

FROM PRECISION FARMING TO AUTONOMOUS FARMING: THE ARTIFICIAL INTELLIGENCE REVOLUTION IN AGRICULTURE

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ABSTRACT

The agricultural sector is rapidly transforming with Artificial Intelligence (AI) and autonomous technologies. This article explores the shift from precision to autonomous farming, showcasing how AI enhances productivity, efficiency, and sustainability. It highlights key technologies like drones, IoT sensors, satellite imagery, and machine learning, enabling data-driven decisions. The article also examines the benefits and challenges of autonomous farming, with examples from John Deere, FarmWise, and Granular. Finally, it discusses AI's future potential to boost food production, promote sustainability, and create new business opportunities.

KEYWORDS: Precision farming, Autonomous farming, Smart agriculture, IoT in agriculture, AI-powered farming,

INTRODUCTION

The agriculture sector is one of the fundamental pillars of the global economy. Although it is one of the oldest industries, it continues to evolve rapidly to meet the growing demands of a rising population. Currently, agriculture contributes approximately 4% to the global GDP, with this figure reaching up to 25% in developing countries. In India, the agriculture sector accounts for 18.2% of the GDP. For billions of people, especially in rural areas, agriculture remains the primary source of livelihood.

However, the sector faces mounting challenges, including climate change, resource constraints, and the need for higher productivity. Simply increasing crop yields is no longer sufficient to meet future food demands. Therefore, the agricultural industry is turning to innovative solutions such as precision farming, biotechnology, and AI-powered autonomous systems to address these challenges.

Modernizing agricultural practices must prioritize environmental sustainability. By using technology-driven solutions like precision agriculture, farmers can optimize resource use while minimizing

environmental impact. Precision farming employs technologies such as GPS, mobile devices, drones, IoT sensors, and machine learning to enhance productivity and efficiency.

THE EVOLUTION OF PRECISION FARMING

With the advent of advanced technologies, precision farming is revolutionizing traditional agricultural practices. Some of the key technologies driving this transformation include:

- ❖ **Drones:** Equipped with cameras and sensors, drones capture high-resolution images of fields, providing insights into crop health, soil conditions, and growth patterns. They also support precision spraying and seeding, reducing waste and enhancing efficiency.
- ❖ **Satellite Imagery:** This technology provides a broad view of agricultural lands, helping farmers monitor large-scale operations. It aids in detecting anomalies, tracking crop health, and making informed decisions.
- ❖ **Internet of Things (IoT) Sensors:** IoT sensors collect real-time data on soil moisture, temperature, and other environmental factors. Farmers can use this information to optimize irrigation, fertilization, and pest control strategies.
- ❖ **Machine Learning and AI:** By analyzing data from drones, satellites, and sensors, AI algorithms can predict yields, detect pests, and optimize farming practices. This data-driven approach minimizes risks and maximizes productivity.

THE RISE OF AUTONOMOUS FARMING

Labour shortages and rising production costs have made automation a necessity in modern agriculture. Autonomous farming leverages AI and robotics to perform labour-intensive tasks without human intervention. This emerging practice, also known as smart farming, uses technologies such as driverless tractors, automated irrigation systems, and AI-powered greenhouse robots.

- ❖ **Autonomous Crop Management:** AI systems combined with IoT sensors enable real-time crop monitoring. Automated irrigation systems, for instance, can regulate water supply based on weather forecasts and soil moisture levels, promoting water conservation.
- ❖ **Smart Greenhouses:** AI-powered greenhouses automatically adjust temperature, humidity, and lighting conditions based on real-time data, optimizing plant growth and productivity.
- ❖ **Nutrient Management:** AI-driven soil analysis helps farmers detect nutrient deficiencies and optimize fertilizer use, improving yields while reducing waste.

EXAMPLES OF AI IN PRECISION AND AUTONOMOUS FARMING

- ***John Deere's Autonomous Tractor:*** John Deere's AI-powered autonomous tractor uses computer vision and GPS technology for navigation and planting. Farmers can control it remotely via the John Deere Operations Center mobile app. The tractor provides real-time video feeds, alerts about obstacles, and operational insights. Its advanced 360° cameras and high-speed processors ensure accurate field navigation and efficient task execution.
- ***FarmWise's Autonomous Weeder:*** FarmWise's AI-powered autonomous weeding system uses computer vision and machine learning algorithms to identify and eliminate weeds with precision. This reduces chemical usage, enhances crop yields, and promotes eco-friendly farming practices.
- ***Granular's Farm Management Software:*** Granular offers AI-based farm management software that helps farmers streamline operations, track profitability, and make data-driven decisions. It enables better resource allocation and improves overall farm efficiency.

BENEFITS OF AI IN PRECISION AND AUTONOMOUS FARMING

- ✓ ***Increased Efficiency and Yields:*** AI automates repetitive tasks, freeing up human labour for strategic roles. It allows farmers to manage larger areas with fewer resources, boosting overall productivity.
- ✓ ***Reduced Labour Costs:*** By replacing manual labour with automated machinery, AI reduces dependence on human workers, lowering labour expenses.
- ✓ ***Improved Accuracy:*** AI-powered systems analyze data from sensors, drones, and satellites, enhancing decision-making accuracy in areas such as pest control, crop monitoring, and irrigation management.
- ✓ ***Resource Optimization and Waste Reduction:*** AI-driven farming optimizes resource use, reduces waste, and minimizes the environmental impact of agricultural activities.

CHALLENGES OF AUTONOMOUS FARMING

- ✓ ***Regulatory Issues:*** The absence of clear regulations for autonomous farming creates legal uncertainties. Governments need to establish policies to ensure the safe and ethical use of autonomous technologies.
- ✓ ***Infrastructure Limitations:*** Autonomous farming requires robust infrastructure, including high-speed internet, GPS networks, and IoT connectivity. Lack of infrastructure in rural areas hampers its adoption.

- ✓ **Public Acceptance:** Farmers may be hesitant to adopt autonomous farming due to unfamiliarity with new technologies. Educational initiatives are needed to promote acceptance.
- ✓ **Cybersecurity Risks:** Autonomous farming systems are vulnerable to cyber threats, which can compromise data integrity and system functionality.
- ✓ **Data Management:** The vast amount of data generated by autonomous farming systems requires effective management and analysis tools to unlock its full potential.

FUTURE OPPORTUNITIES OF AUTONOMOUS FARMING

- ✓ **Increased Food Production:** AI-powered autonomous farming can significantly boost food production, helping meet the demands of a growing global population.
- ✓ **Enhanced Sustainability:** Precision resource management reduces the environmental impact of agriculture by minimizing waste and conserving resources.
- ✓ **New Business Models:** Autonomous farming opens avenues for new business models, including data analytics, precision agriculture services, and farm-to-table logistics.
- ✓ **Rural Development:** Autonomous farming can create new job opportunities in rural areas, driving economic growth and reducing the rural-urban divide.
- ✓ **Improved Food Safety:** AI-powered monitoring systems enhance food safety by detecting pathogens and contaminants early, reducing the risk of foodborne illnesses.

CONCLUSION

The integration of AI and autonomous farming technologies is transforming the agricultural sector, making it more efficient, sustainable, and productive. Precision farming technologies like drones, IoT sensors, and satellite imaging are helping farmers make data-driven decisions, while autonomous systems are reducing labour dependency and optimizing resource use. Although challenges such as infrastructure gaps, cybersecurity risks, and regulatory concerns remain, the future of autonomous farming is promising. With continued innovation, AI-powered agriculture will play a key role in ensuring food security, promoting sustainability, and boosting economic growth in the years to come.

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