Science Societies

Building Trust in AI Farming Tools

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Photo by AdobeStock/IonelV.

Precision agriculture tools like decision support systems increasingly use machine-learning algorithms and other types of artificial intelligence (AI) to analyze large quantities of agricultural data and provide recommendations to producers and crop advisers. However, several barriers threaten adoption of these tools. Three papers in the recent *Agronomy Journal* special section, "Machine Learning in Agriculture," explore this phenomenon and offer solutions and opportunities for building trust in these technologies.

By some estimates, agriculture is 12,000 years old. But today, this ancient pursuit has converged with one of the technologies of the future—artificial intelligence (AI).

Integrating machine learning (ML) and other types of AI into farming tools holds promise for improving production, mitigating environmental impact, and reducing costs. One such group of tools are decision support systems (DSS), models and software platforms that combine and analyze farm data to provide recommendations and assistance to farm decision-makers. While not all DSS are undergirded by AI, these tools increasingly use ML, an AI method that uses algorithms to learn from data, to provide better recommendations to end-users.

Despite their potential, several barriers threaten adoption of these tools. Three papers published in the recent *Agronomy Journal* special section, "Machine Learning in Agriculture," explore this phenomenon. Two of the articles

(https://doi.org/10.1002/agj2.21432 and https://doi.org/10.1002/agj2.21353) look at potential concerns surrounding AI in agriculture, provide recommendations for improving farmers' trust in these tools, and assess successes and misfires. And in the other article (https://doi.org/10.1002/agj2.21358), an interdisciplinary team surveyed South Dakota farmers' opinions about ML‐based DSS, part of a larger effort to understand and ameliorate mistrust of AI in agriculture.

Cost, Knowledge, Security, and Confidence

Precision agriculture (PA) aims to improve the yield and sustainability of an agricultural system using extensive sensing, analysis, and management tools. Because ML models constantly learn as new input data are added to their training and validation datasets, they are well suited for PA applications, and ML‐based DSS hold potential to help farms grow more, use less water, apply fertilizer more efficiently, and save money.



South Dakota State University graduate student Skye Brugler poses with a multispectral drone, which can be used in precision agriculture to capture imaging data and monitor plant health,

productivity, stress, growth, disease, and other qualities. Photo by Deepak Joshi.

When sensors collect data out in the field, DSS can help identify a problem and provide guidance for what action to take. As a result, "you can really precisely—and that's the key word here, precisely—apply your resources onto the field," explains South Dakota State University Ph.D. student Skye Brugler, a Society member and first author of the article "Improving Decision Support Systems With Machine Learning: Identifying Barriers to Adoption."



Illustration by Karen Brey.

But while some PA tools like tractor autosteer have been widely adopted, others like variable-rate fertilizers have not, Brugler says. In their paper, Brugler and her co-authors lay out four broad categories of concerns that might prevent farmers from adopting ML-based DSS: cost, knowledge, security, and confidence.

Sticker shock is a main deterrent, especially for small farms where the cost per hectare is larger and a return on investment takes longer to reach. Decision support systems are also data driven explains Bhavna Joshi, an author on another paper in the section, "Artificial Intelligence in Farming: Challenge and Opportunities for Building Trust." As such, they may require regular paid updates as improvements are installed based on this data collection. "The loop of data collection, data processing, and technology upgrades with these data is largely useful for a limited section of farmers who can afford the technology," says Joshi, a sociology Ph.D. student at Virginia Tech.

This data sharing presents another anxiety: uncertainty about data security, privacy, and ownership. “Farmers are concerned … that if they are buying certain technology which is based on AI and ML, their data will not just be their data … and they don't know what the companies will do with that data,” Joshi says.

Dissemination of knowledge—about what ML is, how DSS tools work, how to use them, and how to interpret their outputs—is another issue, Brugler explains. This includes “learning how to not just run equipment, but also learning how to use the data—the statistical methods that are required to actually take this data and do something with it,” she says.

And finally, a lack of confidence in the recommendations from a DSS, and a reluctance to change extant decision‑making process, threatens their adoption. Many farmers make decisions through discussions with trusted consultants, often Certified Crop Advisers (CCAs). “Crop advisers are really at the forefront of providing nutrient recommendations to farmers,” says Maaz Gardezi, a sociologist at Virginia Tech and an author on the three papers.

Surveying Farmers in South Dakota

But which of these concerns are top of mind for farmers, and how do opinions change across demographics? In the article, “Understanding Farmers’ Engagement and Barriers to Machine Learning‑Based Intelligent Agricultural Decision Support Systems,” an interdisciplinary team of social and natural scientists surveyed South Dakota corn and soybean farmers to study that question.

Through a five‑point “strongly disagree” to “strongly agree” scale, the researchers asked respondents to react to statements relating to each area of concern. Statements included “The cost of purchasing and operating a decision support system

is too high," "Decision support systems lack a user-friendly interface," "There is not enough clarity and transparency about data collection terms and conditions," and "I still need to field check the recommendations made by the decision support system."



Virginia Tech researcher Shreya Mitra (left) seeks farmer Morgan Welch's advice and feedback on developing a research tool that will elicit risks and rewards for farmers to transition toward sustainability. Photo courtesy of Maaz Gardezi.

The researchers used responses from 312 farmers ranging in age from 23–91 years old in their final analysis and grouped the survey pool into four clusters based on shared and overlapping concerns. The largest group, comprising 70% of all the farmers, were labeled "apprehensive adopters" of DSS: most were concerned about security, knowledge, and cost and somewhat concerned about confidence. Another group, 22%, were the most "risk averse" of the bunch: highly concerned about all four categories. One group, including 6% of all applicants, were somewhat concerned about cost and confidence, very concerned about security, and not very concerned about their knowledge level—thus dubbed "knowledgeable skeptics." And a fourth group, 2% of the total, were the most trusting of all the farmers—the "indifferent idealists."

These profiles aren't only useful in grouping these survey results, the authors say. They're necessary for developing targeted interventions and approaches for improving both DSS adoption and design.

Co-Designing Solutions

This is where Gardezi's research comes in. His projects are focused not only on understanding how farmers and crop advisers are, and aren't, using new technology, but also on working with those stakeholders to develop new tools addressing their specific concerns and needs.

Gardezi and his colleagues do this through a “living lab” approach. With farmers working across a variety of cropping systems in South Dakota, Vermont, and Virginia, the researchers pair insights from surveys, interviews, and focus group discussions with field soil tests, data collection with drones, and satellite imagery. “We use those data and fuse them together using various approaches like AI and deep learning models to understand questions such as … where and when or how many nutrients should I be using … where my land needs more help in improving soil fertility, those kinds of things,” Gardezi explains. “The farmer is really at the forefront of telling us which field, what problems they're having.”



A farmer in a tractor/planter equipped with a planter monitor, a precision agriculture tool, to guide seed planting. Photo by Lance Cheung, USDA.

Adds Virginia Tech's Joshi, “We also want to understand their expectations from technology … are they also interested in knowing how much their farming [is] impacting the environment?”

While ML-based DSS and other AI-based farming tools won't be useful for every farm, small farms are at risk if they are wholly left out of the conversation, the researchers say. “Small-scale agriculture is on the decline,”

Gardezi says. “The consolidation of agriculture and farms is a serious problem in the U.S. Eventually if you keep doing this, you will create a system where you basically drive out the small-scale farmers because the models are not going to be effective for them.” As a result, rural communities would lose the biodiversity and social fabric that small-scale agriculture provides.

“It would hurt schools … it hurts community programs,” says South Dakota State's Brugler of the loss of small-scale farms. “People would probably start to move away, and we would lose that special aspect of rural communities that we have now.”

The CCA Perspective

While farmers’ attitudes are an important piece of the puzzle, crop advisers play a crucial role in connecting farmers to new technology. “Crop advisers are the people who fill this knowledge gap and communication gap,” Joshi says. “The crop adviser's role cannot be underestimated.”

In August 2023, Gardezi's team surveyed CCAs across North America on how they perceive the use and efficacy of AI technologies in farming. This survey, like the one sent to South Dakota farmers, asked respondents to rank their level of agreement with statements on how AI products have changed their work life in the recent past, and how they predict the products might do so in the near future.

Though the researchers are still analyzing the results, which are slated for publication in upcoming issues of *Agronomy Journal*, one major takeaway was that 59.6% of CCAs believe AI will impact their work in the next few years. With this response, are CCAs anxious that AI tools are going to replace them or drastically alter their roles? It doesn't seem like there's a lot of trepidation, Gardezi says.

“Generally, I would say half the crop advisers surveyed were very optimistic that AI and these new technologies … would be able to increase yield [and] be better for the environment,” he says.

As these tools continue to play a larger role in farming, crop advisers will help bring them out of the box, out of the lab, and into the field. “Eventually, any of the technologies that are being developed either in our project or by the private sector, they will not be directly adopted by farmers,” he says. “Somebody has to go in and explain to the farmers in meaningful ways how those models work. Crop advisers really are at the forefront of doing that.”

A Special Section in *Agronomy Journal* on Machine Learning and Artificial Intelligence in Food Production

Agriculture is undergoing a “smart” and “digital” revolution. One of the goals of this revolution is to find technological solutions to move farming toward sustainable intensification. This means that farmers who use new technologies in agriculture should be able to increase production of crops and livestock, without the need for more land and resources, and with fewer environmentally harmful impacts.

The new technologies of the digital age include systems and tools that have become common in our daily lives such as unmanned aerial vehicles, high‐resolution remote sensing, decision support systems, robots, algorithms based on artificial intelligence (AI), and machine learning (ML). As the revolution in digital agriculture begins to take form, one of many questions the agricultural community should be asking is what will be changed by AI and ML technology? Will AI change where, how, and who produces our food? And what are the societal impacts of these changes?

This special section in *Agronomy Journal* seeks to open a dialogue about ML and AI technology in agriculture through original research, review of past research, and forum discussion articles. This discussion will build a foundation of knowledge to determine the current and future impacts of human–environmental technology and its role in precision agriculture. Precision agriculture technology is moving quickly, but the direction is difficult to discern. Start-ups and big corporate investors are becoming increasingly attracted to the implications of these technologies while social issues of equity and wealth disparities between farms, concerns about job loss, and data privacy are consistently growing more ethically ambiguous. Therefore, it is critical to understand the social, economic, environmental, and technological narratives surrounding this topic to move the future of this technology in an equitable and efficient direction.

This special section seeks to accumulate scholarship that focuses on the most current scientific and sociological research of "smart" agriculture utilizing ML technology. Papers within this special section demonstrate the latest research to improve crop production, crop disease prevention, irrigation management, and livestock management with various forms of AI and ML.

If you are conducting research in this area, consider submitting your papers to *Agronomy Journal* and/or volunteering for the *Agronomy Journal* editorial board. As technology continues to progress, it is imperative that stakeholders work to break down barriers to adoption of these innovative technologies. This includes reducing economic limitations on farmers who are interested in using the technology, implementing legal regulations to protect farm data privacy, and instilling trust and communication between the farmer and technology researchers. This will set the stage for an equitable and successful digital revolution in precision agriculture that can benefit the entire agriculture community.

—David Clay, Special Section Editor, Past President of ASA, and Technical Editor of Agronomy Journal

DIG DEEPER

The research featured in this article is from an upcoming special section in *Agronomy Journal* on "Machine Learning in Agriculture." Some papers from the special section can be viewed online within the Early View section of the journal: https://acsess.onlinelibrary.wiley.com/toc/14350645/0/0. The journal articles specifically highlighted here, include:

Brugler, S., Gardezi, M., Dadkhah, A., Rizzo, D. M., Zia, A., & Clay, S. A. (2023). Improving decision support systems with machine learning: Identifying barriers to adoption. *Agronomy Journal*. https://doi.org/10.1002/agj2.21432

Gardezi, M., Joshi, B.,Rizzo, D. M., Ryan, M., Prutzer, E., Brugler, S., & Dadkhah, A. (2023). Artificial intelligence in farming: Challenges and opportunities for building trust. *Agronomy Journal*. https://doi.org/10.1002/agj2.21353

Adereti, D. T., Gardezi, M., Wang, T., & McMaine, J. (2022). Understanding farmers' engagement and barriers to machine learning‐based intelligent agricultural decision support systems. *Agronomy Journal*. https://doi.org/10.1002/agj2.21358

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