

Agriculture Practice

# Trends driving automation on the farm

Economic pressures and the push toward more-sustainable practices are driving next-generation automation technologies, benefiting farmers, regulators, and consumers alike.

*by Rob Bland, Vasanth Ganesan, Evania Hong, and Julia Kalanik*



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**The agriculture industry is** under pressure. Dramatic cost increases for inputs and labor are putting farmers' profitability at risk. Globally, farmers report that prices for inputs such as fertilizer and crop protection chemicals have risen by 80 to 250 percent over the past few years.<sup>1</sup> Climate change is also squeezing profits. A warmer climate is resulting in increased weather variability, more frequent acute weather events, longer droughts, and new invasive crops and pests, all of which reduce yields. In the American Southwest, for example, an ongoing megadrought is so severe that the past two decades have been the region's driest in at least 1,200 years.<sup>2</sup>

To navigate these challenges and remain economically viable, farmers must find innovative solutions. Automation shows considerable promise for reducing the impact of farming on climate change and helping growers adapt to its financial impact. Autonomous farming solutions exist on a spectrum, requiring varied levels of operator support. This ranges from semi-automated technology widely adopted today (e.g., assisted steering) to fully automated systems (e.g., weeding robots). Next-generation technologies use a combination of sensors, analytics, robotics, and

equipment to help farmers make smarter decisions on the field and do more with less. In addition, recent developments in generative AI present future opportunities to automate decision making using vast data sets that already exist. Potential examples include helping farmers develop strategic plans about what inputs (fertilizer, crop protection, and seeds) to apply, at what times and what rates, to best support a farm's profitability and sustainable practices. Automated technology can deliver significant value to both row- and specialty-crop growers. For instance, fully autonomous use cases across orchards and vineyards can deliver more than \$400 per acre per year in value, doubling to quadrupling returns on farmers' investment in automation (see sidebar, "Farm automation technologies can deliver \$200 to \$800 per acre in vineyards").<sup>3</sup>

These are still early days for autonomy. McKinsey's 2022 Farmers Global Insights Survey reveals that less than 5 percent of farmers across Asia, Europe, North America, and South America are using this next-generation technology, compared with 21 percent using farm management software. We have observed two trends that are likely to boost adoption: pressures on farm economics and the

<sup>1</sup> David Fiocco, Vasanth Ganesan, Maria Garcia de la Serrana Lozano, and Hussain Sharifi, "Agtech: Breaking down the farmer adoption dilemma," McKinsey, February 7, 2023.

<sup>2</sup> Henry Fountain, "How bad is the western drought? Worst in 12 centuries, study finds," *New York Times*, February 14, 2022.

<sup>3</sup> Based on analysis using data from Monarch Tractor (Connect and Automate features) and Global Unmanned Spraying System (GUSS) data; \$400 per acre EBITDA based on yield increase and cost savings assumptions on Californian vineyards spanning automation use cases (for example, spraying, harvesting, pruning, and weeding); ROI calculation based on EBITDA uplift potential and reported costs of automation solutions (Monarch's Automate package \$699/month and GUSS machines \$298,000).

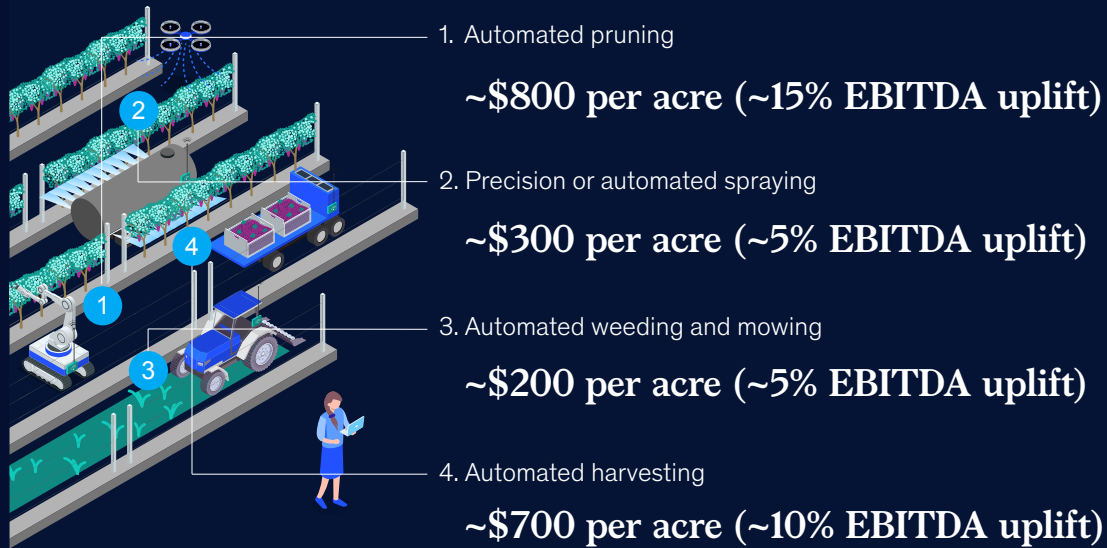
<sup>4</sup> "Agtech," February 7, 2023.

**Automation shows considerable promise for reducing the impact of farming on climate change and helping growers adapt to its financial impact.**

Illustrative

## Farm automation technologies can deliver \$200 to \$800 per acre in vineyards.

Value delivered from farm automation use cases driven by yield uplift and cost savings (CA vineyards)



Source: Jeremy Murdock and Daniel A. Sumner, 2021 sample costs to establish a vineyard and produce winegrapes: Chardonnay Variety: Livermore Valley—Alameda County, University of California, Davis campus, 2021; McKinsey analysis

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push toward more-sustainable farming practices. In this article, we take a deeper look at these trends and how they are positioned to change the future of farm equipment and farm operations.

### Farm economics are an immediate pain point for farmers

Farm automation can help address two problems that have plagued farmers for several years: rising chemical costs and labor challenges.

#### Input costs

Supply chain disruptions and geopolitical challenges have pushed up the prices of widely used fertilizers (for example, urea, diammonium phosphate, and potash) by more than 15 percent per year over the past five years (Exhibit 1). In a McKinsey survey

last year, US farmers ranked input costs as the number-one risk to their profitability, with the price of fertilizers and crop protection chemicals rising the most (Exhibit 2).<sup>5</sup>

Automation can help reduce these costs by enabling farmers to use pesticides and fertilizers more efficiently. For example, automated precision spraying enabled by sensors and field data (both stored and in real time) can sense gaps between crops and adjust the volume and timing of chemical sprayed accordingly, using fewer chemicals. Some herbicide application technologies use computer vision to selectively spray weeds and avoid crops. On large US corn farms, these solutions have been shown to reduce herbicide costs by 80 percent, creating a value of \$30 per acre and a payback period of two years.<sup>6</sup> Similarly, fertilizer application

<sup>5</sup> McKinsey US Farmer Insights Survey, Summer 2022, n = 222.

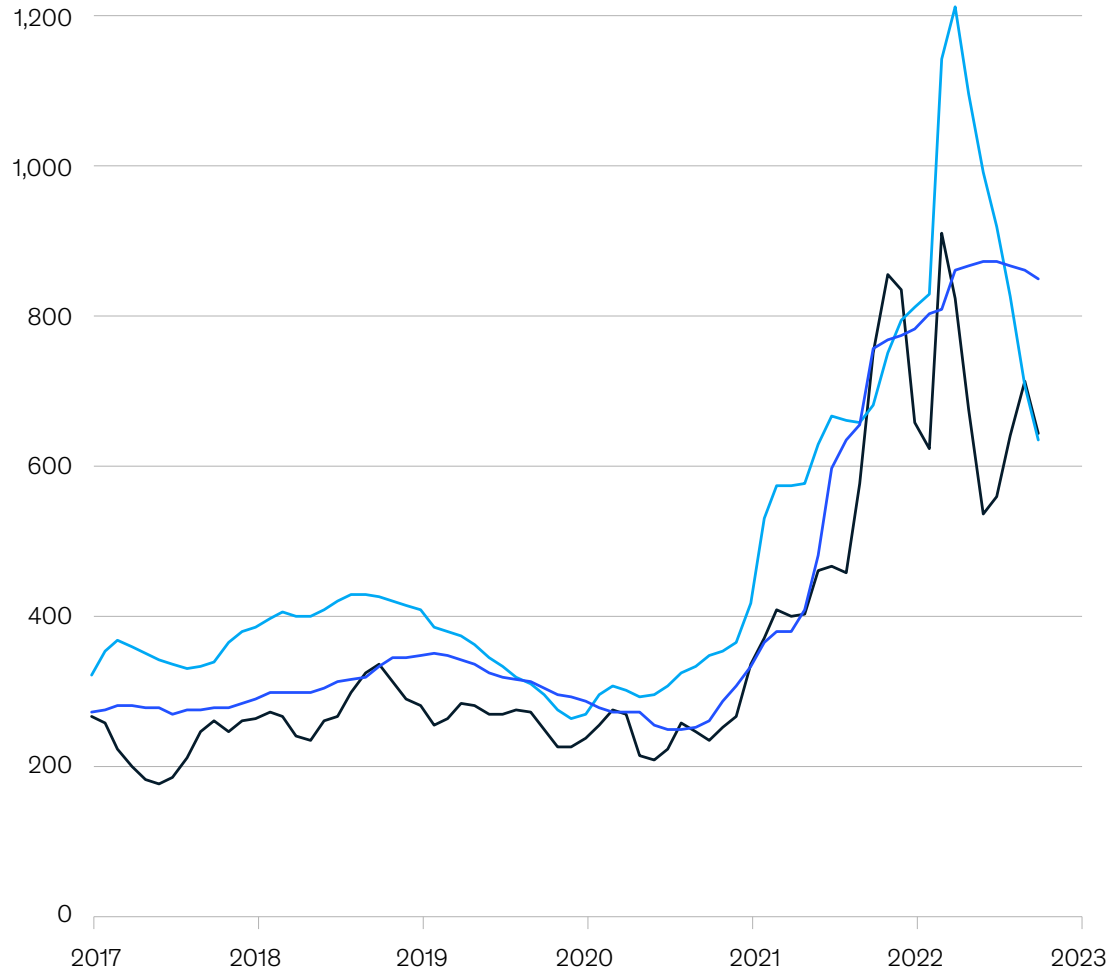
<sup>6</sup> "The long view: Green bytes—the impact of precision agriculture on chemical and machinery coverage," Bernstein, February 22, 2023.

Exhibit 1

**In the past five years, fertilizer prices have risen by more than 15 percent per year, spiking after 2021.**

**North American fertilizer prices,<sup>1</sup> \$ per metric ton**

— Urea (nitrogen) — DAP<sup>1</sup> (nitrogen and phosphorus) — Potash (potassium)



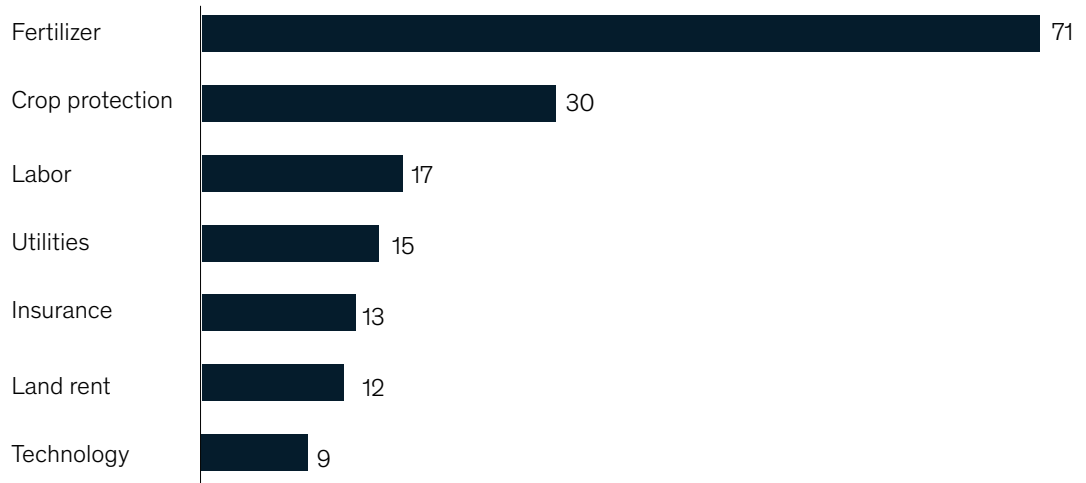
<sup>1</sup>Diammonium phosphate.  
Source: Fertecon

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Exhibit 2

## US farmers have experienced rising input costs and expect continued pressure through 2023.

**Current impact of inflationary environment on farm costs, % cost increase experienced in the past few years**



**Expected change in spend in the next 12–18 months, % of respondents**

■ Decrease by 6–10%   ■ Decrease by 0–5%   ■ Don't expect any change to spending   ■ Expect to increase by 0–10%   ■ Expect to increase by 11–20%



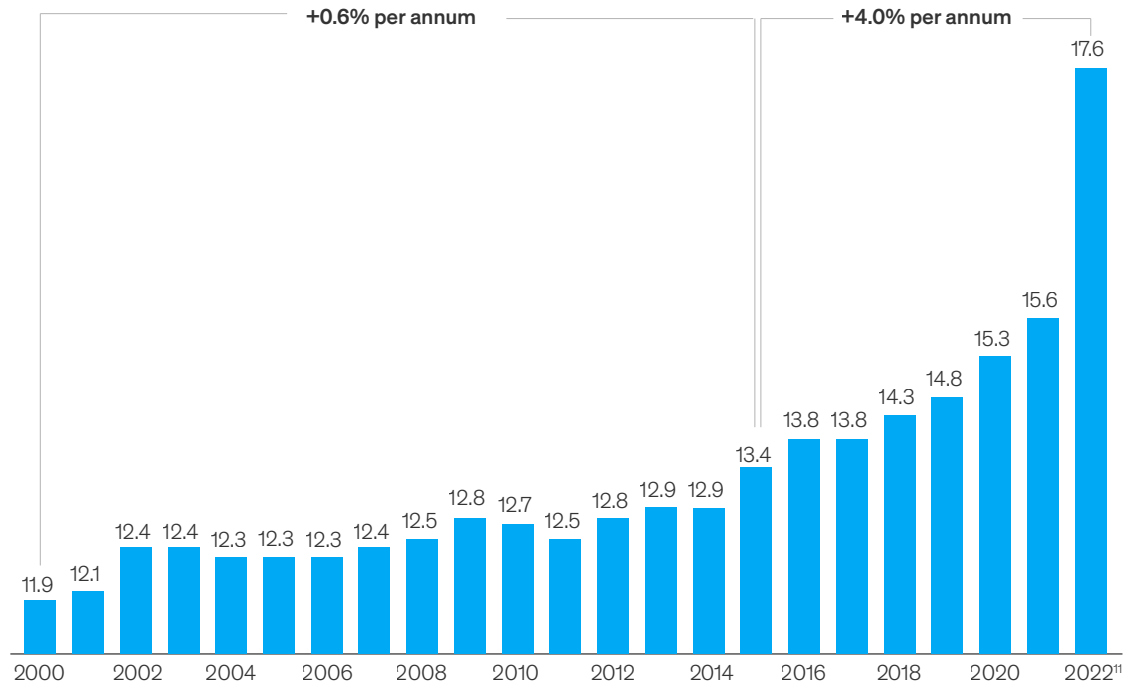
Note: Question: "Given the current inflationary environment, where have you experienced costs up the most? Please assign a percentage between 0–100% for each input that represents the increase you have seen."  
Source: McKinsey US Farmer Insights Survey, Summer 2022, n = 222

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Exhibit 3

**Farm labor wages have increased at a faster rate than in previous years, increasing economic pressure on farmers.**

Real wages for US nonsupervisory farm workers, \$ per hour



<sup>1</sup>January 2022 levels.  
Source: US Department of Agriculture

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robots enabled with sensors can control the amount of fertilizer that is directly applied onto individual seeds during the planting process. This can save more than 93 million gallons of starter fertilizer annually across US corn farms alone.<sup>7</sup>

**Labor challenges**

Labor is also a persistent pain point for farmers. Farmworkers are at high risk of injuries and have the highest rate of fatal occupational injuries in the United States.<sup>8</sup> Prolonged exposure to chemicals and sun also adds to the perception of farm work as difficult and dangerous.<sup>9</sup> In the United Kingdom, for instance, more than 22 million pounds of fruits and vegetables were wasted in 2022 because

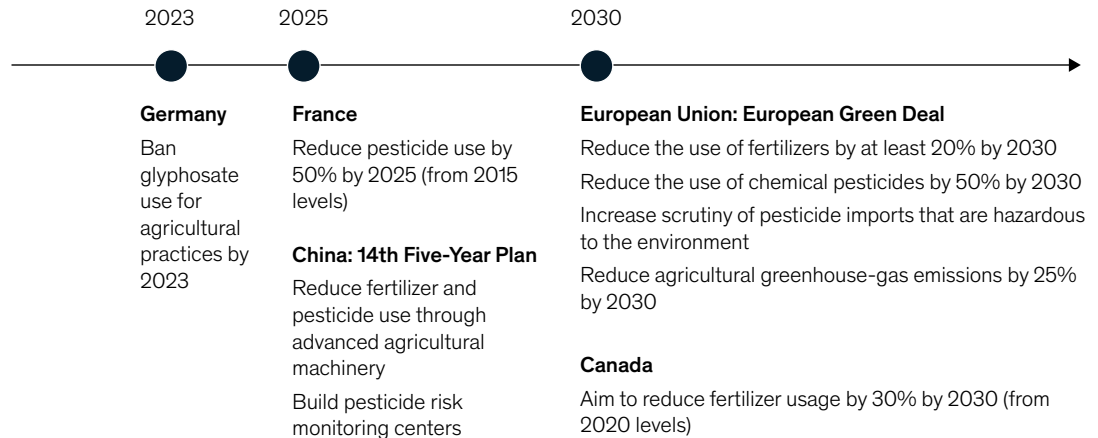
of a shortage of workers to pick crops.<sup>10</sup> Such labor shortages and demands from workers to be compensated for adverse work conditions have accelerated an increase in farmworker wages. In the United States, wages rose 4 percent annually between 2015 and January 2022, compared with less than 1 percent annually between 2000 and 2014 (Exhibit 3).

Automation can help ease these challenges in several ways. It can improve working conditions on the farm, lower the operating skills required by workers, and reduce a farm’s labor costs. For example, semiautomated technology such as assisted steering systems guides tractors to

<sup>7</sup> “John Deere debuts new planting technology & electric excavator during CES 2023 keynote,” John Deere, January 5, 2023.  
<sup>8</sup> “Census of fatal occupational injuries summary, 2021,” US Bureau of Labor Statistics, December 16, 2022.  
<sup>9</sup> “Agricultural operations,” US Department of Labor, accessed March 16, 2023.  
<sup>10</sup> Megan Durisin, “UK worker shortage leaves £60 million of food to rot in fields,” Bloomberg, August 15, 2022.

## Stricter fertilizer, pesticide, and emissions regulations are tailwinds for the adoption of automated technology on farms.

### Timeline of chemical-use policies by country



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reduce overlap between passes, making equipment operation less physically taxing. Fully autonomous equipment takes this a step further. Instead of sitting in a cab doing hazardous activities such as spraying, machine operators can serve as fleet managers who oversee multiple machines. This also enhances worker productivity and reduces labor costs. In a scenario in which automation enables one worker on a US corn farm to manage four machines, the savings amounts to \$15 to \$20 per acre, which can unlock up to about \$1.5 billion in value annually across all US corn farms.<sup>11</sup> For US specialty crops, for which labor is a larger cost driver, the value potential for growers is even greater. For example, in the same scenario in which one worker manages four machines, automated weeding and mowing alone could generate \$30 per acre in labor savings on US vineyards. Automation could also help reduce herbicide costs while maintaining yields due to the ability to complete mechanical weeding more frequently given relaxed labor requirements (savings of \$100 per acre).

### Sustainability is poised to become a future catalyst for change

Unlike input costs, which are an immediate tailwind for adoption, sustainability pressures have yet to be fully realized and are expected to become material in the near future. In a few years, however, action on two fronts—regulators and consumers—could be an even bigger accelerant for automation technologies.

#### Regulators

Around the world, many governments have set ambitious targets for more environmentally sustainable practices (Exhibit 4). The European Green Deal, for example, calls for a transformation of European agriculture by 2030, including a 50 percent reduction in pesticide use, compared with 2020 levels. Additionally, the plan seeks to transition one-quarter of all agricultural land to organic farming to reduce the use of synthetic fertilizers and herbicides. Similarly, Canada is

<sup>11</sup>US corn data shows about 1,200 equipment hours used throughout the season, translating to an average of about \$24 per acre in equipment operating spend in corn (assuming \$15 per hour and 725 acres per farm). For more, see “Corn planted acreage down 4% from 2021, soybean acreage up 1% from last year,” National Agricultural Statistics Service, June 30, 2022; scale across about 82 million acres in harvested corn: see Ganesh C. Bora, John F. Nowatzki, and David C. Roberts, “Energy savings by adopting precision agriculture in rural USA,” *Energy, Sustainability and Society*, 2012, Volume 2, Number 22.

urging farmers to reduce fertilizer emissions by 30 percent by 2030, compared with 2020 levels. This is a voluntary target that farmers can achieve through the efficient management and application of fertilizers.

Automation represents a significant lever for meeting these requirements. By using automated precision-spraying equipment combined with automated weeding or mowing solutions, farmers can dramatically reduce their use of pesticides and fertilizers or potentially eliminate them altogether. Moreover, because automated equipment digitally records what's been applied to crops, farmers can seamlessly collect data and keep records on their operations. This makes it easier for farmers to participate in current programs such as organic certification and GLOBALG.A.P. Down the road, it could also help farmers comply with the reporting

requirements of programs such as the European Green Deal.

### Consumers

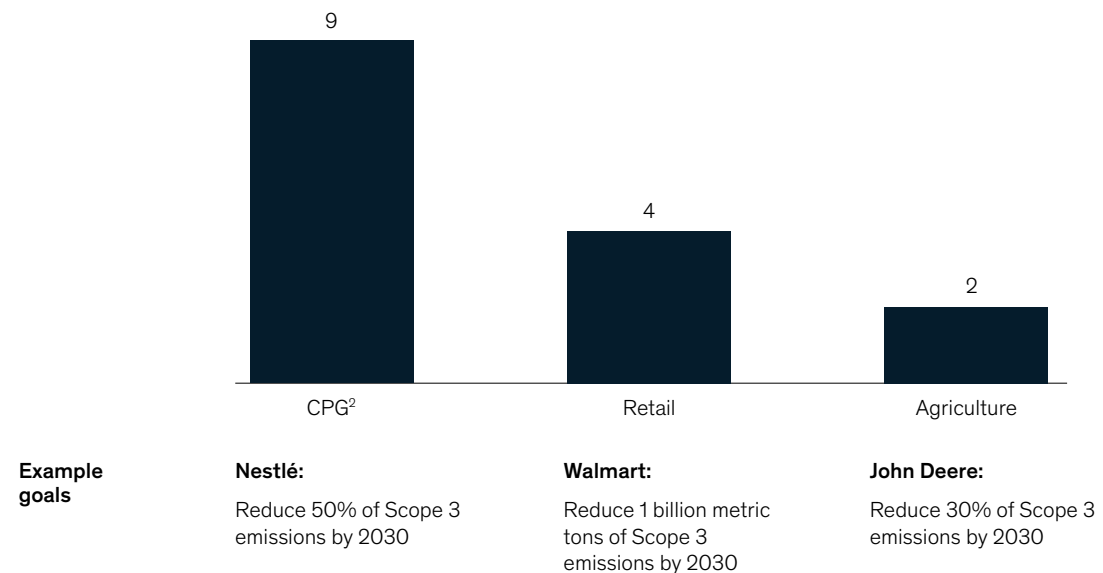
Consumer interest in a more sustainable food system is growing, with motivated shoppers exerting downstream pressure on farmers to change the way they produce food. A 2023 McKinsey US consumer study found that sustainable brands are already seeing market progress, due to an increased interest among consumers. Products making environmental, social, and governance (ESG)–related claims averaged 28 percent cumulative growth over the past five years, compared with 20 percent for products that do not make such claims. Products making multiple types of ESG claims—such as environmental sustainability and organic-farming methods—grew about twice as fast as products that made only one claim.<sup>12</sup>

<sup>12</sup> “Consumers care about sustainability—and back it up with their wallets,” McKinsey, February 6, 2023.

### Exhibit 5

## Consumer-packaged-goods companies, retailers, and agriculture companies have made a range of environmental commitments.

Number of announcements of committed reduction in Scope 3 carbon emissions by top 10 companies<sup>1</sup>



<sup>1</sup>Top 10 companies by 2022 revenue.

<sup>2</sup>Consumer packaged goods.

Source: “Climate change,” Walmart, April 6, 2022; *Creating shared value and sustainability report 2021*, Nestlé, March 2022; Science Based Targets; McKinsey analysis



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Responding to consumer demand, consumer-packaged-goods (CPG) companies have been actively making a range of environment commitments, including how the raw materials and ingredients that go into their products are sourced and grown (Exhibit 5). Nestlé, for example, has pledged to achieve net-zero emissions by 2050, improve the traceability of its raw materials, and reduce chemical use on farms by 2030.<sup>13</sup> Further consumer adoption of sustainability-oriented products is likely to accelerate companies' ESG journeys.

Software solutions—including farm measurement, reporting, and verification (MRV) platforms as well as farm management systems—are already offering avenues for farmers to begin providing consumers with farm-to-fork traceability. This includes the aggregation and storage of data on planting locations, growing time, and the use of fertilizers and crop protection chemicals. Autonomous equipment with cameras and sensors can take this a step further by collecting and transmitting rich, standardized data with minimal effort from farmers. This can help farmers substantiate the sustainable farming practices that CPG companies increasingly want, including reduced chemical applications, more efficient irrigation, and better harvest conditions.

### **Excitement for automation is likely to grow**

The adoption of automated farm equipment will be influenced by many factors, including technological maturity and performance, macroeconomic conditions, geopolitical dynamics, regulatory decisions, and environmental changes. As they shape their offerings, agriculture companies may want to consider several levers:

- Clearly communicate the ROI and near-term value drivers of autonomous equipment as part of their value proposition, sales pitches, and sales materials.
- Reimagine the farming experience with not only automated equipment but also a suite of software and services that create a digital ecosystem for measuring, tracking, and optimizing everything that happens in a field.
- Evolve business models to reduce the up-front capital costs associated with new automation equipment. For instance, models in which farmers pay regular subscription fees or share a portion of their cost savings with a vendor (such as through price-to-performance) can help make new technology more attractive and affordable for farmers.
- Collaborate more closely with CPG companies to help bring more transparency and traceability to farming, while supporting farmers with the tools and capabilities to make it easy to collect and share data.

If farm economics and sustainability continue to apply pressure on farmers, we anticipate that adoption of automated technology will accelerate dramatically. As more growers realize the triple win that farm automation can represent—greater agricultural productivity and profits, improved farm safety, and advances toward environmental-sustainability goals—excitement about these technologies will spread.

<sup>13</sup> *Creating shared value and sustainability report 2021*, Nestlé, March 2022.

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