

# Precision Agriculture in the Digital Era: Recent Adoption on U.S. Farms

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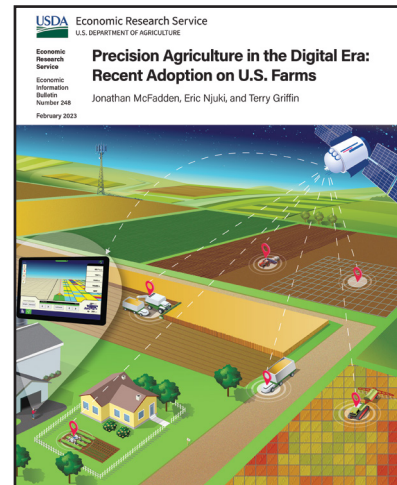
## What Is the Issue?

The global population is projected to exceed 9.7 billion by 2050 (United Nations, 2022). This population growth will require substantial increases in food production, both in the United States and abroad, placing additional pressure on limited agricultural resources. Similarly, there are growing concerns about rising production costs, labor shortages, environmental changes, and unsustainability of intensive natural resources use in the U.S. farm sector. Public awareness of these issues has increased, leading to calls for the agricultural sector to develop innovative solutions. Digital agriculture (DA) provides an important opportunity to respond to several of these challenges.

DA technologies such as soil maps, yield monitors, yield maps, variable rate technologies (VRT), auto-steer and guidance systems, unmanned aerial vehicles, and satellite imagery have been available to farmers for several years.

Adoption rates have varied considerably for wide-ranging reasons, including field topography and soil type, adjustment costs (e.g., subscription fees, training, maintenance, and replacement costs), and farmers' production scale and risk preferences. Adoption also varies by crop type and farmer socioeconomic characteristics. The benefits that accrue from adoption are numerous for most farmers and have been well documented.

As digital technologies and analytics continue to evolve, the digitalization of U.S. agriculture has become a major focus of the sector. Digitalization entails the use of data analytics, automated production processes, and development and commercialization of artificial intelligence applications. The potential to transform the U.S. agricultural sector by these technologies is considerable. Specifically, we expect that digitalization has the potential to increase efficiency in the farm sector—while contributing to cost reductions, yield increases, and/or enhancement to the well-being of farm operators. Although digitalization is a complex transformation with many components, it can be partly tracked by examining farmers' use of established and emerging technologies.



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## What Did the Study Find?

The report analyzes farmers' DA adoption rates for soil maps, yield maps, yield monitors, VRT, auto-steer and guidance systems, and aerial imagery across six major crops: corn, cotton, rice, sorghum, soybeans, and winter wheat.

- **A majority of row crop acreage is managed using auto-steer and guidance systems:** Auto-steer guidance systems were used on only 5.3 percent of planted corn acres in 2001, growing to 58 percent in 2016. Estimates for 2019 suggested 72.9-percent and 64.5-percent adoption rates for sorghum and cotton (planted acreage). In the same year, GPS applications were used on 40 percent of all U.S. farm and ranchland acreage for on-farm production.
- **Adoption rates vary by farm size:** At least half of relatively large row crop farms (those at or above the third quintile of acreage, i.e., with at least 60 percent of fields on farms with lower acreage) rely on yield maps, soil maps, VRT, and/or guidance systems. Meanwhile (except for cotton), less than 25 percent of smaller farms (those with acreage in the first quintile) use any of these four technologies. This use could be due to scale benefits (i.e., the returns to technology adoption could be greater on larger farms than on smaller farms).
- **DA technology adopters use data, acquire crop management recommendations, and employ technical/consultant services at higher rates than DA technology nonadopters:** DA technology adopters are more likely than nonadopters to download public data for use in decision-making, though overall adoption remains uncommon. By contrast, farmers more frequently obtain crop management recommendations based on technologies that collect data in their fields. And while technical/consultant services are hired on a small fraction of surveyed acres, such services tend to be sought somewhat more by DA technology adopters.
- **Farmers are likely to use precision agriculture technologies for a variety of reasons:** As technological capabilities continue to evolve, so have farmers' rationales for their use. For example, corn and winter wheat farmers tend to rely on yield monitors to track crop moisture content. By contrast, yield monitors are primarily used to help determine chemical input use in cotton, soybeans, and sorghum production. Many precision agriculture technologies are used in combination with other precision agriculture technologies.

## How Was the Study Conducted?

The study uses data from the Agricultural Resource Management Survey (ARMS), administered jointly by the USDA, Economic Research Service (ERS) and the USDA, National Agricultural Statistics Service (NASS). The authors analyze precision agriculture adoption, emphasizing the most recent commodity-specific surveys: rice (2013), corn (2016), winter wheat (2017), soybeans (2018), cotton (2019), and sorghum (2019). To illustrate the continuity of historical trends, we also use data from earlier ARMS surveys dating to 1996. Data from the 2013 and 2019 ARMS Cost and Returns Report are also used to track national adoption of global navigation satellite systems (GNSS). The focus is on the key precision agriculture technologies mentioned above. The study also explores several drivers of DA adoption using ARMS data and information via the RCA (Soil and Water Conservation Act of 1977) Data Viewer from USDA's Natural Resources Conservation Service. Additionally, the study incorporates evidence from the literature and makes comparisons with other U.S. farm sector trends.