TECHNOLOGY ASSESSMENT

Precision Agriculture

Benefits and Challenges for Technology Adoption and Use

Highlights of GAO-24-105962, a report to congressional addressees

January 2024

Why GAO did this study

Precision agriculture involves collecting, analyzing, and taking actions based on data. It can help the agricultural sector meet increasing demand for food products, while also helping farmers improve efficiencies such as through reduced input costs.

The Advancing IoT for Precision Agriculture Act of 2021, contained in what is commonly referred to as the CHIPS and Science Act of 2022, included provisions for GAO to conduct a technology assessment and review federal programs.

This report examines (1) emerging precision agriculture technologies and precision agriculture technology adoption; (2) federal programs providing support for precision agriculture; (3) benefits and challenges of adopting and using precision agriculture technologies; and (4) policy options that could address challenges or help enhance benefits of adopting and using precision agriculture technologies.

To conduct this technology assessment and review, GAO reviewed scientific literature and other key reports; interviewed officials and representatives from government, industry, academia, and associations; conducted two site visits to observe technology operations and obtain stakeholder perspectives; and convened a 3-day virtual expert meeting in collaboration with the National Academies of Sciences, Engineering, and Medicine. GAO is identifying policy options in this report.

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What GAO found

Precision agriculture technologies can improve resource management through the precise application of inputs, such as water, fertilizer, and feed, leading to more efficient agricultural production. Precision agriculture can be implemented through a suite of technologies that can be used in isolation or in conjunction with other technologies. Examples of emerging precision agriculture technologies are in the table below.

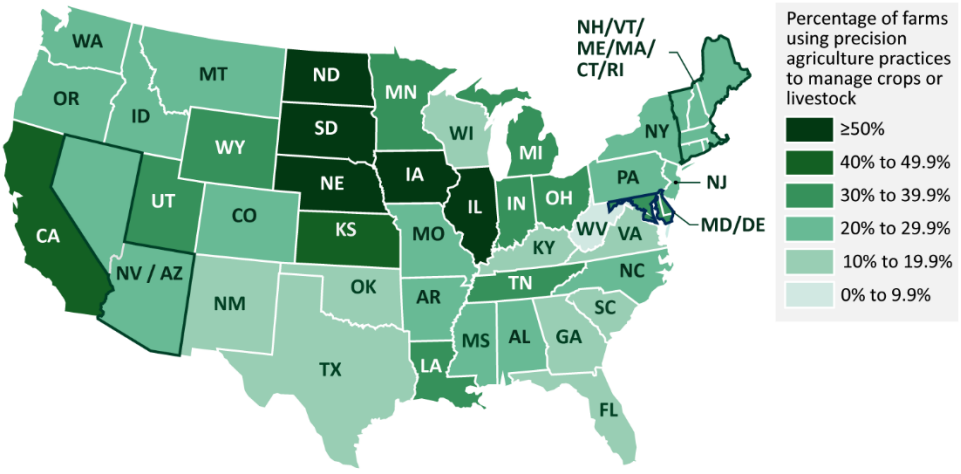
Examples of emerging precision agriculture technologies

Technology	Description
Remote sensing platforms	Drones and ground robots can provide new ways to provide measurements on crop conditions.
In-ground sensors	Provide farmers near-real-time information on soil and plant properties such as temperature, moisture, and nutrients.
Targeted spray systems	Use machine learning to precisely spray in a specific spot.
Automated mechanical weeders	Use machine learning to start and stop weeding blades to avoid damaging the growing crops.

Source: GAO summary of literature, interviews, and agency documentation. | GAO-24-105962

While precision agriculture technologies, such as variable rate fertilizer applications and yield monitoring, have been available since the 1990s, only 27 percent of U.S. farms or ranches used precision agriculture practices to manage crops or livestock, based on 2023 U.S. Department of Agriculture (USDA) reporting.

Use of precision agriculture practices by U.S. farms, June 2022–June 2023



Source: GAO summary of data reported in 2023 by the U.S. Department of Agriculture; Map Resources (map). | GAO-24-105962

Federal agencies support precision agriculture adoption, research and development, education, and training. USDA supports precision agriculture technology adoption with financial assistance and loan programs, such as through payments for implementing practices that provide a conservation benefit. USDA and the National Science Foundation (NSF) have provided almost $200 million for precision agriculture research and development funding in fiscal years 2017—2021. This funding includes partnerships between the two agencies to support artificial intelligence (AI) research institutes.

Benefits to using precision agriculture technologies include:

- **Increased profits**. Farmers can increase yields and thus profits with the same amount of inputs or achieve an equivalent yield with fewer inputs.
- **Reduced application of crop inputs.** Technologies can reduce the application of crop inputs such as fertilizer, herbicide, fuel, and water. They can also address water scarcity by promoting the efficient use of water in agriculture.
- **Environmental benefits**. Technologies can prevent excessive use of chemicals and nutrients in a field, potentially reducing runoff into soil and waterways.

Challenges limiting the broader adoption and use of precision agriculture include:

- **High up-front acquisition costs**. Acquisition costs for the latest technologies can be prohibitive for farmers with limited resources or access to capital.
- **Farm data sharing and ownership issues**. Concerns regarding farm data sharing and ownership can pose obstacles to the widespread use of AI in agriculture.
- **Lack of standards**. An absence of uniform standards can hamper interoperability between different precision agriculture technologies.

GAO examined three policy goals and associated options that could help address adoption challenges or enhance the benefits of precision agriculture technologies. These policy options identify possible actions by policymakers, which include Congress, federal agencies, state and local governments, academic and research institutions, and industry. In addition, for each policy goal, policymakers may choose no additional policy interventions, maintaining the status quo by continuing existing activities.

Policy Goals and Options That Could Address Challenges or Help Enhance Benefits of Adoption and Use of Precision Agriculture Technologies

Policy goals and options	Implementation approaches	Opportunities and considerations
Encourage greater adoption and use (report p. 43)		
Provide additional incentives or other financial support	• Consider modifying eligibility criteria for existing governmental financial assistance programs. • Consider expanding levels of financial assistance through new or existing programs.	• Consider what types of programs to provide to farmers, such as loan guarantees or grants. • Overall program cost, the extent to which equipment acquisition and operating costs are covered, and the potential trade-off with other agricultural programs could be factors. • Programs could be devised to realize goals, such as environmental protection and food insecurity.
Better understand and quantify benefits and costs	• Support development of analytical tools and models to quantify benefits and costs.	• Analytical tools could be configured for farm geography, soil type, and other factors. • Farmer confidence could increase if estimates of benefits are data-driven and based on real-world experiences.
Promotion and outreach to farmers	• Consider expanding Extension services to enable development of more expertise and technical support to farmers. • Increase on-field demonstrations.	• The extent to which federal agencies could provide more training, such as through USDA service centers. • Technology companies and dealerships could assume more of a role in educating or helping farmers.
Encourage further innovation (report p. 48)		
Conduct research and development to improve on-farm data gathering and analysis	• Support research for in-ground sensors for measuring soil conditions. • Examine ways that remote imagery, such as from drones, can be more effectively used to gather data.	• In-ground sensors can provide more detailed information on soil conditions, which can enable farmers to further optimize the application of inputs to increase yields and minimize costs. • New remote imagery sensors from drones or ground robots promise to provide greater resolution, more frequent data, and quicker data delivery than traditional satellite sources.
Promote the development and use of standards	• Promote data standards that could improve equipment interoperability. • Financial assistance programs could specify that precision agriculture equipment comply with certain standards.	• Standards can improve interoperability and compatibility among different devices and platforms. • A lack of standards could result in challenges assessing the quality of the data derived from farm measurements. • Consider the level of federal involvement in standards development and use.
Manage greater amounts of data (report p. 52)		
Enhance data analysis	• Support the development of software to help farmers better manage their farms. • Examine how AI and machine learning could help facilitate analysis and interpretation of data.	• Data analytics and high-performance computing approaches promise to generate valuable information for farmers but are dependent on the availability of large amounts of data. • Farmers may have tools, such as yield monitors, to help identify outcomes of decisions, but few analytical tools and software are available to enhance analysis and translate farm data into actionable decisions.
Encourage data sharing	• Develop a governance framework to manage and store agricultural data and its access. • Establish easy-to-understand data license agreements and codes of conduct to enable better flow of data.	• Farmers often do not trust the ways farm data are being collected and managed; thus, terms and conditions regarding data use should be simple, transparent, and accountable. • Farmer concerns about data sharing include a potential loss of competitive advantage, data security, and additional regulatory scrutiny may increase as AI is increasingly used for data analysis.

Source: GAO. | GAO-24-105962