields and higher-quality produce. Essentially, AI is helping to create a smarter, more sustainable, and more productive future for farming.

INTRODUCTION

Using artificial intelligence (AI) in farming is a great way to improve efficiency and solve many common problems. **AI-powered solutions** can help with things like choosing the right crop varieties, managing irrigation, checking soil health, scouting for pests and diseases, and controlling weeds. By using **agricultural robots** and other AI technologies, farmers can get more out of their land with less effort. This is becoming even more important as the world's population grows and the demand for food increases. AI helps farmers produce more food, improve the quality of their crops, and get their products to market faster. Essentially, it's a powerful tool for creating a more sustainable and productive future for agriculture.

Vertical farming is a style of agriculture where crops are grown in vertical stacks instead of on flat land. This technique is a great space-saver, allowing farmers to grow much more food in a smaller footprint.

Figure 1 Vertical farming

The world population is rapidly growing, with projections showing it will reach 9.9 billion by 2050. This growth means we'll need to produce 35% to 56% more food. However, as cities expand and more people build homes, less land is available for farming. Many farmers are hesitant about adopting **artificial intelligence (AI)**. They don't see how this digital technology can be applied to their physical work in the fields. This resistance isn't from being afraid of new things; it stems from not knowing how AI tools can actually help them in their daily farming tasks. When agricultural technology companies don't clearly explain the benefits and uses of their products, new tools often seem complicated and too costly. This is a common problem with the adoption of **AI in farming**. Even though AI can be very helpful, tech companies still need to do a better job of teaching farmers how to selection criteria are all very important. To make AI technology effective, you also need skilled data engineers and analysts. Now, let's explore some specific examples of how AI is used in farming.

1.1. Big Data and Informed Decision-Making

The main reason for collecting and producing data is to use it effectively. When **AI** is combined with **big data** in farming, it can lead to bigger yields and major cost savings.This combination gives farmers dependable, real-time advice on their crops' needs. Instead of guessing, they can make smarter and more exact decisions about things like watering, fertilizing, protecting crops, and harvesting. This improved accuracy is what's known as **"precision farming."** (Anand et al., 2015)

1.2. Making Smarter Choices with AI

use it correctly. Farming involves many different steps, most of which are still done by hand. AI can simplify both the most difficult and the most repetitive tasks by working alongside existing farm equipment. When paired with other technologies, AI can collect and analyze huge amounts of information, decide on the best course of action, and even carry out those actions automatically.

1. AI: A New Solution for Agriculture's Challenges

As mentioned earlier, AI relies on other technologies like **big data**, sensors, and software to function. In turn, AI is often necessary for those technologies to be truly useful. For example, big data on its own isn't that valuable. What's important is how that data is processed and used to provide meaningful insights. When AI provides recommendations based on a set of data, factors like timing, location, and the specific

Using **predictive analytics** with **AI** can be a game-changer for farmers. AI allows them to gather and analyze much more data, and do it much faster than they could on their own. Farmers can use AI to tackle important challenges like understanding market demand, forecasting prices, and deciding the best time to plant and harvest their crops (Anthony et al., 2014).AI can also gather information on soil health, recommend the right amount of fertilizer, check the weather, and track when crops are ready. All of this helps farmers make smarter decisions at every step of the farming process (Arvind et al., 2017).

1.3. Cutting Costs with Artificial Intelligence

Precision agriculture is a form of farm management that helps farmers produce more crops with fewer resources.

The future of farming may very well be in **AI-assisted precision agriculture**. This method combines the best soil management techniques, variable-rate technologies, and data management plans to help farmers get bigger harvests while lowering their expenses (Figure2;Baketal.2003).Using **AI** gives farmers real-time information about their fields, helping them find exact spots that need water, fertilizer, or pesticides. Additionally, new farming methods like **vertical agriculture** can boost food production while using fewer resources. This approach leads to less use of herbicides, better quality crops, higher profits, and significant cost savings (Bakker et al., 2006)

1.4. AI Solutions for Labor Shortages

Working in agriculture is tough, and there's often a shortage of farm workers. **Automation** can help solve this problem. Farmers can save money by using driverless tractors, smart systems for watering and fertilizing, intelligent sprayers, vertical farming software, and **AI-powered harvesting robots**. These tools are faster, stronger, and more precise than any human worker (Bendig et al., 2012).

1.5. AI and the Future of Work

Farming is tough work, and finding enough labor has always been a challenge for the industry. **Automation** will experience an innovative shift after the web, sometimes referred to as

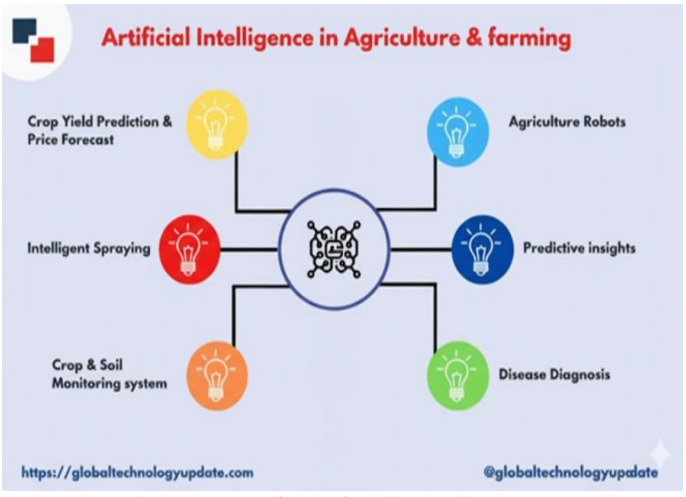

Figure 2 The Future of Artificial Intelligence

can help solve this problem. Farmers can cut costs by using tools like **driverless tractors, smart irrigation and fertilization systems, intelligent sprayers, vertical farming software, and AI-powered harvesting robots**. These **AI-driven farm tools** are faster, stronger, and more precise than any human worker (Bhagyalaxmi et al., 2016)

2. Farming of the Future

AI technology is bringing a new era of change to agriculture. **Computer vision technology**, in particular, has many uses, from monitoring soil and crop yields to diagnosing diseases and creating data models (Bhaskaranand & Gibson, 2011).Farming is one of the world's oldest jobs. With the global population increasing, there's a growing need to grow more and better-quality crops. New technologies like **AI and deep learning** can help people in rural areas by giving them access to the same tools that are available in cities. This can help with issues like low productivity, language barriers, and a lack of water. With voice assistants like Alexa and Siri, even those who don't speak or understand English can use these tools to communicate. These days, **AI, machine learning, the Internet of Things, cloud computing, and blockchain** are some of the most talked-about technologies. We

The use and adoption of new technologies are leading to what's being called the **"Fourth Industrial Revolution." Blockchain and AI** are at the heart of these changes. Blockchain stores information in a scrambled, secure way. Both AI and blockchain offer significant potential for businesses, and many companies are currently trying to figure out how to best use them (Birrell et al., 1996).

Creating a business that uses both blockchain and AI requires a lot of specialized knowledge and careful research. Blockchains are great for storing personal data securely when set up correctly, and they can bring a lot of value and convenience to our lives. Think about smart medical systems that make decisions based on our health data, or the recommendation engines used by Amazon and Netflix that suggest what we might want to buy or watch. These are all examples of how this technology can be applied.

The main difficulties in farming are:

1. Getting enough water.
2. Dealing with the timing of rainstorms.
3. Having access to natural fertilizers.
4. Finding transportation to move crops.
5. Having enough production capacity.
6. Market values for popular crops can go down.

Figure 3 Image of drones'

overuse of pesticides and other chemicals, which keeps our food safer (Figure 3; Blascoetal., 2002)

AI can be used in many parts of agriculture, including **supply chain management, smart farming, autonomous transportation, and smart retail**. By analyzing weather, temperature, water use, and soil, AI helps farmers make better choices for growing healthy and productive crops.AI systems are used in **precision farming** to improve both the quality and accuracy of harvests. In this method, AI helps identify plant diseases, pests, and poor plant nutrition. AI-powered sensors can detect weeds and apply the right herbicides only where they're needed. This prevents the

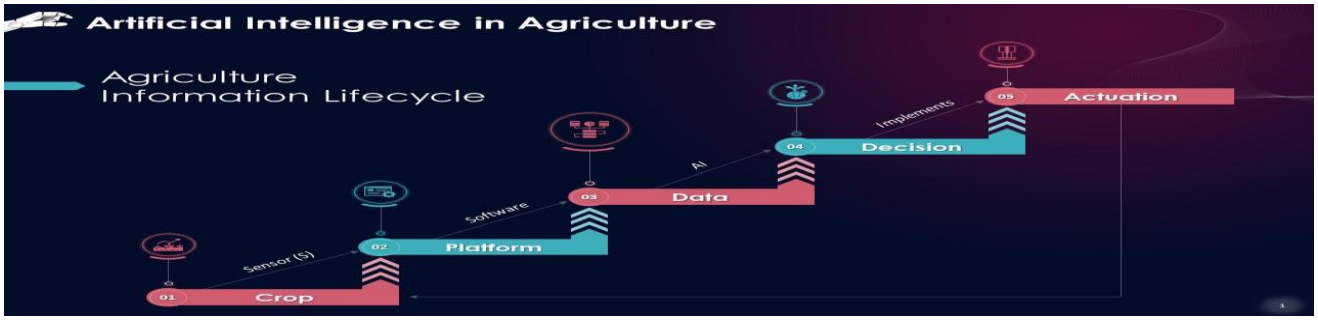

Figure 4. The function of artificial intelligence (AI) in the agricultural information management cycle

Farmers use **AI** to build powerful forecasting models that help improve farming precision and efficiency. These models can predict future climate patterns far in advance, allowing small-scale farmers to make better, more informed decisions. Since information is often hard to come by in developing countries, these small farms need to be able to predict events regularly. Given that small farms produce 70% of the world's crops, it's crucial to support their continued operation and development (Bond & Grundy, 2001)

Here are some applications for **agricultural drones**:

- **Planting seeds**
- **Analyzing soil** and fields
- **Targeted spraying** for specific spots or entire harvests

- **Mapping and surveying** of crops
- **Monitoring and managing** water systems
- **Continuous surveillance** of livestock

The most promising new **AI technologies** that could change agriculture are:

- **Monitoring crops and soil**
- **Observing when crops are ready** to harvest
- **Detecting plant diseases** and insects
- **Smart spraying**
- **Automatic weeding**

3. How AI Revolutionizing Agriculture

A lot of the tasks and steps in farming are still done by hand. **AI** can assist with the most complicated and repetitive jobs by working with technology that's already in use. When combined with other tools, AI can collect and analyze huge amounts of data on a digital platform, decide on the best steps to take, and even start those actions on its own (Figure 4; Buchanan, 1989).

The following processes could benefit from combining AI with agriculture:

AI can simplify crop selection by analyzing market demand and assisting farmers in identifying the most profitable product.

- Risk management

Forecasting and predictive analytics can help farmers reduce errors in business processes and lower the chance of crop failure.

- Seed breeding

By gathering information about how plants grow, **AI** can help create crops that are more resistant to diseases and better suited to different environmental conditions

- Monitoring soil health

AI systems that check soil health can perform a chemical analysis of the soil and give a precise estimate of any missing nutrients (Anand et al., 2015)

- Protecting crops

AI can monitor the health of plants to find and even predict diseases. It can also identify and get rid of weeds, and provide the right solutions for pest control (Anthony et al., 2014).

- Crops that are fed

AI can help farmers determine the best irrigation schedules, the right times to apply fertilizer, and even predict the best combination of crops to grow (Anand et al., 2015).

- Harvesting

AI can assist farmers in deciding the best times for irrigation, when to apply fertilizer, and even what mix of crops would be most successful (Anand et al., 2015).

4. Crops and Soil

The health and quality of crops, along with how much they produce, depend on the **micronutrients** and **macronutrients** in the soil. Traditionally, farmers have had to rely on their own eyesight and experience to judge the quality of the soil and the health of their crops. Rather than collecting aerial image data and training computer and sense of direction models to use it for insightful crop and soil monitoring, we can now employ drone technology (UAVs) to capture aerial picture data and train computer and sense of direction models to use it (Figures 5 and 6). An Unmanned Aerial Vehicle (UAV).

This data can be analyzed and interpreted by visual sensing AI to:

- Keep tabs on crop health.
- Predict yields with accuracy.
- Identify crop deficiency far more quickly than humans.

AI technologies can alert farmers to particular problem regions, allowing them to take rapid action (Chang & Lin, 2018).

5. Using AI to Observe Crop Maturity

Researchers can learn more about crop maturity by collecting alternate years and doing timely experiments on them. They will learn about the crop ripeness from time to time, but this information may not be correct. It is like putting on a show for wheat (Figure 7).

This vision-based idea was discovered to surpass human objective observation in properly recognizing crop (wheat) growth stages, eliminating the requirement for farmers to visit the fields on a regular basis to monitor their crop (Figure 8; Choudhary et al., 2019). Farmers used to check the ripeness of tomatoes by visiting the field everyday and checking them with their hands to see how they were developing, but today they must and-check the maturity of fresh

Figure 5 Large-scale drip irrigation sprinklers using water

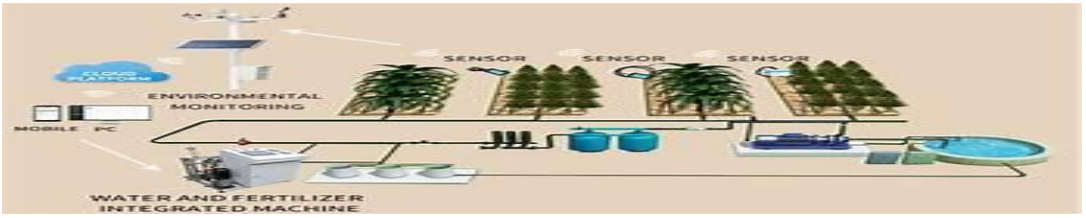

Figure 6 AI and Visual Sensing

Figure 7 Ripening of tomatoes

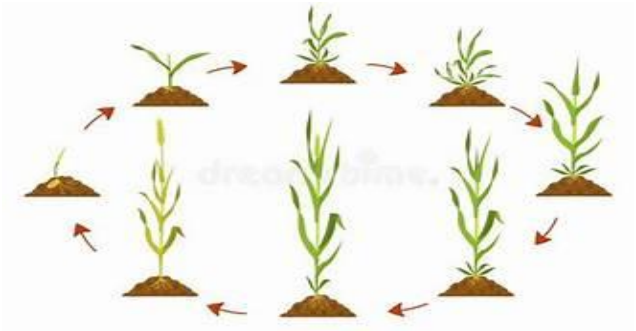

Figure 8 Stages of growth of wheats

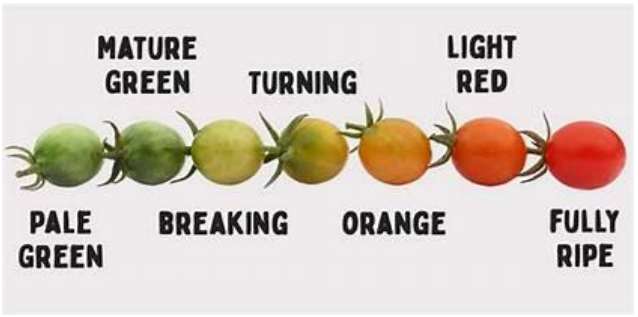

Figure 9 Stages of ripening of tomatoes in a farm

tomatoes on an industrialized level. Computers, on the other hand, have made life easier in every way. Machines, for example, can check for waste and ripeness in factories; in the field, various AI technologies allow farmers to assess the freshness of tomatoes without touching them (Figure 9; Chung et al., 2016).

6. Applying Computer Vision in the Field

Farmers must collect soil samples and transport them to a research facility for time-consuming and energy-intensive analysis. Instead, the researchers decided to investigate if picture-relevant data from a ridiculously low easily portable scanning electron microscope could be used to create training model to perform the same thing. For monitoring insect and plant diseases, deep learning-based image identification technology can

be used to identify plant pathogens and pests. This technique builds systems that can "keep an eye" on plant condition by utilizing categorization, detection, and picture segmentation methodologies (Artificial Neural Network Based Segmentation) (Cillis et al., 2018).

As shown in Figures 10 and 11, the insecticides can be verified using AI method in farm to protect plants from harmful insects.

The investigators utilized a sticky pit to capture six different organisms of flying insects and take a picture of them in real- time basis. They utilized YOLO object recognition for detection and coarse counting and support vector machines (SVMs) having worldwide features for the data and fine counting. After that, their computer vision model correctly detected and counted bees, flies, mosquitoes, moths, chafers, and fruit flies with 92.5% and 90.18% accuracy, respectively. Cattle Eye is a great example of a farming company that prioritizes AI. Cow health and activity are monitored using overhead cameras and computer vision algorithms. This implies that a cattle farmer does not have to be right next to the cow always to notice a problem (Costa et al., 2012).

Alternatively, the cattle may be remotely viewed and tracked in real time, alerting farmers as soon as an issue emerges. This can be used to:

• Count animals, detect sickness, spot aberrant behavior, and keep track of major events like births. Gather information from cameras and drones (UAVs).

• Combine with other technology to keep farmers up to date on animal health, food and water availability, and so on.

7. AI-Powered Spraying

Drones (UAVs) with **computer vision AI** can spray pesticides and fertilizer evenly across a field. This technology is so precise that it avoids damaging crops or the surrounding environment. Previously, farmers who sprayed by hand would often apply too much or too little in certain areas, which could be harmful. While this technology improves efficiency, we should also think about reducing our reliance on chemicals. Using natural alternatives like manure, cow dung, and kitchen waste is better for both our health and the environment, as chemicals can be very harmful to humans (Figure 12; DeOca et al., 2018).

8. The Automation of Weeding

When weeds are removed by hand, it saves farmers both time and hard work. It also means fewer chemicals are needed, which makes farming better for the environment and more sustainable (Figure 13; Dela Cruz et al., 2017).

A group of scientists is working to make this even easier by creating **agricultural robots** that can detect weeds and check soil moisture levels on their own.

9. The Evolving Role of Farmers: From Cultivators to AI Engineers

Throughout history, farming has used technology to become more efficient and reduce the amount of physical labor needed. Since the beginning of agriculture, people have made progress by inventing things like better plows and irrigation systems, and later, tractors and now **AI**. A major recent advancement in this area is the widespread and

affordable availability of **computer vision** technology (Figure14).

Figure 10. Insecticides using AI method in farm

Figure 11 Insecticide Application with AI Technology

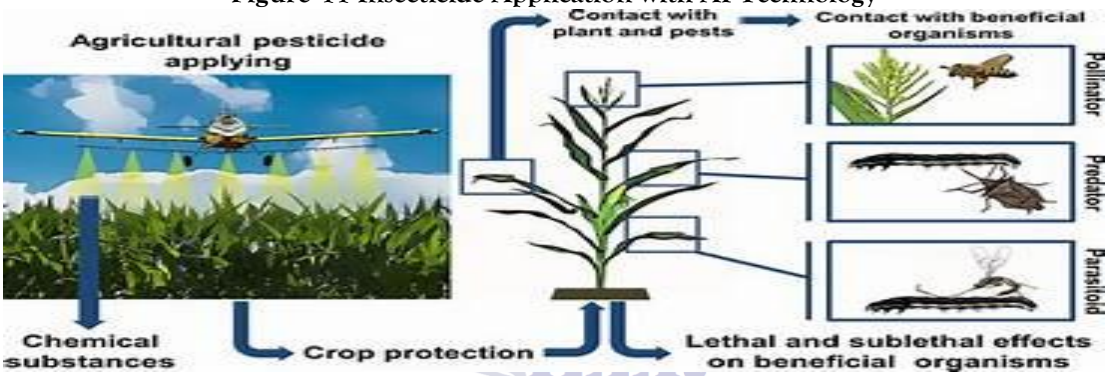

Figure 12 On-Farm Research for Insect Monitoring

Figure 13 Using AI and Drones for Precision Weeding

Figure 14 How artificial intelligence is revolutionizing the agriculture industry

AI has the potential to revolutionize agriculture in the twenty- first century, given substantial changes in our climate, environment, and global food needs by:
Improving time, labor, and resource efficiency.

- Improving the long-term viability of the environment.
- Improving resource allocation's "smartness."
- Providing real-time monitoring to improve the quality and health of crops.

As a result, changes in the agriculture business will be necessary. Farmers' "field" expertise will need to be converted into AI training, which will need more technological improvements. Education costs a lot in the agriculture industry. Agriculture, on the other hand, is no stranger to innovation and adaptability. Computer vision and agricultural robotics are two recent examples of how farmers may use new technology to fulfill rising global food demand and improve food security. AI's future hope is our next generation, which has the power to build chemical-free agriculture. Society's thinking need to change as sending their children into technological and medical professions has promise, but we also needed to consider agriculture. Many engineers choose the agricultural business after graduation, and with the help of AI, they are revolutionizing the future of agriculture, making it easier and more ecologically friendly while still earning revenue.

10. Conclusion

Agriculture faces significant challenges, including a lack of proper irrigation, weeds, and the difficulties of plant care in harsh weather. However, with the help of technology, these problems can be solved and performance can be greatly improved. This is possible through AI-driven tools like remote sensors that measure soil moisture and GPS-assisted automatic watering systems. Farmers used to worry

that precision weeding would cause them to lose too much of their crop, but now self-driving robots can not only increase productivity but also reduce the use of unnecessary pesticides and herbicides. Additionally, farmers can effectively use drones to spray their fields, making plant monitoring much simpler. This allows farmers to use their intelligence to analyze resources and job limitations in a way that wasn't possible before. Traditional methods of gathering agricultural data—such as plant height, soil texture, and content—required a lot of time-consuming physical work. The new technologies being explored allow for quick, non-damaging analysis, providing flexible, on-demand access to information and spatial goals (Doherty & Rudol, 2007).

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