

The AI Paradigm Shift: Orchestrating Sustainable Productivity in Modern Agroecosystems

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Abstract

The study aims to find out the participation of artificial intelligence in modern farming. By drawing on John Deere's newest innovations, we explore the role of AI-driven machines in agriculture.

The See & Spray technology has a system equipped with high-speed cameras and "digital brains" that can immediately differentiate between crops and weeds. It scans a 195 square meters at once, ensuring that chemicals are applied only where they're truly needed.

The results display a significant 60% decrease in chemical usage. This study highlights that AI goes beyond merely enhancing profits; it serves as a vital partner in safeguarding the soil, cultivating healthier crops, and maintaining a balanced relationship between agriculture and nature.

Keywords: Artificial intelligence, Sustainability, John Deere company, Protecting the environment, Smart agriculture

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1. INTRODUCTION

Artificial intelligence is shifting the core of farming; it is no longer just about machines, but about giving farmers the "smart" tools they need to be better guardians of the land. By drawing on data and machine learning, we are making agriculture more suitable for nature. Today, these technologies are more than just a choice, but they are a lifeline. They assist us in facing the serious challenges of our time: feeding and protecting dwindling resources.

AI monitors the soil, weather, and crops to provide farmers with real-time insight about what is best for their land.

More than just a technological pioneer, John Deere is a trusted brand that sees its success as an opportunity to do essential procedures.

AI and machine learning act like partners that learn and grow alongside the farm. By taking on the heaviest and most complex tasks, they give farmers back a priceless gift: the time to focus on what truly matters. In the end, this autonomy isn't just a tech revolution; it's a way to make life better and more balanced. (John Deere, 2022).

By wisely choosing to spray only the weeds, See & Spray Select acts as a watchful protector of the land, helping farmers reduce their chemical footprint by an amazing 77%. (BEDORD, 2021).

Farmers work hard to make sure nothing goes to waste. John Deere is right there with them, creating technology that looks at every single plant as an individual, giving it exactly what it needs to thrive, while protecting the land by using only what is necessary.

Since partnering with See & Spray in 2017, John Deere has given machines 'eyes' of their own. They've built a technology that actually looks after the land by meticulously employing AI to detect weeds. For Julian Sanchez of John Deere, this is more than simply a clever move; it's a fundamental method to help farmers preserve their crops with considerably less pesticide.

Farmers can now treat their land with exceptional precision thanks to See & Spray Select, which reduces chemical use by 77% on average. By focusing just on the weeds, they may apply the best, most effective treatments

without incurring high costs. It's a wiser, more intelligent approach to dealing with even the hardest weeds while protecting both the budget and the land.

In a world where we demand more from the land than ever before, how can artificial intelligence assist farmers in caring for each plant and allowing them to provide enough food for everyone while also conserving the soil?

OBJECTIVES

- To comprehend how AI is transforming our lives and jobs in the digital era.
- To uncover the real-world doors AI can open, while remaining conscious of the human barriers we must overcome.
- To show how AI can actually help farmers grow better harvests and create a more sustainable future for everybody.

2. The digital transformation

2.1 The Digital Transformation Processes:

Every business has its own rhythm when it comes to technology, but regardless of the area, the road toward turning digital generally occurs in four basic stages. (Coursera, 2023).

- **Early stage.** The first stage of the process includes planning, cultivating the necessary partnerships, and testing the organization's capabilities.
- **Mid-stage.** During this stage, business leaders choose focus areas like business processes, digital products, or key roles within the organization.
- **Growth stage.** The growth stage in a digital transformation project emphasizes scalability. It focuses on adopting new business processes, products, and protocols across the organization.
- **Mature stage.** The final stage in a digital business transformation is centered around continued innovation and improvement. A strategic approach to governance should also be defined during the mature stage.

2.2 Benefits of digital transformation:

Embracing these digital tools not only updates our systems, but it opens up a world of new possibilities, such as:(Managed Outsourcing solutions, 2022).

- Helping the team do their best work without the usual errors or extra stress.
- Giving the business the freedom to pivot quickly and keep things running smoothly.
- Expanding the business's reach and potential.
- Creating true connections with consumers and ensuring they feel appreciated.
- Improving the bottom performance to sustain the firm and support its people and objectives.

3. Artificial Intelligence

3.1 The Definition of Artificial Intelligence:

At its basic components, AI is about designing robots that can help with the 'thinking' side of life by taking on duties like solving puzzles, making choices, and working through difficulties that previously required a human touch. (Coursera, 2023).

In a way, AI is our attempt to share a bit of our own intelligence with machines. It's about building technology that doesn't just follow orders, but can actually learn, find meaning in information, and grow wiser from experience. (copeland, 2023).

According to John McCarthy, the man who first gave the field its name, described it in 2004:"It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence." (www.ibm.com).

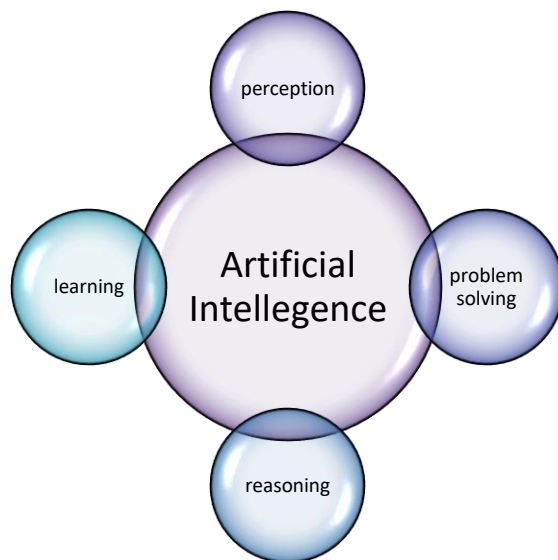
Basically, AI is about building computers that can handle the heavy lifting of the mind—taking on those tricky problems and big decisions that usually require a human brain to figure out. (www.ibm.com)AI is really about teaching technology to follow our lead; it's the effort to give machines a way

to handle information and reach conclusions with the same kind of logic and intuition we use every day. (Ed & Nicole , 2023). While AI is set to redefine enterprise workflows, organizations must first navigate significant operational and technical hurdles to truly capture the value of this fast-moving technology. (Tucci, 2023).

3.2 Components of Artificial Intelligence:

Essentially, we're training AI to perform the things that come easily to us: learn from experience, think through a choice, solve a challenge, perceive the environment around it, and most importantly, speak our language.

Fig.1. The main compounds of artificial intelligence



Source: developed by authors.

3.3 Types of Artificial Intelligence:

When we talk about AI, we're usually looking at two different kinds of artificial intelligence, which are weak and strong.(FRANKENFIELD, 2023).

- **Weak artificial intelligence:** Weak AI is a specialist who excels at one task but is unable to perform any others. It's like a world-class chess computer that can defeat anyone at the game but can't brew a cup of

coffee, or assistants like Siri and Alexa that are great at finding answers but don't know you in the same way your partner does.

- **Strong artificial intelligence:** Strong AI is the 'independent thinker' of the tech world. Instead of just following a script, these systems are designed to handle life's messy, unpredictable moments on their own, whether that's a self-driving car navigating a busy intersection or a surgical robot helping a doctor save a life. It's about giving machines the ability to make the right call, even when we aren't there to guide them.

3.4 The history of artificial intelligence:

The history of AI has gone through several stages:(FRANKENFIELD, 2023).

- Back in the 50s and 70s, scientists built what they called neural networks—basically a digital version of the human brain. These networks pass information through a web of digital neurons over and over again until they finally have that machine.
- 1980s-2010s: Machine Learning became popular. Machine learning automates analytical model building. It uses methods from neural networks, statistics, operations research, and physics to find hidden insights in data without explicitly being programmed for where to look or what to conclude.
- From the 80s through 2010, by using a clever mix of math and science, these machines became like digital detectives; they can dig through a mountain of data to find their own clues and spot patterns that we might never notice, all without us having to tell them exactly what to look for.
- Right now, Generative AI is the superstar of the tech world. While today's AI is like a brilliant assistant that follows instructions, AI would be more like a partner—a machine that doesn't just process data, but truly 'gets' the world and can think, learn, and solve problems. (Maansi_gupta, 2020).

4.The role of artificial intelligence (AI) in transformative agriculture

AI is utilized in agriculture to address plant and soil-related issues, not only to decrease resource waste, but to safe guard human lives from chemicals by targeting just the weeds. (Piddubna, 2024).

Fig.2. The role of AI in the agriculture field



Source: (Fadziso, 2019)

4.1 Precision agriculture:

- **A personal guardian for every plant:** With drones and sensors functioning as "eyes in the sky," farmers can monitor the health of every single crop in real-time.
- **The end of guesswork:** AI replaces that "gut feeling" with certainty, revealing exactly what is occurring beneath the surface, allowing farmers to respond with confidence.
- **The right care, in the right place:** Instead of treating an entire field the same way, AI acts like a precision tool. It spots exactly which corner of a field is thirsty or needs extra nutrients, ensuring every drop of water and bit of fertilizer goes exactly where it's needed.
- **A protected planet:** By cutting out waste and only using what's necessary, this technology makes farming much gentler. It's about

growing more food while being more respectful and protective of the land.

4.2 Predictive Analytics :

- **Predicting the trouble:** It helps farmers spot incoming storms, pest invasions, or crop diseases before they even hit, allowing them to act before it's too late.
- **Turning uncertainty into confidence:** Instead of just reacting to the unpredictable weather, farmers get clear alerts.
- **Perfect timing:** By reading both the climate and the market, AI helps farmers decide exactly when to plant or sell. It's like having a weather expert and a financial advisor 24/7.
- **Predict the harvest:** The goal isn't just about data; it's about anticipating the amount of harvest at the end of the season.

4.3 Autonomous Machinery:

- **Taking over the heavy tasks:** AI-powered tractors and harvesters can now drive themselves, handling the most exhausting parts of the day. This gives farmers a much-needed break and allows them to focus on the bigger decisions.
- **Monitor in the field:** Technologies like John Deere's "See & Spray" can actually tell the difference between a healthy crop and a weed in an instant.
- **Targeting only the damaged pants:** Instead of covering an entire field in chemicals, the machines only spray the weeds. It's a precision approach that keeps the soil cleaner and the plants healthier.
- **A good assistant:** It's giving farmers better tools to manage their land with less stress, making the work faster, more precise, and much more sustainable.

4.4 Smart Irrigation and Water Management:

- **A smart watering:** AI caters to the soil and knows exactly how much moisture is left, ensuring that plants only get water when they truly need it.
- **A quiet forecaster:** The system anticipates weather, including rain, wind, and sun, in addition to ground conditions.

- **Respecting every drop:** By riding out the overthinking, AI helps farmers become better partners to the environment. It protects precious resources, making sure that water is used wisely and never wasted.

4.5 Livestock Monitoring:

Instead of just spraying water everywhere on a timer, AI acts like a thoughtful guardian for the fields. It caters to the soil needs to see how dry it is and checks the forecast to see if rain is on the way. By making sure every plant gets the perfect amount of water, it keeps the crops thriving while being incredibly respectful of our water supply.

5.5 Crop Monitoring and Disease Detection:

AI acts like a watchful protector that never fails. Using smart cameras, it scans the plants to catch the first signs of need or sickness. It gives farmers a notification, so they can step in and help a struggling plant before a small problem turns into a lost harvest.

3-7. Supply Chain Optimization:

AI acts like a 'field protector' with perfect vision. It scans every leaf to catch the first signs of a plant feeling 'sick' or 'hungry' long before we could ever notice. By giving farmers a quick notice, it allows them to step in and help exactly where it's needed, saving the crop and keeping the whole farm healthy and thriving. Examples of these AI technologies in the agriculture area are as follows:

- **Blue River Technology:** This technology can differentiate between a healthy plant and a weed in a split second, making sure it only targets the "bad leaves" and keeps the rest of the field clean and chemical-free.
- **Farm Bot:** This technology handles the heavy work of planting seeds and tending to the soil with perfect accuracy, with accurate programs.
- **Prospera Technologies:** This acts like a 24/7 caretaker for indoor farms. It watches over every greenhouse plant like a protective guardian, automatically adjusting the "weather" inside to make sure every leaf is comfortable, hydrated, and healthy.

Bringing AI into farming is about more than just technology; it's about making sure we can feed our world without hurting the earth. By helping farmers grow more food while using less water and fewer chemicals, these tools are building a future where our food supply can handle upcoming challenges.

5. CASE STUDY OF JOHN DEERE COMPANY

5.1 About the Company:

The iconic green image represents nearly 200 years of history. It all began back in 1837 with a small-town blacksmith named John Deere, who wanted to make life easier for farmers by inventing a better plow. What started in a tiny workshop has grown into a global family that spans over 30 countries. Today, they still carry that same spirit, using modern technology to help people work the land and protect the environment.

5.2 Technologies Used:

Fig.3. Corn field equipped with blue river technologies



Source:.(Irina, 2022)

Blue River Technology: The heart of precision farming is about doing more with less cost, using fewer chemicals while taking better care of the land. In the past, farmers had to treat their entire field the same way, like giving everyone the same medicine whether they were sick or not. But today, technology acts like a set of 'eyes' for the tractor. Tools like John Deere's See & Spray™ can actually differentiate between a healthy crop and a weed. Instead of a wasteful spray, it only targets the 'bad leaves,' keeping the soil

cleaner, the plants healthier, and the farmer's budget in much better shape. (Mississippi State University, 2024).

Blue River Technology is essentially giving tractors a brain and a pair of eyes. Their 'See & Spray' system doesn't just treat a field as one giant green field; it sees every individual plant. It's smart enough to say, 'That's a crop, leave it alone,' and 'That's a weed, get it!' By being so selective, it stops the wasteful 'rain' of chemicals, saving the farmer money and keeping the local ecosystem much healthier. It even leaves behind a digital 'treasure map' of the field, so farmers can understand their land better than ever before.

See and spray technology:

Fig.4. corn field using see and spray strategy



Source: (Clean Fields. Better Yields., 2024)

The company has created a machine with 36 'eyes' that can scan an area the size of a large house at once. Known as See & Spray™ Ultimate, this technology uses lightning-fast AI to spot weeds hiding among crops with pinpoint accuracy. By moving away from spraying blindly, the organization helps farmers cut chemical use by more than 66%. It's a shift from using a giant floodlight to a focused laser beam, protecting the plants, saving the farmer money, and being much friendlier to the earth.

5.3 The Agriculture Benefits from John Deere Company AI-Driven:

5.3.1 Enabling real-time decision-making: By using AI in farming, that enables farmers can benefit from these features:

- **Work Anywhere, Every Time:** The company puts the "brain" directly on the machine so it doesn't need a cell signal to work. This allows the equipment to make instant decisions in remote fields, to make sure the work never has to stop.
- **Tough Enough for the Job:** The organization builds rugged systems designed to handle trillions of calculations while standing up to heat, dust, and constant shaking. They are built to be as tough as the people using them.
- **The core of the Fleet:** This technology isn't merely an isolated innovation; rather, it represents the foundational system embedded within all their smartest machines. Whether a tractor is driving itself or a sprayer is spotting weeds, this underlying technology is what makes it all possible.

Fig.5. AI-Driven machines



Source: (John Deere, 2022)

5.3.2 Machine Learning: To make technology like 'See & Spray' possible, the software scans millions of photos, learns to tell what the difference between a healthy crop and a weed, even in tough conditions like dust, clouds, or low light. The organization doesn't just program these machines once; they help them learn from real-world experience. Once the software has 'studied' enough to become an expert, that wisdom is sent back to the equipment, providing the farmer with a partner in the field that actually gets smarter every single day. (JOHN Deere , 2024)

6. WHAT ARE THE COMPANY'S GOALS?

6.1 Specific Goals for Farmers: (John Deere, 2022)

- **A Massive Support Network:** By 2026, 1.5 million machines will be "talking" to each other. This means farmers aren't working alone; they are backed by a huge library of shared data that helps them make the best choices for their specific soil.
- **Walking the Fields Together:** The company doesn't just sell machines from an office. They spend time on the land with farmers, listening to their challenges and using that real-world experience to design better tools for the future.
- **Doing More with Cost Less:** The organization is helping farmers become incredibly precise. By making sure every drop of fertilizer or spray goes exactly where it's needed, they ensure that nothing is wasted.
- **A Legacy for the Future:** By making farming more efficient, the company helps families stay profitable while protecting the environment. It's about keeping the land healthy.
- **Helping with heavytasks:** The company is bringing "smart" tech to people in construction and logging. These tools take the guesswork out of the job, making the workday smoother, safer, and more successful.
- **A Proven Success Story:** Their "See & Spray" technology is already at work on over a million acres. It allows farmers to treat their land with a level of care that simply wasn't possible before.

- **Saving a crop of chemicals:** By helping farmers target only weeds and skip the crops, the company has saved over 8 million gallons of spray. That is like keeping 12 Olympic-sized swimming pools of chemicals out of the environment while saving the farmer money.
- **Cutting the Red Tape:** The company knows that "green" programs can often mean a mountain of paperwork. To help, they added a new Sustainability Section to their digital center, making it easy for farmers to get rewarded for the good work they do for the planet.
- **Good assistance:** By welcoming Smart Apply into the fold, the company is giving more people tools that treat every plant with care. It is all about being precise so that nothing goes to waste.
- **Sharing the "Brains":** The organization believes its best technology should be for everyone. Whether someone is building a road, managing a forest, or running a construction site, they now have access to the same smart "dashboard" used by farmers to stay organized.

6.2 Global Goals:

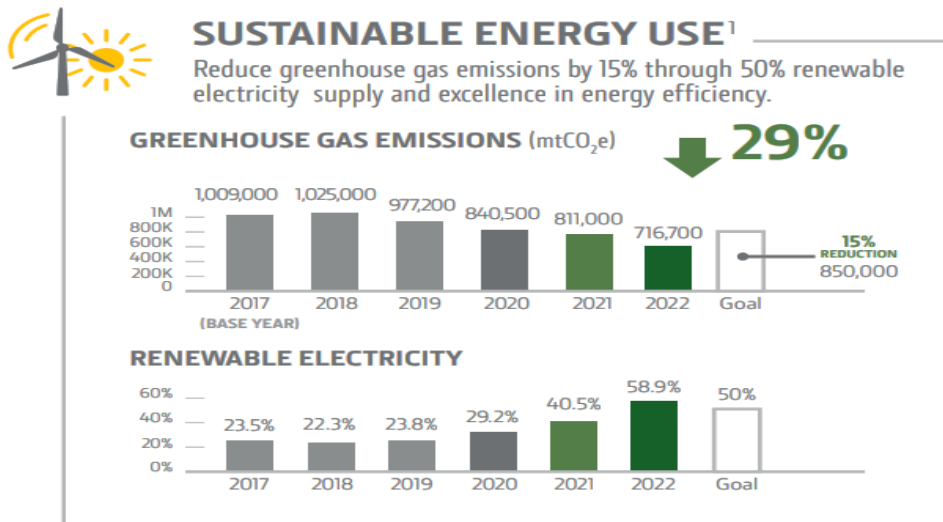
- **Sustainable Energy Use**
- **Safe water:** Taking care of our water isn't just a science project; it's about making sure the lakes, rivers, and land we love stay healthy and beautiful.
- **Save money:** When we use water wisely, we're protecting our wallets. It keeps farms producing, businesses growing, and grocery prices stable for everyone.
- **Good life:** This is about making sure that when our kids and grandkids grow up, they don't have to worry about where their next glass of water is coming from. It's about building a world where every community can thrive.

6.3 Recycling Goal:

6.3.1 Sustainable Energy Use: The company has reduced by 29 %greenhouse gas emissions exceeding the plan's target of 15%. In addition, it used58.9 percent of its renewable electricity supply and achieved

excellence in energy efficiency, surpassing its goal of 50% only, as follows in figure 06.

Fig.6. Sustainable Energy Use



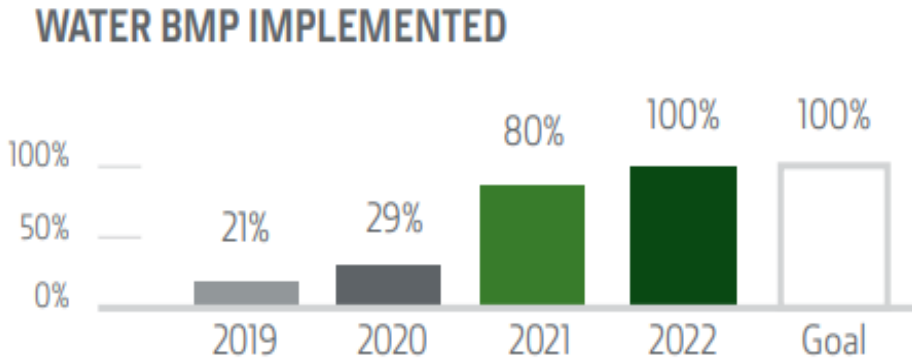
Source: (John Deere, 2022).

The firm not only fulfilled but exceeded its sustainability targets, exhibiting a strong commitment to environmental management.

6.3.2 Use Water Responsibly: The Figure demonstrates strong progress in adopting water management best practices, with the organization successfully achieving its full implementation goal by 2022. (John Deere, 2022)

- a. **Steady Improvement (2019–2020):** Implementation increased gradually from 21% to 29%.

Fig.7. Water Bmp Implemented

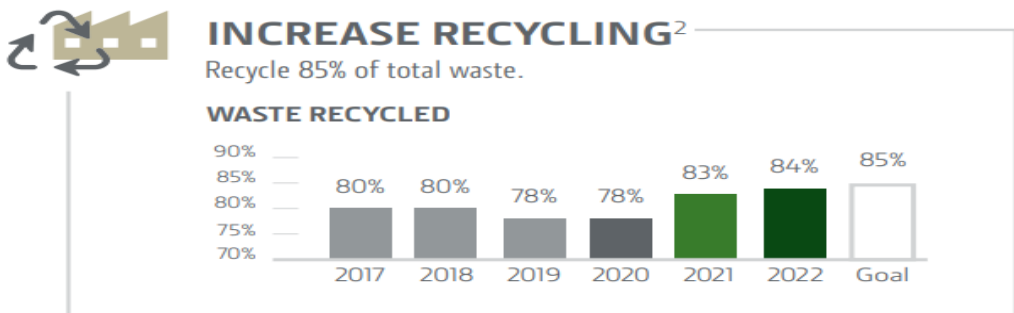


Source: (John Deere, 2022).

- b. **Major Progress in 2021:** A significant jump occurred, reaching 80%.
- c. **Goal Achieved in 2022:** The company reached 100% implementation, meeting its target.

6.3.3 Recycling Rates: The company set a big goal to recycle 85% of its waste, and today, it is right on the finish line. By reaching an 84% recycling rate in 2022, the organization is now just 1% away from its target. This amazing progress isn't just about the numbers; it shows the heart and hard work of a team that truly cares about the planet. It is clear that their daily efforts are paying off, and they are now more motivated than ever to close that tiny final gap and reach their goal together. (John Deere, 2022)

Fig.8. Increase recycling in the company



Source: (John Deere, 2022).

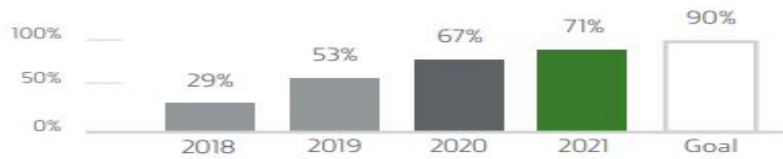
5-3-4- Product Sustainability

The company showed continuous improvement from 29% to 71% between 2018 and 2021. However, although significant progress was achieved, the company had not yet reached its planned target of 90%. There is still a gap of 19 percentage points between the achieved result (71%) and the goal (90%), as illustrated in Figure9.(John Deere, 2022)

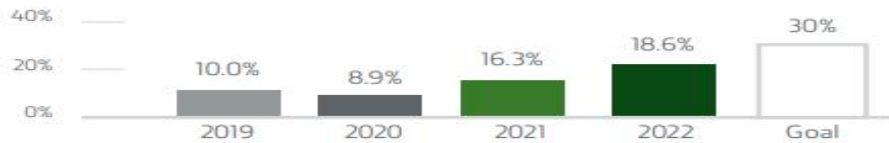
Although there was a small decline in 2020, sales growth improved significantly afterward, reaching 18.6% in 2022. However, the company **has not** yet achieved its planned growth target of 30%. The difference between the achieved result (18.6%) and the goal (30%) is 11.4 percentage points.

Figure 9:Increase recycling in the company (John Deere, 2022).

NEW PRODUCT PROGRAMS WITH LOWER ENVIRONMENTAL IMPACT³



REMANUFACTURED AND REBUILD SALES GROWTH



7 CONCLUSION

The company's See & Spray™ technology is a game-changer for farmers, helping them cut their herbicide use by an average of 77% by targeting only the weeds. Because the system is so precise, farmers can now afford to use better, more effective treatments that were previously too expensive to spray everywhere. This doesn't just lower their overall costs; it gives them a much stronger tool to fight tough, resistant weeds while being far more efficient with every drop.

The company wrapped up its 2024 fiscal year with a solid net income of \$7.1 billion. While these results are lower than the record-breaking \$10.1 billion seen in 2023, the figures show the business remains resilient. For the final quarter of the year specifically, the company earned \$1.245 billion, as the industry naturally shifts away from the exceptionally high peaks of the previous year. (JOHN Deere , 2024).

In 2024, the company saw a dip in its global sales as the market began to cool down from previous highs. Total revenue for the year reached \$51.7 billion, a 16% decrease compared to the year before. This trend was more noticeable in the final quarter, where sales were down 28% to about \$11.1 billion. While the numbers are lower than the standout results of 2023, they reflect a year of adjustment for the business in a changing global economy. (JOHN Deere , 2024).

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