AEM
Association of Equipment Manufacturers

AI in Agriculture Equipment

Supporting Productivity, Efficiency, and Decision-Making Through Technology

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Executive Summary

Artificial intelligence is increasingly becoming a foundational capability in agricultural equipment. The technology enables farmers to remain resilient, productive, and competitive, especially as operational challenges continue to intensify. Rather than another "nice-to-have" tool, AI in agriculture is purpose-built, task-focused, and embedded directly into machines that operate in highly variable, real-world environments.

Across modern farming operations, producers face growing pressure from weather variability, labor shortages, rising input costs, and increasingly narrow operating windows. AI-enabled equipment helps farmers manage this complexity by supporting timely, consistent, data-informed decisions during critical moments in the field. By integrating advanced data processing, machine vision, and automation directly into equipment, AI allows farmers to leverage the benefits of sophisticated technology without needing to become experts in data science or software.

Ultimately, as global competition increases and expectations around productivity, cost, sustainability, and traceability continue to rise, AI-enabled ag equipment plays a critical role in helping producers do more with fewer resources in an affordable, sustainable, and reliable manner.

This paper explores how when AI is deployed responsibly and supported by appropriate frameworks, it strengthens farm level resiliency, supports a competitive agricultural sector, and contributes to a stable and secure food system for the future.

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Introduction

In agriculture, AI is not a standalone digital product or a content generation tool. It is embedded directly into physical equipment and operational systems. These applications use machine learning, machine vision, and automation to support tasks such as identifying crops and weeds, optimizing input applications, monitoring equipment health, preventing unsafe operating conditions, and enabling automated or autonomous operation. The goal is not to replace farmers or operators, but to complement their expertise by reducing cognitive burden, simplifying decision-making, and enabling actions that would otherwise be impractical or impossible to perform manually. This approach allows farmers to focus more of their time and expertise on the aspects of farming they care about most: *managing their operations, stewarding land and resources, and producing food.*

This equipment-centered context makes agricultural AI fundamentally different from the general conception of AI. Unlike many consumer or enterprise AI tools that automate repetitive digital tasks or make decisions about people, AI in agriculture primarily influences operational outcomes. Decisions affect how machines move, apply inputs, respond to changing field conditions, or recover from faults. Most systems act on data generated by the farmer's own equipment and land, with impacts contained within that operation (rather than broadly affecting external individuals).

Agricultural AI also must function across a wide range of time horizons. Some applications require immediate, realtime decision-making, such as collision avoidance, rollover prevention, or on-the-fly application adjustments where delays are unacceptable. Other uses are intentionally non-time sensitive. As a result, agricultural AI often relies on edge computing, with models running directly on the machine rather than exclusively in the cloud. These systems are designed to be reliable, powerefficient, and capable of operating independently of factors such as internet connectivity to ensure reliability and safe operation.

Safety is another defining driver. AI in agricultural equipment is explicitly built with safety top of mind, including preventing accidents, reducing operator fatigue, working alongside farmers/operators, as well as supporting safe transitions between manual operation, automation, and autonomy. These safety considerations differ substantially from those governing digital-only AI systems.

Underlying all of these applications is a clear objective: *helping farmers make better decisions with the data they already generate.* Agriculture produces vast amounts of machine, agronomic, and environmental data, but many users lack the time, tools, or desire to manually analyze it. AI enables this data to be transformed into actionable insights that support productivity, efficiency, sustainability, and equipment longevity, all without requiring farmers to become data scientists.

Levels of AI Integration in Agriculture

Artificial intelligence in agriculture is not a single, uniform capability. Rather, it exists across a spectrum of integration, ranging from systems that assist operators with specific tasks to those that are capable of independently executing complex operations. Understanding these varying levels of integration is critical to accurately representing how AI is used in ag equipment today, and how it will continue to evolve into the future.

At a high level, AI in agriculture can be grouped into three categories based on the role it plays in decision-making and execution: ***Assist, Advise, and Act***.

1. **Assist-level AI** includes systems that support narrowly defined tasks while the operator remains fully in control of the overall operation. In these applications, AI is used to improve precision, consistency, and ease of operation without replacing human decision-making.
2. **Advise-level AI** represents a more advanced form of integration in which AI systems process and interpret large volumes of data to provide actionable insights and recommendations. In this category, the operator remains the decision-maker, but AI enhances their ability to make timely and informed choices.
3. **Act-level AI** involves systems that can execute decisions with a higher degree of autonomy. These applications incorporate perception, planning, and control, allowing equipment to perform tasks with limited to no real time operator input.

Core AI Use Cases in Agricultural Equipment

Assist-Level AI

Automated Equipment Operation (AEM Non-Road Levels 1-3)

How it works: AI enables equipment to perform defined operating tasks such as guidance, implement control, or headland management with reduced operator input. Higher levels of autonomy remain supervised and constrained by operating conditions.

Why AI is required: Field environments are dynamic and unpredictable. AI enables new features and functionalities that can be better equipped to adapt rather than follow rigid scripts.

Value delivered:

- Increased productivity per operator
- Reduced fatigue and safety risk
- Longer effective operating windows

Importantly, industry recognizes a spectrum of automation and autonomy rather than a single endpoint of full autonomy.

> **"AI enables data to be transformed into actionable insights that support productivity, efficiency, sustainability, and equipment longevity."**

Real-world scenario: A tractor equipped with various operator assistance technologies, such as auto steer, begins a full day of tillage to work the field before rain arrives. AI systems manage steering accuracy, implement depth, and headland turns, while the operator supervises operation.

As daylight fades and fatigue sets in, the system maintains consistent performance across passes. The operator remains responsible for oversight but benefits from reduced workload and improved accuracy.

The combination of human supervision and AI assistance improves productivity while reducing fatigue-related risks.

Advise-Level AI

In-Cab Operator Decision Support

How it works: AI systems synthesize machine telemetry, as well as implement feedback and historical operating data to provide contextual guidance to operators through existing displays. Recommendations may include optimal speed, machine settings, or alerts when conditions deviate from expected parameters.

Why AI is required: Operators manage increasing machine complexity while working under time pressure. AI helps translate data into actionable insight without removing control.

Value delivered:

- More consistent outcomes across operators
- Faster onboarding of less experienced labor
- Reduced cognitive load during operation

Real-world scenario: A combine operator begins harvesting a field with variable terrain and crop moisture. As conditions change across the field, onboard AI systems continuously analyze machine data, crop flow, and historical performance.

The display provides real-time recommendations on ground speed and header settings, helping the operator maintain optimal throughput while minimizing grain loss. Alerts notify the operator when performance deviates from expected ranges, allowing timely corrections.

Rather than replacing operator judgment, the system improves situational awareness and consistency, particularly during long operating days or when less experienced operators are in the cab.

Diagnostics and Predictive Maintenance

How it works: AI models analyze sensor readings, fault histories, and usage patterns to detect early indicators of component degradation. These insights can prompt maintenance actions before failures occur.

Why AI is required: Modern equipment systems generate large volumes of data that exceed the capacity of manual diagnostics alone.

Value delivered:

- Reduced unplanned downtime
- More efficient dealer service operations
- Extended equipment lifecycle

Real-world scenario: During planting season, an operator receives an alert indicating abnormal vibration patterns in a drivetrain component. AI-driven diagnostics compare current sensor readings to historical machine data and known failure patterns.

The system recommends inspecting a specific component during the next scheduled stop. Addressing the issue early prevents a breakdown that would have otherwise occurred during peak operations.

By identifying problems before failure, AI-enabled diagnostics reduce downtime, improve service efficiency, and help keep critical equipment in the field when timing matters most.

Data-Driven Continuous Improvement

How it works: Aggregated machine data is analyzed to identify long-term performance trends, validate agronomic outcomes, and inform future operational decisions.

Why AI is required: Agricultural equipment gathers vast amounts of data that operations don't always have the capabilities or capacity to utilize. AI can help streamline the process of leveraging this data into actionable recommendations and informed decision-making.

Value delivered:

- Better planning and benchmarking
- Continuous operational improvement
- Evidence-based operational decisions

Data governance, ownership, and privacy remain foundational principles across all such applications.

Real-world scenario: At the end of the season, a producer reviews aggregated machine data collected across planting, application, and harvest operations. AI analytics identify an opportunity to change the farmer's planting rotation based off a given field's historical performance to maximize inputs and ROI on that given parcel.

Act-Level AI

Targeted Spray Application

How it works: Machine vision and AI models analyze realtime imagery from cameras mounted on sprayers to distinguish between crops, weeds, and non-target areas. The system dynamically controls spray application at the nozzle level while the machine is operating in the field.

Why AI is required: Field conditions change continuously, requiring split-second decisions that cannot be preprogrammed through static rules alone.

Value delivered:

- Significant reduction in chemical use and input costs
- Improved environmental stewardship
- Enhanced documentation and traceability

This use case exemplifies AI as a realtime operational tool rather than a postseason analytical system.

Real-world scenario: A self-propelled sprayer enters the field during a narrow application window. As the machine moves, cameras mounted along the boom continuously capture imagery of the crop canopy and soil surface.

AI models process this imagery in real time, identifying weeds growing between crop rows while ignoring healthy crop plants. When weeds are detected, individual nozzles activate only where treatment is needed. As field conditions such as lighting, crop density, and residue levels change, the system adapts instantly.

The operator remains fully engaged, monitoring system performance through the cab display and retaining authority to override or adjust operation at any time. After task completion, the system provides a clear record of applied product.

The result is reduced chemical use, lower input costs, and improved environmental outcomes that are achieved through realtime, equipment-embedded AI operating under human supervision.

Autonomous Equipment Operation (AEM Non-Road Levels 4 & 5)

How it works: Autonomous agricultural equipment is designed to perform in defined field operations without an onboard operator while remaining supervised by a human responsible for deployment, task definition, and monitoring. AI systems integrate perception, localization, path planning, and obstacle detection to allow the machine to operate within geofenced areas and pre-defined conditions.

Why AI is required: Unlike controlled industrial environments, agricultural fields are highly dynamic. AI can help to interpret unpredictable terrain, weather changes, crop variability, and unexpected obstacles in real time.

Value delivered:

- Addresses persistent labor shortages
- Enables longer and more flexible operating windows
- Improves task consistency and repeatability
- Reduces operator exposure to fatigue and safety risks

Importantly, autonomy in agriculture is deployed purposefully and incrementally. Systems are constrained by task type, field conditions, and regulatory requirements.

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Real-world scenario: An autonomous machine is deployed to perform a repetitive field task within a geofenced area. Before operation begins, a human supervisor defines the task parameters and monitors progress remotely.

AI systems manage navigation, obstacle detection, and task execution, adapting to changing field conditions in real time. If unexpected conditions arise, the system alerts the supervisor and pauses operation as needed.

This supervised approach enables longer operating windows and addresses labor constraints, all while keeping human accountability central to safe deployment.

Conclusion

Artificial intelligence is becoming a foundational capability for modern agricultural operations, playing a critical role in helping farmers remain resilient amid mounting operational challenges. Weather variability, input cost volatility, labor shortages, and tighter operating windows are placing unprecedented pressure on agricultural productivity. AI-enabled equipment helps farmers manage this complexity by supporting timely, data-informed decisions, maintaining consistent performance (even as conditions change rapidly), and allowing farmers to focus their time and expertise on the aspects of farming they value most. By embedding advanced data and technology directly into equipment, AI enables producers to benefit from sophisticated analytics and automation, without needing to become technology experts, while freeing them to do what they do best: *farm*.

Operational resiliency in agriculture increasingly depends on the ability to adapt in real time. AI-embedded in equipment allows farmers to respond dynamically to variable crop conditions, unexpected disruptions, and equipment issues before they escalate into costly downtime or lost yield. From precision application and predictive maintenance to automated and autonomous operation, AI strengthens the reliability of critical field operations during the moments when timing and execution matter most.

At the same time, AI is essential to maintaining global competitiveness across the ag sector. Farmers around the world are operating in an increasingly competitive, technology-driven environment where efficiency, sustainability, and consistency directly influence market access and economic viability. AI-enabled equipment helps level this playing field by allowing producers to do more with fewer resources while meeting rising expectations for environmental stewardship and traceability.

Looking ahead, the continued responsible development and deployment of AI in agricultural equipment will be vital to ensuring a resilient, competitive, and sustainable food system. It serves as a powerful tool that strengthens human decision-making and equips farmers to meet the challenges of today and the demands of the future. In this way, AI-enabled agricultural equipment not only strengthens individual farm operations, but it also plays a critical role in supporting national food security by helping ensure a reliable, resilient, and productive agricultural system capable of meeting both domestic and global demand.

Appendix: Industry Initiatives Supporting AI in Agriculture

This appendix is a non-comprehensive list of industry efforts that provide foundational support for AI-enabled agricultural equipment. Together, these initiatives help ensure that AI technologies are interoperable, secure, safe, and aligned with the practical realities of agricultural operations.

- **ISO/TR 22100** part 5 - Implications of artificial intelligence machine learning
- **ISO/IEC 42001** - Information technology — Artificial intelligence — Management system
- **ISO/IEC 23894** - Information technology — Artificial intelligence — Guidance on risk management
- **ISO/IEC 5338** - Information technology — Artificial intelligence — AI system life cycle processes
- **ISO/IEC 5259** parts 1-6 - Artificial intelligence — Data quality for analytics and machine learning (DQAM)
- **ISO 26604-1** - Safety of autonomous machinery— Part 1: Soil-Working Machinery
- **ISO 10975** - Auto-guidance systems safety requirements
- **ISO 18497** parts 1-4 - Agricultural machinery and tractors — Safety of partially automated, semi-autonomous, and autonomous machinery
- **ISO 15143** - Worksite data exchange
- **ISO 15817** - Safety requirements for remote operator control systems
- **ISO 16001** - Object detection systems and visual aids – Performance requirements and tests
- **ISO 17757** - Autonomous and semi-autonomous machine system safety
- **ISO 21815** - Collision warning and avoidance
- **ISO 23724** - Remote stop function for mining equipment
- **ISO 23870** - Secure high speed mobile data communication gigabit onboard speed
- **ISO 3502** - Reference framework and architecture for advanced automation and autonomy
- **ISO 3991** - Robotic feed systems — Safety
- **ISO 7334** - Taxonomy and vocabulary for automation and autonomy
- **ISO TS 15143-4&5** - Worksite data exchange: Parts 4 & 5
- **ISO 21815-4&5** - Collision warning and avoidance: Parts 4 & 5
- **ISO TS 22133** - Test object monitoring and control for active safety and automated/autonomous vehicle testing - Functional requirements, specifications, and communication protocol

About the Association of Equipment Manufacturers (AEM)

AEM is the North America-based international trade group representing off-road equipment manufacturers and suppliers with more than 1,000 companies and more than 200 product lines in the agriculture and construction-related industry sectors worldwide. The equipment manufacturing industry in the United States supports 2.2 million jobs and contributes roughly $415 billion to the economy every year.

AEM's robust history began 130-plus years ago from a unique vantage point – its industry segments came together to create a fundamentally more powerful voice and advocate for the non-road equipment manufacturing industry.

AEM built on the successes and continued the legacy of its founding groups – the Construction Industry Manufacturers Association (CIMA) and the Equipment Manufacturers Institute (EMI). Both groups had a common goal – advocating for better roads that brought products to market faster, safer, and more efficiently.

For more than a century, AEM has provided a manufacturer forum for industry-wide action that transcends individual member company size, product line, or individual business concerns. Companies participating in AEM work together for the betterment of the industry and public needs, at the state, national, provincial, and international levels. In enabling growth together, AEM and its members build momentum for equipment manufacturers and the ag and construction markets they serve.

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