S. HRG. 118–372

INNOVATION IN AMERICAN AGRICULTURE: LEVERAGING TECHNOLOGY AND ARTIFICIAL INTELLIGENCE

HEARING

BEFORE THE

COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY

UNITED STATES SENATE

ONE HUNDRED EIGHTEENTH CONGRESS

FIRST SESSION

November 14, 2023

Printed for the use of the
Committee on Agriculture, Nutrition, and Forestry

Available on http://www.govinfo.gov/

U.S. GOVERNMENT PUBLISHING OFFICE
56–338 PDF WASHINGTON : 2024

COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY

DEBBIE STABENOW, Michigan, *Chairwoman*

SHERROD BROWN, Ohio
AMY KLOBUCHAR, Minnesota
MICHAEL F. BENNET, Colorado
KIRSTEN E. GILLIBRAND, New York
TINA SMITH, Minnesota
RICHARD J. DURBIN, Illinois
CORY BOOKER, New Jersey
BEN RAY LUJÁN, New Mexico
RAPHAEL WARNOCK, Georgia
PETER WELCH, Vermont
JOHN FETTERMAN, Pennsylvania

JOHN BOOZMAN, Arkansas
MITCH MCCONNELL, Kentucky
JOHN HOEVEN, North Dakota
JONI ERNST, Iowa
CINDY HYDE-SMITH, Mississippi
ROGER MARSHALL, Kansas
TOMMY TUBERVILLE, Alabama
MIKE BRAUN, Indiana
CHARLES GRASSLEY, Iowa
JOHN THUNE, South Dakota
DEB FISCHER, Nebraska

EYANG GARRISON, Majority Staff Director
CHU-YUAN HWANG, Majority Chief Counsel
JESSICA L. WILLIAMS, Chief Clerk
FITZHUGH ELDER IV, Minority Staff Director
CALEB CROSSWHITE, Minority Chief Counsel

C O N T E N T S

Tuesday, November 14, 2023

Page

HEARING:

Innovation in American Agriculture: Leveraging Technology and Artificial Intelligence 1

STATEMENTS PRESENTED BY SENATORS

Stabenow, Hon. Debbie, U.S. Senator from the State of Michigan 1
Boozman, Hon. John, U.S. Senator from the State of Arkansas 3

WITNESSES

Earles, Mason, Ph.D., Assistant Professor, Viticulture & Enology, Biological & Agricultural Engineering, CO-PI and Lead of Agricultural Cluster, AI Institute For Next-Generation Food Systems, University of California, Davis, Davis, CA 6
Krishnan, Sanjeev, Chief Investment Officer and Senior Managing Director, S2G Ventures, Chicago, IL 8
Griffiths, José-Marie, Ph.D., President, Dakota State University, Madison, SD 10
Hindman, Jahmy, Ph.D., Senior Vice President and Chief Technology Officer, Deere & Company, Moline, IL 12
Janzen, Todd J., President, Janzen Schroeder Agricultural Law LLC; Administrator, AG Data Transparent Organization, Indianapolis, IN 13

APPENDIX

PREPARED STATEMENTS:
Earles, Mason, Ph.D. 36
Krishnan, Sanjeev 40
Griffiths, José-Marie, Ph.D. 57
Hindman, Jahmy, Ph.D. 65
Janzen, Todd J. 69

QUESTION AND ANSWER:
Krishnan, Sanjeev:
Written response to questions from Hon. Raphael Warnock 82

INNOVATION IN AMERICAN AGRICULTURE: LEVERAGING TECHNOLOGY AND ARTIFICIAL INTELLIGENCE

Tuesday, November 14, 2023

U.S. SENATE
COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY
Washington, DC.

The committee met, pursuant to notice, at 10 a.m., in room 328A, Russell Senate Office Building, Hon. Debbie Stabenow, Chairwoman of the Committee, presiding.

Present: Senators Stabenow [presiding], Brown, Klobuchar, Bennet, Gillibrand, Durbin, Booker, Luján, Welch, Boozman, Hoeven, Ernst, Braun, Grassley, Thune, and Fischer.

STATEMENT OF HON. DEBBIE STABENOW, U.S. SENATOR FROM THE STATE OF MICHIGAN, CHAIRWOMAN, U.S. COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY

Chairwoman STABENOW. Well good morning. I call this hearing of the U.S. Senate Committee on Agriculture, Nutrition, and Forestry to order. Welcome to our witnesses. Thank you all for being here today.

American agriculture has always been at the forefront of innovation, and artificial intelligence has the potential to revolutionize the way we grow, harvest, and distribute our crops. In this rapidly evolving landscape, it is imperative that we strike a balance between harnessing the benefits Artifical Intelligence (AI) offers while addressing the concerns it raises, such as data privacy, work force implications, and equitable access to technological advancements.

Our discussion today will help us navigate this intricate path, ensuring that American agriculture remains sustainable, competitive, and resilient in the face of a changing world.

The reality is that artificial intelligence is already being integrated into our daily lives. In fact—I am going to pause—my Statement up to this point was entirely generated by AI, and it is something I would have said, so it is incredible, actually, to me. I did not ask them to put my voice with it, so we are not sure how that would have worked.

This just shows us how real this technology and its implications can be. It is opening new pathways to address the climate crisis, increase production, lower input costs, and automate planting and harvesting.

Tractors that scan for weeds and apply targeted herbicides, harvesting machines that use AI to determine ripeness in real time and autonomously pick crops, and systems that integrate satellite and soil data to more efficiently apply fertilizer are not in the realm of science fiction. These technologies are being put to use on farms across the country today, and we will hear more about it today. These are exciting opportunities, and this Committee must work to ensure that America does not fall behind.

USDA is taking steps to explore the future of this technology. For example, the National Institute of Food and Agriculture is investing in cutting-edge research to study how we can apply AI to some of American agriculture's greatest challenges.

We must also be cautious about the significant risks. Placing vast amounts of data in the hands of a few private companies could accelerate the trend of consolidation in the agricultural industry or perpetuate bias that has harmed small farmers and farmers of color for decades.

High costs are putting AI and precision agriculture technology out of reach for everyone except the largest operations. We must work to ensure that its application does not force even more small and medium-sized farms out of business by ensuring that there is fair access to its benefits.

I also remain concerned that a small handful of companies that provide this technology will be the same companies that sell the fertilizer and seeds that their technology recommends as a solution. Farmers should be the ones benefiting from their data, not big corporations.

I cannot allow the opportunity pass to remind everyone that this technology cannot work on farms if we do not continue to extend the reach of broadband and high-speed internet into every rural community, the very best quality possible.

There is a tremendous opportunity to use this technology to bring new and high-paying jobs into rural communities. This opportunity should not be forfeited to big cities, but it should have a chance to thrive in the heartland where it is being put to use in fields and on farms across the country.

I am glad that President Biden issued an Executive order as a first step to managing these kinds of risks. I am grateful that Majority Leader Schumer has initiated a thoughtful bipartisan effort so that we in the Senate can fully evaluate the potential risks and benefits of AI in every part of our lives and our economy. The responsibility of this Committee is to understand the implications of regulating this technology on farms and in our food system.

We also cannot allow flashy headlines about the potential of AI to distract us from the very real need we know we have to support agriculture research broadly. Today's hearing is not just about AI and precision agriculture. We also need a moonshot in agriculture research. Every dollar invested in agricultural research generates $20 in domestic economic activity.

Meanwhile, China has quintupled its investment in public agriculture research since 2000, and now it invests twice as much as we do. As farmers work to tackle the climate crisis, navigate constantly changing markets, and feed a growing global population, in-

vestments in agriculture research and trustworthy economic data will only become more important.

My goals for the farm bill are to keep farmers farming, keep families fed, and keep rural communities strong. Investing in research and leveraging technology and artificial intelligence will be a critical component to achieving all three.

With that, I will turn to my partner and Ranking Member Boozman for his opening comments.

STATEMENT OF HON. JOHN BOOZMAN, U.S. SENATOR FROM THE STATE OF ARKANSAS

Senator BOOZMAN. Thank you, Madam Chair, and we are very anxious today to have this hearing to examine the current and potential uses of artificial intelligence in our agricultural system. We have a panel of experts before us who are able to discuss and educate this Committee on the potential of this technology within agricultural industry. Thank you all for being here. I look forward to learning from you all.

While agriculture faces many challenges, there are also tremendous opportunities on the horizon. I am excited to explore some of those opportunities here today.

AI-powered technology takes many forms across agriculture, making it difficult to pinpoint just one definition. Diverse uses such as monitoring of livestock for disease protection or climate monitoring to mitigate the chance and impacts of wildfire are just the starting point.

Precision agriculture powered by artificial intelligence holds promise for American agriculture. From targeted fertilizer and pesticide applications guided by dozens of high-resolution cameras to irrigation systems that can sense the source of leaks before crop losses, AI has the potential to dramatically increase efficiency, minimize waste, resulting in improved yields and profitability.

AI also has a role to play in our food supply chain. In 2023, researchers at the University of Arkansas were awarded a $5 million U.S. Department of Agriculture-National Institute of Food and Agriculture grant to establish the Center for Scalable and Intelligent Automation in Poultry Processing. This center will study ways to increase use of AI and robotics in poultry processing to reduce waste and detect pathogens. This technology may be useful in so many different ways for processing plant employees to achieve consistency in the specifications of products while also mitigating the threats posed by pathogens and making our food supply even safer.

However, while AI holds great potential, we should also ask tough questions about the potential risks. New regulations may be needed to ensure that consumers are kept safe, especially when it comes to the use of applications that handle sensitive data.

For decades, the United States has led the world in innovation. One-third of the $5 trillion global information technology market in 2022 was located in the U.S. Since the beginning of the technological revolution, America exercised a light-touch approach toward regulating this budding industry while others like Europe took a different approach. We must determine if that approach is appropriate when it comes to regulating AI and its uses in agriculture.

Before concluding, I would like to discuss the pending farm bill extension. Text was unveiled this weekend outlining the agreement among Chairwoman Stabenow, myself, and our colleagues leading the House Agriculture Committee. We have agreed to provide a one-year extension of the 2018 Farm Bill and to maintain funding for the orphan programs.

I want to thank the Chair very, very much for her leadership and partnership to provide certainty to our farmers and ranchers, so they can go about running their businesses as we continue our work to reauthorize the farm bill.

It is more important than ever to pass a farm bill that reflects the needs and challenges of today and gives certainty to those responsible for producing the food and fiber that feeds and clothes the world. We owe it to them to get this farm bill and get it done right.

In closing, I am encouraged by the work of my colleagues on this Committee to explore risk and regulatory remedies needed to protect Americans from potential risks posed by AI while also encouraging innovation to thrive.

Before I end my remarks I wanted to recognize a member of Senator Ernst's staff, Steph Carlson, who serves as the deputy legislative director and ag advisor to Senator Ernst. Steph is returning to her home State of Iowa to be closer to family and to work for the National Pork Producers Council, so we will still be seeing you around.

I was fortunate to spend some time with Steph this spring during my visit to Iowa. There is no question that Steph is committed to helping Iowa's farm families. I appreciate her contribution to the work of this Committee and wish her the best.

Thank you again, Madam Chair, and I look forward to today's discussion.

Chairwoman STABENOW. Well thank you so much, Senator Boozman. I want to thank you as well for our work on a full extension for up to one year. We want to get the farm bill done before that year is up. I am confident we can do that. I very much appreciate your leadership as well and am pushing forward to make sure we continue the full farm bill programs and to know that we have agreement from our House partners. The Four Corners agreement gives me optimism that we can move forward and get a farm bill done. I really look forward to working with you on that.

We will introduce each of our witnesses now and then turn it to you for your comments.

Our first witness is Dr. Mason Earles. He is an Assistant Professor at the University of California, Davis, where he leads a research lab and team focused on AI and agriculture. Dr. Earles is also a co-lead for the USDA-funded National AI Institute for Next-Generation Food Systems. Prior to joining UC Davis, he worked at Apple as a data science engineer, and recently founded an agriculture technology startup called Scout.

Our next witness is Mr. Sanjeev Krishnan. Mr. Krishnan is the Chief Investment Officer and Founding Managing Director at S2G Ventures. He has nearly 20 years of experience in sourcing and managing venture and capital equity investments, focusing on agriculture and food companies. Mr. Krishnan is a graduate of the Lon-

don School of Economics and grew up in Grosse Pointe, Michigan, so that is a special reason why I am glad that you are here. He enjoys spending time with his family and friends in their home city of Chicago, Illinois. Thank you so much for being here.

I am now going to turn to Senator Thune to make the next introduction.

Senator THUNE. Thank you, Madam Chair, and let me just echo what was said earlier by the Ranking Member, Senator Boozman. Thank you to you and to him for working and facilitating an extension of the farm bill and dealing with the orphan programs. I am pleased we are able to get that done, although I would say that it is no substitute for a multi-year authorization and I hope we keep our heads down and try and get that accomplished.

I do want to welcome Dr. José-Marie Griffiths to the panel today. She President at Dakota State University. I have had the privilege of working with her for several years, and she has testified numerous times in front of the Senate Commerce Committee where she shared her expertise, and I am grateful that she is willing to share that expertise today with the Senate Ag Committee.

Dr. Griffiths has served in Presidential appointments for the National Science Board, Commission on Libraries and Information Science, and she has recently been appointed to be a member of the National Security Commission on Artificial Intelligence. Because of Dr. Griffiths' passion about expanding research and educational opportunities, Dakota State University is a leader in the Nation in developing a high-quality skilled technology and cyber work force, and DSU has played a critical part in ensuring that our farmers and ranchers are able to take part in the technological revolution.

DSU, in partnership with South Dakota State University, launched a joint doctorate program on precision ag and cyber. This program brings an important focus to the cybersecurity threats the agricultural economy faces, and this is critically important as new technologies like artificial intelligence become more prevalent in the agriculture sector.

It is important work. This hearing is important. There is a huge intersection between agriculture, which is our State's No. 1 industry, and technology, all of which can boost yields and incomes for agriculture and make us more competitive in the global marketplace. Dr. Griffiths, thank you for your great work and welcome here today, and we look forward to hearings yours. Thank you to all the panelists for being here to share your expertise with this panel. Thanks.

Chairwoman STABENOW. Thank you. Senator Boozman will have the next introduction.

Senator BOOZMAN. Yes. I am pleased to welcome Dr. Jahmy Hindman, who is Senior Vice President and Chief Technology Officer at Deere & Company, a position he has held since July 2020. He is responsible for building Deere's tech stack, the company's intuitive end-to-end software, end-to-end equipment solution, made up of hardware and devices, embedded software, connectivity, data platforms, and applications. It is so complicated I cannot even read it.

He leads the company's Intelligence Solutions Group, its global network of technology, innovation centers, and the shared engineer

function. Working in both the Agriculture and Turf and Construction and Forestry Divisions, Dr. Hindman has more than 25 years of advanced technology, artificial intelligence, product engineering, and manufacturing experience. Most recently he led the engineering team for Deere's flagship tractor product line.

Dr. Hindman holds a bachelor's degree in mechanical engineering from Iowa State University, as well as master's and doctoral degrees in mechanical engineering from the University of Saskatchewan. His doctorate focused on the application of artificial neural networks in heavy equipment applications. He sits on the Industrial Advisory Council for Iowa State University's College of Engineering and leads the Technology Leadership and Strategy Initiative for the U.S. Council on Competitiveness.

Dr. Hindman, thank you very much for being here.

Chairwoman STABENOW. Welcome. For our last introduction, Senator Braun.

Senator BRAUN. Thank you, Madam Chair. I am happy to introduce a fellow Hoosier, Todd J. Janzen. He is an attorney and cofounder of Janzen Schroeder Agricultural Law LLC, a law firm dedicated to serving the needs of farmers, ag technology providers, agribusinesses, located in Indianapolis, Indiana. Todd also serves as the Administrator for the Ag Data Transparent Project, a national effort to bring transparency to contracts between farmers and technology providers.

Todd grew up on a grain farm in Kansas. He served as chairs of the American Bar Association's Agricultural Management Committee and the Indiana State Bar Association's ag law section. In addition to his regular law practice, Todd serves as general counsel to the Indiana Dairy Producers. Todd publishes a nationally recognized ag technology blog, the "Janzen Ag Tech Blog."

Thank you for being here, and the rest of the witnesses.

Chairwoman STABENOW. Welcome to all of you. Now we will turn to Dr. Earles first for minutes minutes of testimony. We certainly welcome any other information you wish to give us for the record.

STATEMENT OF MASON EARLES, Ph.D., ASSISTANT PROFESSOR, VITICULTURE & ENOLOGY, BIOLOGICAL & AGRICULTURAL ENGINEERING, CO-PI AND LEAD OF AGRICULTURAL CLUSTER, AI INSTITUTE FOR NEXT-GENERATION FOOD SYSTEMS, UNIVERSITY OF CALIFORNIA, DAVIS, DAVIS, CA

Dr. EARLES. Thank you. Good morning, Chairwoman Stabenow, Ranking Member Boozman, and members of the Committee. I am happy to be here today to discuss the topic of leveraging technology and artificial intelligence for innovation in American agriculture.

My name is Mason Earles, and I am an Assistant Professor at the University of California, Davis. I am also a CO-PI and Agricultural Production Cluster Lead at the USDA-funded National AI Institute for Next Generation Food Systems, and as mentioned earlier, a co-founder of an ag tech startup. Prior to joining UC Davis, I worked as a Data Science Engineer at Apple, and before this I worked on the basics of how plants work, the fundamentals of plant physiology.

Today, my lab at UC Davis sits at the crossroads of agriculture and artificial intelligence, or AI. I lead a team of engineers, computer scientists, and biologists who are making AI-enabled sensing systems that aim to help agricultural producers manage more precisely, efficiently, and sustainably. However, I am not here just to talk about what we do in my lab but I want to more broadly discuss the rapidly growing trend of AI and technology in agriculture and food systems, and the role of research institutions in spurring such innovation.

We are sitting here today because of unprecedented advancements in hardware and software which have massively expanded the capacity of AI computer programs to learn from complex real-world data like what we see in agriculture and food systems.

Before going any further, however, I would like to define "AI" using a relevant example. Put simply, an AI is a computer program that takes in one or more inputs, like an image, audio recording, or table of data, and outputs some prediction or physical action. Okay, so what do I mean by that?

As an example, let's say we input into our computer program thousands of images taken from a camera mounted on a tractor weeding implement in a carrot field and we want the AI to predict if an invasive weed, such as nightshade, is present in the image, which could, in response, trigger a precise herbicide spray application, for instance. We typically train these AI computer programs by showing them many examples of inputs with "correct" outputs. In our carrot versus nightshade example, this means that a human first categorizes which images do or do not have nightshade, literally clicking "yes" or "no" on a screen. The AI computer program then repeatedly tries to predict which images contain nightshade versus carrots and is penalized for incorrect predictions. Once training reaches a desired performance target, this AI can then be used to automate the detection, and potentially spraying, of nightshade based on input images without the need for human categorization. This is just one of many, many possible examples of the growing number of current and potential applications of AI in agriculture and food systems.

At the AI Institute for Next-Generation Food Systems, our team of more than 40 researchers across six national institutions aims to accelerate critical solutions to big challenges in the food supply chain, from crop breeding and farming to food processing and nutrition. Imagine if AI could bring together genomic and sensor data to uncover novel molecular patterns to enable plant breeders to discover more flavorful and nutritious strawberries.

Now, imagine those same strawberries growing in a field where hundreds of cheap, paperclip-sized soil sensors are measuring nutrient and water stress, and wirelessly sending data to a drone that flies overhead each day. After harvest, these strawberries are transported to a processing facility that rapidly samples washwater to rule out the presence of E. Coli pathogens using AI-enabled microscopy. Finally, a consumer points their phone at their plate which uses AI to estimate the macro and micronutrients of the strawberries and every other ingredient they are about eat.

Critically, the socioeconomic and ethical risks of introducing AI tools across the food supply chain, such as data privacy and secu-

rity, and potential effects on labor must be considered. Our researchers and industry partners at the AI Institute for Next-Generation Food Systems are investigating each of these topics, among many others. We see ourselves as one of the world's leaders in research, development, and commercialization of such novel, importantly open-sourced, AI-based solutions in food and agriculture. We do this through a three-pronged strategy of multidisciplinary science, industry engagement, and work force development.

Such a massive effort and innovation is made possible by more than $20 million in funding provided over five years by USDA's NIFA as part of NSF's National AI Institutes. In fact, four additional National AI Institutes focused on food and agriculture are funded by USDA NIFA, totaling more than 30 research institutions and industry partners across America. These National AI Institutes are working on programs that aim to relieve labor shortages via AI-driven robotic harvesters in tree crops, monitor the health and stress of livestock using AI-enabled sensors, and predict climate and crop risk by building AI-accelerated models that could eventually be used to precisely control irrigation and nutrient emitters. Each of these AI Institutes is focused on tech transfer and meeting industry needs, with partners including dairy producers, soybean farmers, chemical and agricultural machinery producers, among others.

Thinking to the future of our work force, in 2021 more than 161,000 undergraduate and graduate computer science degrees were awarded in the U.S. alone. While we do not have exact numbers, a very small fraction of these students end up working in the agricultural and food sector. This needs to change.

Building on these accomplishments and to keep America as a global leader in agricultural innovation, I strongly encourage the Committee to continue, and even expand, funding for these National AI Institutes among other funding sources provide through the USDA that focuses on AI solutions for food and agriculture. I believe that this is how we will accelerate more research innovation and industry collaboration, and create a wider funnel for motivating more computer science and engineering students to solve the big challenges in the agricultural sector via AI and new technology. Thank you.

[The prepared statement of Dr. Earles can be found on page 36 in the appendix.]

Chairwoman STABENOW. Thank you very much.

Next we will hear from Mr. Krishnan. Thank you, Mr. Krishnan, for coming and sharing your thoughts.

STATEMENT OF SANJEEV KRISHNAN, CHIEF INVESTMENT OFFICER AND SENIOR MANAGING DIRECTOR, S2G VENTURES, CHICAGO, IL

Mr. KRISHNAN. Chairwoman Stabenow, Ranking Member Boozman, and members of the Senate Agriculture Committee, thank you for the opportunity to speak to you today. My name is Sanjeev Krishnan. I am a founding team member and Chief Investment Officer of S2G Ventures.

S2G was founded in 2014, and is now one of the largest investment firms focused on sustainable food and agriculture solutions

and technologies. Today we manage $2 billion of capital, and our portfolio includes investments in more than 90 companies. We are based in the Midwest and deploy capital that creates jobs and returns in the heartland.

At S2G I help lead a team of more than 40 sector experts and investors focused on identifying and making investments in technologies and entrepreneurs. Nearly all 90 portfolio companies are either headquartered or maintain operations in the United States. Across our portfolio we have companies that either operate, manufacture, or distribute in every State represented by members of the Senate Agriculture Committee.

We do not just write checks. We ask what problems need to be solved and seek to understand how individuals experience them. What does the consumer in Iowa see in terms of price and quality? What is the farmer in Michigan or a rancher in Colorado experiencing? How are communities in Mississippi impacted? We explore those leverage points and make targeted investments across the ecosystem. In practice, this might look like identifying a durable consumer trend. We might consider investing in new consumer products to meet this trend. Or companies using machine learning to develop more flavorful and nutrient-dense ingredients through improved seed genetics; what farmers might need to plant this hypothetical crop; the infrastructure needed to take crops from farm field to finished goods; less intense ways to nourish those crops; tools that enable farmers to measure and profit from those environmental benefits, and fintech solutions that de-risk the transition to a new crop.

My comments today will draw from this system's perspective, focusing on four themes.

One, the journey of the American farmer is a remarkable story of embracing innovation and transformation. Technology and artificial intelligence build on this tradition. These technologies and their applications and implications are just beginning to emerge, but they offer a unique toolkit to rapidly accelerate breakthrough solutions and significant per-acre value generation.

Today, farmers are drowning in data and not in solutions. We now have aggregated data points from sensors, machinery, and many other sources. Improving that data's quality and utilizing the data will drive better, faster, and more efficient and precise ag tech solutions. These solutions will be able to automatically adapt and moderate the impacts of extreme weather, volatile commodity prices, and more. This also represents a new frontier of deriving value from on-farm data.

Third, AI can help enhance the foundation of U.S. agriculture: trust and community. This sounds counterintuitive, but ag technology, data analytics, and AI have an important role to play in strengthening human relationships. For example, AI offers nearly instant power to analyze and identify patterns across massive amounts of historical research and on-farm data. Combined with the real-world experience, AI can enable independent agronomists or certified crop advisors to offer faster, more precise advice and actual insights to farmers. AI can help make existing ag technologies better and more effective and help weed out ineffective approaches.

This enables farmers to focus their resources and time on options that work best with the conditions on their operations.

Fourth, public policy plays a critical role in developing and scaling critical ag tech solutions. Federal loan guarantees and other financing opportunities offer security to the developers of nascent technology that, once they are at scale, offer a public good in the form of improved sustainability or profitability. Financial instruments will continue to be an important area for public-private partnership and innovation. Improving data quality and sharing will be critical. The public and private sector should work together to avoid duplicative work and focus limited resources on filling data gaps, and it will be critical to protect privacy, support the farmer, and build tools that account for the full diversity of the food and agriculture system.

Thank you again to the Committee for your leadership in convening today's hearing. I look forward to responding to your questions.

[The prepared statement of Mr. Krishnan can be found on page 40 in the appendix.]

Chairwoman STABENOW. Thank you very much.

Now we will hear from Dr. Griffiths. Welcome.

STATEMENT OF JOSÉ-MARIE GRIFFITHS, Ph.D., PRESIDENT, DAKOTA STATE UNIVERSITY, MADISON, SD

Dr. GRIFFITHS. Good morning, Chairwoman Stabenow and Ranking Member Boozman and members of the Committee. Thank you for this opportunity to testify today. I am José-Marie Griffiths, President of Dakota State University, located in Madison, South Dakota.

At our institution we are focused on training the next generation of professionals in emerging technology fields such as AI, cybersecurity, and quantum computing. Dakota State University is one of only ten universities nationwide to hold all three Center of Academic Excellence in Cybersecurity designations from the National Security Agency and Department of Homeland Security, and we have innovative R&D campus facilities and public-private partnership models that empower students to immediately enter the cyber work force upon graduation. One example is the Dakota State University Applied Research Corporation, which operates and manages the Dakota State University Applied Research Lab.

Additionally, we are partnering with South Dakota State University, the State's leading agricultural institution, on collaborative research through a precision CyberAg partnership, where South Dakota State University brings the data generated by precision technologies and we leverage our cyber and AI expertise.

Agriculture has evolved tremendously over the past 100 years. Innovative technology is now being leveraged to drive farming equipment, predict crop health, optimize yields, and monitor the entire produce supply chain from seeds to stomach.

The integration of technology and AI stands to shape the future of agriculture with both tremendous benefits and risks. Amidst the modern cyber threat landscape, further research is needed to ensure AI can reach its full potential.

As the Committee considers how to deploy AI across agriculture, Dakota State University offers the following recommendations.

First, support the increased adoption of AI and its transformative potential in the U.S. agriculture sector. When embedded in connected systems, AI technologies enable the widespread collection of vast amounts of data from crops and livestock through satellites, drones, sensors, and robots. Analysis of these data can lower costs and improve yields and production

Second, support stronger cybersecurity protections to safeguard the critical infrastructure of the U.S. agriculture industry. Embedding AI into internet-connected farming machinery vehicles and devices does inherently make systems more vulnerable to cyberattacks, but there are solutions to protect this critical infrastructure powering our national food supply.

Third, support the expansion of agricultural research focused on AI to help increase the sustainability of the agriculture industry. This research can led to the creation of new technologies and improved policies that will enhance agricultural productivity and resilience.

Fourth, intellectual property confidentiality risk is another key consideration. As AI applications are rapidly developed and deployed, IP confidentiality is essential to protect and prioritize the development of leading innovations in the field.

Finally, the fifth recommendation is for a heightened concern for cyber and national security that involves the acquisition of land by unfriendly nations, especially in sensitive areas or close proximity to critical infrastructure and agricultural areas. It is crucial to secure our land for the sake of national security.

The United States has a critical opportunity to advance the use of AI to further innovation the agriculture sector while also helping address very real cyber risks and challenges associated with a growing attack surface. There are crucial steps that academia, in partnership with industry and Federal agencies, can take to ensure the safe, responsible, and effective use of AI.

The agriculture industry has been automating and innovating for decades. While the deployment of AI across agriculture is a transformative shift, it is nothing we cannot be prepared for. I would like to recognize our leaders in South Dakota, including Senator Thune, Senator Rounds, Representative Johnson, and Governor Noem for their continued leadership in this area.

Dakota State University looks forward to continued collaboration with the Committee to develop policies to advance the safe, responsible, and effective deployment of AI across agriculture.

Thank you for your time.

[The prepared statement of Dr. Griffiths can be found on page 57 in the appendix.]

Chairwoman STABENOW. Thank you very much.

Dr. Hindman, welcome.

STATEMENT OF JAHMY HINDMAN, Ph.D., SENIOR VICE PRESIDENT AND CHIEF TECHNOLOGY OFFICER, DEERE & COMPANY, MOLINE, IL

Dr. HINDMAN. Good morning. On behalf of Deere's 80,000 employees worldwide, I want to thank the Committee for the opportunity to address you here today.

John Deere is dedicated to assisting customers in meeting the increasing global demand for food, fuel, shelter, and clothing. We tackle challenges like limited land, water, and rural labor by leveraging technology, including artificial intelligence, to empower growers to achieve higher productivity with fewer resources. This approach allows farmers to accomplish more with less while improving both their economic and environmental sustainability.

Deere currently connects over 650,000 machines around the world using terrestrial cellular networks. This allows data generated during farming tasks like planting and harvesting to be sent to the cloud for analysis. The insights gained from this analysis help optimize a farmer's current tasks, such as improving logistics, and contribute to enhancing future farming seasons.

A common concern regarding farmers' data is ownership, and we are unequivocal on this matter: John Deere customers retain control over their data, including how it is collected, stored, processed, and shared. That said, we also believe that the valuable insights that can be derived from this information will play a crucial role in meeting our industry's collective objective of sustaining a growing global population.

Farmers use these same connections to deliver data-driven instructions back to their machines, such as prescriptions for applying different rates of fertilizer to different parts of a field, navigation information used to auto-steer machines, and input specifications like seed and fertilizer. These network services are offered to farmers through partnerships with third-party companies, allowing farmers to have greater flexibility in choosing the services based on their own preferences and needs. However, it is vitally important to address connectivity challenges in rural areas, including in-field connectivity, to fully unlock the benefits of technology for farmers.

In addition to connecting our products, we have significantly increased the computing capability embedded within those products. This allows for more advanced control and enables a unique "plant-level management" capability, where each plant can be nurtured to achieve its optimal potential. Our self-propelled sprayers, for example, feature nine graphical processing units and 36 cameras. These cameras can scan a distance of 120 feet at a speed of 12 miles per hour. Through artificial intelligence, they analyze images to identify weed pixels, allowing precise herbicide application only where necessary. This See & Spray TM technology is not some futuristic vision. It is already in the field. In 2023, U.S. farmers achieved an impressive 61 percent reduction in contact herbicide usage across 275,000 acres of corn, soy, and cotton, saving approximately two million gallons of herbicide.

Reducing herbicide use is just the start of AI's potential in agriculture. For instance, we have integrated the same graphical processing units with stereo cameras in our autonomous tillage solution. This application of artificial intelligence allows us to identify

obstacles in the fields, prompting the fully autonomous tractor and tillage tool to pause and await further instructions from the farmer, who may be engaged in other, higher-value tasks. This solution directly addresses labor scarcity, especially during critical agricultural periods such as harvest and planting. In the past two growing seasons, this AI technology facilitated autonomous operations on approximately 45,000 acres of corn and soy in North America. As rural-to-urban migration continues, AI-powered solutions like this one become even more essential to U.S. farm productivity.

Additionally, we leverage the power of AI to train models using our technical assistance data. This enables us to promptly address customer or dealer machine issues, ensuring swift problem resolution. AI allows us to efficiently identify similar issues across a machine population and expedite solutions for affected customers. As a result, the impact duration during crucial agronomic timing windows is significantly reduced.

The future of U.S. agriculture is being built today with tools that enable data-driven decisionmaking by farmers. Artificial intelligence plays a crucial role in unlocking the value of that data and turning it into actionable insights in the field. We need your help.

U.S. farmers would benefit greatly from incentives to help them acquire the precision technology needed to do their jobs more effectively and sustainably. As you deliberate the upcoming farm bill, I urge you to consider such proposals as the PRECISE Act, and the Precision Ag Loan Act, that would expand eligibility for USDA conservation and loan programs to include the adoption of precision technologies. Further, bills like the Last Acre Act are essential for farmers to fully leverage the benefits of AI and precision technologies.

Putting these technologies in the hands of America's farmers not only improves productivity and profitability for growers, but also enables them to produce enough food, fuel, shelter, and clothing to sustain the growing world population. That benefits us all.

Thank you.

[The prepared statement of Dr. Hindman can be found on page 65 in the appendix.]

Chairwoman STABENOW. Thank you very much.

Now we ask Mr. Janzen. Welcome.

STATEMENT OF TODD J. JANZEN, PRESIDENT, JANZEN SCHROEDER AGRICULTURAL LAW LLC; ADMINISTRATOR, AG DATA TRANSPARENT ORGANIZATION, INDIANAPOLIS, IN

Mr. JANZEN. Thank you, Chairwoman Stabenow, Ranking Member Boozman, and members of the Committee. My name is Todd Janzen. I am an attorney at the law firm of Janzen Schroeder Agricultural Law LLC, based in Indianapolis, Indiana, and we serve the needs of America's farmers, agribusinesses, and also ag tech providers. I am also here today because I grew up on a farm in south-central Kansas and so I have agriculture at my roots.

I would like to make three points here today about agricultural technology, the digitalization of farming, and artificial intelligence.

First, there are many ways that farmers are already interfacing with digital technologies today. We have everything from farm management information systems, which provide a suite of services

to farmers in exchange for collection of data and allow farmers to analyze their decisions and make informed decision based upon all that data.

On the other end of the spectrum we have remote sensors and items that are very specific about performing one task, but these are also connected to the internet and often referred to as Internet-of-Things devices. They allow farmers to remotely monitor what is going on on the farm.

Then, of course, there is everything in between, from aerial imagery, satellite imagery, connected machines, and even connected livestock on the farm.

All of these tools share one common denominator, which is that they all collect a lot of data from farmers, and farmers are a sensitive group when it comes to talking about sharing their data, and they have a good reason to be so.

Second I want to talk about what are some of the reasons that farmers are reluctant to share data with companies that want to offer these digital tools. When farmers are polled, it is almost always the same three things bubble to the surface, and I would say the first is a lack of trust in a lot of these platforms. Farmers just do not know what happens after the data moves to these cloud-based platforms.

Second, privacy concerns. Obviously, this is proprietary data for a lot of farmers, and so it is their livelihood, so they want to know that it is protected.

Third, from my standpoint, what I also see is a lot of overly complex technical agreements that make it difficult for farmers to understand exactly what it is they are giving up as far as the data.

Much of my work has been done to try and alleviate these concerns in the technology space as a number of companies want to move into the agricultural area. I have done this through a project called the Ag Data Transparent Organization. What Ag Data Transparent does is certify companies that work to show that they are transparent with how they are collecting and using and storing farmers' data. To date, this Ag Data Transparent Organization has certified over 40 companies, and there are still many more that need to be certified, and there is much work to do.

I would like to also talk just a couple of minutes about artificial intelligence and how that is arriving on the farm. I like to think of it in different buckets. On one end we have narrow AI, or narrow artificial intelligence, which takes a number of datapoints to make a single, informed decision about something, like is this a weed or is this a valuable crop.

On the other end of the spectrum we have the general AI, which takes a lot of data from different sources and is focused on trying to mimic human behavior. An example might be analyzing a whole catalog of different seeds that are available and then applying those to a specific farmer's fields for a specific area, based upon the weather predictions for that year, to suggest this is the ideal crop to plant for you.

With all of these, though, of course, there is more data collection, and so that remains a concern for protection. Farmers should know how their data is going to be used. They should know, when they

sign up for AI platforms, if it is going to be used to train these platforms and what that means for them.

Finally, I would like to offer just three policy considerations based upon my work as an attorney in this sector. First, I think that any policy should focus on leveling the playing field and not stifling innovation because this is such an innovative sector. Second, when I think trust is lacking, then transparency becomes even more important. If anyone is collecting data and they do not have that farmer trust, they have to be extremely transparent with how they are using it.

Finally, any platform that uses agricultural data should try to return an equal or greater value of that data back to the farmer in the resulting product. I would say to you that all three of these recommendations are true whether it is private industry collecting data or whether or not it is the government collecting data for use in some farm program.

Thank you very much. I look forward to the questions today.

[The prepared statement of Mr. Janzen can be found on page 69 in the appendix.]

Chairwoman STABENOW. Well, thank you to all of you for your thoughtful testimony and raising what I think are really important issues. Let me start with Dr. Earles.

The world was a very different place five years ago when we wrote the last farm bill, and from your position now, through your leadership, when you see firsthand how quickly everything is changing, how is our understanding of artificial intelligence in the agriculture sector different than five years ago? Where are we going, specifically? Could you talk more specifically about what we need to be paying attention to and doing.

Dr. EARLES. Sure, yes. That is a great question. When I think of what has changed in the last five years, I think the biggest change has been for actually software developers. What I mean by that is, this has upstream consequences for everybody that is going to consume the products from AI. What that means is it is a lot faster to go from nothing to product today than it was five years ago.

For example, today it may only take a day to build an AI model that counts destructive versus beneficial moths on a piece of paper from images, whereas five years ago a smaller group of people, of skilled individuals, software developers, it would have taken them much longer to do this. What that ends up meaning is that we get more products to market faster for agricultural AI startups and industry.

What has not changed, though, I think, is that AI models still require data, and they require human supervision. What I mean by that, as I mentioned earlier, someone has to go in and punch in a computer what they see, and that person is an expert, an agricultural expert, and those are still in high demand but low supply. Being able to connect those agricultural experts to the software development process is something that is changing quickly but still needs to change faster.

In the next five years, I think you had asked what I see going into the next five years as well, I think even in the last week or two weeks we have seen a huge change in how AI and humans communicate.

I am going to give a quick example of this, and what I did last night. I sat down and I took my phone out, opened up an app–and you mentioned you generated your comments through AI–I asked it, I said, "I am soybean farmer outside of Des Moines, Iowa. I have some small worm that is infesting my crop. I am near a river. What do you think it is?" It came back with five different possible responses within 30 seconds, and it said, "I might be able to help you figure this out if you show me an image."

First I did this with my voice. I said this to the AI, and it responded with its voice and text. It then gave me an option to show it an image. This was just like talking to a person, right? I show it an image of what I know to be this certain type of worm, and it correctly identifies this type of worm.

To me this is how we communicate with AI that is changing rapidly, and they have the soon-to-be role, if not already role of being AI advisors.

I think this is something we need to think a lot about is what are the recommendations that they are making and how are we training those models such that they are giving reliable, robust recommendations, and how are we regulating what is coming out of the models, which may end up being easier than thinking of how farm advisors are actually doing, but we also need to take that into consideration.

Chairwoman STABENOW. Thank you very much.

Mr. Krishnan, when we look at these innovations, of course none of them matter if they are just in the lab. They have to be out in the hands of farmers. To do that we will need a partnership between researchers and the private sector with a willing and able work force also.

Could you speak to what you hear from others in the private sector about their reluctance to invest in agricultural technology and how can we use these advances to bring new high-paying jobs to our States?

Mr. KRISHNAN. Thank you. Given the need to feed a population of 10 billion globally and America's leadership, there is increasing interest in the venture capital community in this space. Ten years ago it was less than $1 billion, and at its peak we hit $12 billion. Year-to-date venture capital has invested close to $6 billion in this sector.

I will say, though, a lot of venture capital investors recognize this takes longer. This is more tough tech than traditional tech, so the sales cycle and product cycle takes longer. There is more risk aversion across the field. That is why you have seen less than three percent of venture capital dedicated to ag tech. We think we need to improve that, and there is a huge amount of opportunity for the public sector and private sector to be in partnership to accelerate this adoption cycle and get more venture capital into the sector.

Chairwoman STABENOW. Thank you very much. Senator Boozman.

Senator BOOZMAN. Thank you, Madam Chair. We do appreciate you all being here. It is interesting the Ag Committee really is, for almost everything that we deal with, is very bipartisan, and the minority selects witnesses, the majority selects witnesses, but all of you all, again, could be witnesses for any of us. Like I say, you are

just trying to figure out answers, trying to come up with solutions, in this very interesting field that has the promise of really making a huge difference to humanity in so many different ways. Thank you all for what you are doing and what you are working on.

Dr. Hindman, in your testimony you State "John Deere customers retain control over their data, including how it is collected, stored, processed, and shared." Can you talk a little more about how this works in practice, including the process for producers who may wish to make changes in the way their data is being handled?

Dr. HINDMAN. Yes, sure. Thanks for the question. Today, in our digital application, John Deere Operations Center, that is where customers can control, modify, change the information that they have that is reflecting their particular farm operation. They get the opportunity to invite people within their organization to participate in that application and define the access rights for those people. That might be other labor on the farm. It might be an agronomist that they are working with. It might be a third company that potentially is working with them on different aspects of their operation. They get to determine what that information is, where it goes, and what it is used for.

They can change that dynamically. They can change it on their mobile phone if they want. They can change it in the desktop application. They can do that at any point in time.

They also have the ability, if they so choose, to delete that information if they want to remove the record. Generally that is a pretty unlikely thing in our experience, but they have the capability and the opportunity to do that if they choose.

Senator BOOZMAN. Very good. Dr. Griffiths, what are the cybersecurity risks associated with integrating more technologies like AI into the agricultural sector? Why is it important to research and explore the transformative potential of AI in this area?

Dr. GRIFFITHS. Thank you for the question. Well, the risks are the same kinds of risks that you get with any AI application. Artificial intelligence, first of all, it is basically a set of algorithms or computer programs, and it is data, whether it is test data or live data, and you have the opportunity to attack either. Hackers will and can attack either, for whatever reasons they wish to do it.

In the agricultural sector we really need to start protecting the data, and that is part of the kinds of research that we are engaged in with industry and with South Dakota State University. For example, we have been looking at how data go from satellite to the cloud–we also have data in the cloud these days–and how can we ensure data confidentiality and integrity as the data move from one place to another, because it is easy to attack those data.

We look at developing an effective method both for encrypting the data and then doing that at a speed and cost without involving any delay in the processing of the data, which, as you just heard, sort of operates in sort of milliseconds in time. It is very, very important for the data to get to the person who is making ultimate decisions from the AI.

I think as AI evolves we are seeing more and more technology being incorporated into the agricultural sector, and that increases what we call the threat landscape. There are more and more points

at which you can begin to attack the system. You are only as strong as the weakest link, as it were.

I will give you another example. Just before Russia invaded Ukraine, we saw pictures of tractors stuck in fields, unable to move because the systems had been attacked, and that created an impetus for us to do some work on trying to protect farm vehicles from similar kinds of attacks that could occur from unfriendly States.

We have looked at enhancing the security of these farming vehicles, developing artificial intelligence-enhanced, we call intrusion detection systems, people who are trying to get into the system to do damage. These systems are designed to strengthen the cybersecurity of agricultural machine. We are looking at this not just for today's technology but we are looking five years out at the technology that will be in the fields, to try and ensure that they are robust and cyber protected from the beginning.

I think it is important to remember that this entire supply chain, this entire food and security and clothing supply chain, it needs to be addressed at every single point and scale. I often say we talk a lot about protecting the data from sensors and from tractors and other vehicles, but we also have to protect the seeds and the treatment of seeds and how the fungicides and herbicides are being measured to be put on seeds for seed production, because we actually could see a significant latent effect on the actual development or non-development of crops going on in the future.

I hate to be the negative person here. I am very excited about what artificial intelligence can do in the agricultural sector. I feel like the child in the Sixth Sense. You know, I see cyber threats everywhere. When I see a vulnerability I think we have to find a way to attack it. I just ask that you be fully aware that you cannot separate any new technology these days from cybersecurity. The two have to go together. As technology evolves and as artificial intelligence evolves–it is multiple things; it is not a single thing–we have to evolve the cybersecurity that goes with it.

Senator BOOZMAN. Thank you very much. Thank you, Madam Chair.

Chairwoman STABENOW. Thank you very much. Senator Klobuchar.

Senator KLOBUCHAR. Thank you very much to both of you. I am excited about the work that is going on.

This summer I toured a number of farms in Minnesota that were making impressive use of precision agriculture. On one of the farms the sprayer had been configured to only spray on plants that it correctly identified as weeds. I know you are seeing this all over in our agriculture communities. We know it helps reduce input costs, better for conservation. That is why Senator Fischer and I introduced the Precision Agriculture Loan Act, and I know, Dr. Hindman, you mentioned the Precision Ag bill in your testimony, which I appreciate.

I guess I would start with you, Mr. Krishnan. In your testimony you discussed the important role that Federal financing opportunities can have in helping scale these kinds of technologies. Could you talk a little more about that?

Mr. KRISHNAN. I think as agriculture goes from data poor to data rich everyone is talking about precision agriculture, so drones, sat-

ellites, remote sensing, et cetera. We also see a more data-driven food and ag system supporting new risk management lending solutions, particularly not only to adopt and de-risk scaling of new technologies but also for longer term decisionmaking, focused on soil health and sustainability. I think this is a really important area for public policy to get involved in, to give farmers not just the tools but the financing to increase yield per acre and profit per acre.

Senator KLOBUCHAR. Exactly. Senator Thune and I lead a different bill that would require the USDA to identify and collect and analyze the data. What you are saying is that it is helpful to have both the data as well as the financing.

Mr. KRISHNAN. I think both are really important and critical.

Senator KLOBUCHAR. Okay. Dr. Earles, in your testimony you talked about the work you are leading at UC Davis to develop AI-enabled sensing systems that help producers manage their operations more precisely. Can you talk about how that can help with costs in the long term. It is an investment in the short term, please. Thank you.

Dr. EARLES. Absolutely. In terms of on the farm, you know, we think of the breakdowns in terms of cost. I think more of specialty crops because I am coming from California, but I think this applies across many different types of crops. Where we have all of these inputs that farmers are facing, they are spread across a number of different activities.

AI has the potential to hit various activities, whether it be fertilization, pest management, yield forecasting and prediction, and other types of irrigation and so on. I think these are cost-saving measures that may be somewhere between 5 to 15 percent, on average, in any given farmer's operations. One of the challenges in going from an idea to a product in agricultural for cost savings is finding those real value propositions, I think, in precision agriculture.

What we have been working on is really identifying what those are. That really depends on what crop type we are looking at, and I think this is a big challenge for AI going forward, is finding each one of those crop types' pivot points that they are willing to bring AI into adoption.

Senator KLOBUCHAR. You cannot really do most of this without broadband, and as we know, that is a big piece of this, to get broadband to every corner of our country. We made sure that the Bipartisan Infrastructure law that many of us at this table supported included a significant investment in broadband infrastructure. I actually led that bill before it got included in the Bipartisan Infrastructure law.

Dr. Griffiths, can you talk about the importance of broadband to making AI-enabled ag technologies work for farmers, and how can we do more to solve the work force shortage, which is another issue that is plaguing us in rural.

Dr. GRIFFITHS. Absolutely. Thank you for that. Yes. I will start with the broadband question. Given the fact that we are able to potentially generate huge amounts of data, we have to send the data somewhere, and we have to do it in a timely manner, and in order to do that we need the broadband infrastructure to become ubiq-

uitous across the entire country, but especially in the farmlands and in the middle of the United States, where it is not necessarily uniformly available at this time. That has been something, actually, that I have testified on before, and here it is again. We cannot ignore that as enabling infrastructure for the use of many of these additional and new and emerging technologies.

Even in South Dakota, we are doing pretty well on broadband infrastructure on one side of the State and the other side not so good. Then we have Badlands and topologies where it is very, very difficult to try and ensure that equal access to broadband technologies. We are working on it, and will continue to do so.

The work force issue is another issue that is plaguing us, because we really do not have sufficient numbers of people who are fully aware of the capabilities of our artificial intelligence. I classify the work force needs into three areas. We have the need for additional experts who are actually going to help develop these AI-related applications to agriculture and to other sectors, and we are in relatively short supply of those people. We need to encourage more people to go into STEM, and I think that particular issue will not be solved with domestic personnel alone. We are going to have to look at legal immigration.

The second area, though, we are going to have more people engaged in what we call the users. There are two kinds of users of AI technologies. They are the producers of products and services who are using AI technologies to create their offerings, and then we also have the end users of those products and service, so you could say the individual farmers or ranchers who actually need to use those products and service. Then we ultimately have the general public. What should the general public know about artificial intelligence?

I think the key here is, one, we do need more people moving into these fields, and second, we need to do more to educate the users and end users of the capabilities and the risks associated with these technologies so that we can develop artificial applications, artificial intelligence applications responsibly that actually do what we want them to do, that carry the kinds of values the United States wishes to spread and continue to spread around the world, and minimize the risk that is associated with these technologies so that we can optimize the use.

Senator KLOBUCHAR. Thank you.

Chairwoman STABENOW. Thank you very much. Senator Ernst.

Senator ERNST. Thank you very much, Madam Chair, and thanks to our witnesses for being here today as well, and thank you, Senator Boozman, for mentioning Steph Carlson. We will miss Stephanie as she returns back to Iowa to be closer to her Iowa family, friends, and, of course, her great Iowa Army National Guard unit as well. We really appreciate Steph and the great contributions that she has made to the Committee and to my office, so thanks, Steph.

When we passed the farm bill of 2018, we thought it was a very significant accomplishment, but here we are today, five years later, and we still have no farm bill. It actually expired on September 30th. I am encouraged to see that we do have a one-year extension agreed to, contingent on the continuing resolution being passed.

The lack of urgency and progress on this once-every-5-year piece of legislation has been a real disservice to rural America, and I hope that we can see more farm in the farm bill as we move forward and that we can get it done early this next year. We really need to work hard for our farmers and ranchers.

I always make this point. Many of you have heard it before. I believe that food security is national security, so we need to continue on and make sure that we get this over the finish line.

The topic on hand today, it really does have so much potential for the future of ag. Whether it is identifying that specific type of insect, just as was pointed out—thank you for that example—or whether it is monitoring animal behavior in a hog barn, AI has the ability to provide our farmers with new tools to help them navigate through very difficult decisions.

I am very proud to say that Iowa has been leading when it comes to AI, and my alma mater, Iowa State University, is home to the AI Institute for Resilient Agriculture. By partnering with Iowa farmers and companies like John Deere—and thank you very much, Dr. Hindman, for being here today—I am excited to see the future of agriculture. Together they are focused on technology that makes smarter, more profitable, and more sustainable, to better meet the demands of our future generations. Thank you for engaging.

Dr. Hindman, I will start with you. As you mentioned in your testimony, the utilization of AI in ag requires a significant amount of user data, which our Iowa farmers are collecting when they plant, spray, fertilize, or harvest their crops. My brother-in-law uses this technology as well. It is pretty exciting to hear him talk about the opportunities there.

How do you ensure that the information and the privacy—which is something even my father, he has a good dose of Iowa farmer skepticism—how do you ensure that all of that privacy is protected for those farmers when they are utilizing your particular technology?

Dr. HINDMAN. Thank you, Senator. It is a great question. I think first I will go back to they control who accesses their data within their account, within the Operation Center.

Before we even get to that stage, we take this very seriously within Deere, and we start with a principle of security by design, so making sure that as we are developing software we are doing it with a seriousness about the security aspects of that software, first and foremost, making sure that it is secure by design. That is sort of the bedrock of how we do software development, whether it is digital or embedded. Even with that we still, no doubt, create opportunities for threat actors, given the complicated threat surfaces that are involved to infiltrate that data.

We then look toward external partners to help us do things like penetration testing, testing the systems to make sure that they are resilient to external people trying to get into those systems. We partner with white hat hackers. HackerOne would be an example where we do a bug bounty program. We pay for ethical hackers to try to hack into our systems and expose vulnerabilities before they become public so that we can remedy those and keep that data intact.

Senator ERNST. No, that is really good to know, and that will help some of these older generations of farmers understand the new technology is safe to use and their data is safe.

Once you have captured all of that data, then how is John Deere—do you turn around and use that data to help our farmers?

Dr. HINDMAN. Yes, it is used in a variety of ways for growers, ways for us to look at how to improve the next product. You know, is the current product performing to the expectations of the customer or not? If not, what can we do to move the needle to make it perform better?

We also utilize it for things like predicting when failures might occur in the equipment so that we can provide proactive service parts, proactive support for those failures. Especially in those critical timing windows of planting and harvesting, when every minute matters machine downtime is a problem, and so we work to make sure that we can try to position both customers and dealers in the best position possible to be able to address those disruptions.

Senator ERNST. That is really great. The military has actually been using predictive maintenance and models for a very long time, which does save the Federal Government a lot of money, and in this case, utilizing this technology on our farms may save our farmers a significant amount of money and downtime as well.

Thank you very much. Thank you, Madam Chair.

Chairwoman STABENOW. Absolutely. Senator Welch.

Senator WELCH. Thank you very much. I do want to thank Senator Stabenow and Senator Boozman for the one-year Farm Bill extension. Time is wasting and we have a sketchy situation over there on the other side of the building so we better get to work pretty quickly to get that five-year farm bill passed.

There is a lot of opportunity with AI. I'm concerned about the viability of AI for our small-scale producers. We have a lot of small farms in Vermont. A lot of times something will come up that is an opportunity for bigger ag where you can spread the cost over time, but for a lot of small-scale producers they are skeptic about whether they can get a return on investment.

A McKinsey poll fund that fifty-two percent of North American farmers cite high costs, and 40 percent cite uncertain returns as the biggest challenges to adopting farm-management systems. Many of our farmers have greater confidence in a fellow farmer or some of the folks from Extension, people they have worked with over the years. They have confidence in them to understand the dynamics of AI and agriculture. This is going to get to a point where we talk about the profitability over yield per acre.

The big question I have about AI is with the entry cost. How can we do things that are going to help the smaller farmers get the benefit of AI when they are just not going to be able to take that risk about the high upfront cost. Can you address that, Dr. Earles?

Dr. EARLES. Absolutely. I think there are two buckets that I would put what AI might help farmers do. One is decision support. This has typically been the role for small farmers of Extension types of agents. They rely very heavily on Extension oftentimes for various sorts of advice. Then the other one is mechanization and automation, which I think those two can often come with very different costs associated with them.

I think in terms of AI and their impact on those two areas, on the Extension side I mentioned this idea of there are not enough Extension agents out there right now, because really, they are experts in 100 different things.

Senator WELCH. Let me put a little ripple on it too, because in addition to that, the smaller farmers, a lot of times will be wanting to do this, focus on profitability and value added products. The data that goes into the AI algorithm is essentially generated by the larger operations. How is that going to make it more difficult for the smaller farms that have a different business model, in effect, to be able to take benefit of AI? How do we integrate that into the systems?

Dr. EARLES. Yep. I think there is an opportunity for using things people already have, like their phones, and people are taking advantage of this because our phones are loaded with many different types of sensors. You know, we may not realize it but there are probably 15 different types of sensors on there, from cameras through accelerometers, et cetera.

I think there is an opportunity for smaller farmers, and people are leveraging this opportunity to develop products around phones.

Senator WELCH. Okay. Thank you. That is helpful. I will ask you, Mr. Krishnan, I know in your work you focus on profitability per acre to better incentivize climate-friendly practices. That is a big deal for our farmers. They are trying to do things that regenerate the soil. They are trying to do things that reduce the cost of a lot of these inputs so that their profitability is greater, at the end of the day, obviously what is important.

Talk to me about AI and how our farmers can focus on profitability as opposed to anything else, really.

Mr. KRISHNAN. I think what AI and better sensing allows you to do is focus on precision agriculture, so improve the resource efficiency of water, pesticide, fertilizer management. This should increase resource efficiency and profit per acre.

I think the second thing that AI will allow us to do is sort of understand agriculture and the farm as a soil health asset class, and effectively really mine what is already naturally occurring in the topsoil.

Senator WELCH. Talk to me about that soil health, because that is a real concern for our farmers. I mean, everybody. The more of these inputs we have to put in, the herbicides, pesticides, and so on, the more it challenges the soil health, is what I understand.

Mr. KRISHNAN. Yes. There are close to a trillion living things within six inches of our soil, and there are different consortia—microbes, fungi, bacteria. I think there is a real opportunity to focus on organic matter, which is a measurement of all that life——

Senator WELCH. The better the soil health, the higher the yield, right?

Mr. KRISHNAN. Exactly.

Senator WELCH. Yes. Did you want to add something, Dr. Griffiths?

Dr. GRIFFITHS. Yes, if I may. The Extension Service at South Dakota State University just received a significant grant for soil conservancy in the State, to look at areas of soil in fields that are not

very productive right now, and replanting natural grasses that go down sometimes 20 feet, with roots down 20 feet——

Senator WELCH. Really?

Dr. GRIFFITHS [continuing]. to rejuvenate and re-nutrient the soil so that it will be available for future use. The idea of farming, on the one hand, and conservancy on the other, it is a balancing act, and AI is going to help with that balancing act saying where and when you should start conserving.

Senator WELCH. Yes. Well, I hope it is affordable to the smaller farmers. Thank you all very much. Madam Chair, thank you. I yield back.

Chairwoman STABENOW. Thank you very much. Senator Braun.

Senator BRAUN. Thank you, Madam Chair. Before I got to the Senate I ran a company that was a distribution and logistics company, very kind of mundane, until we discovered technology. Once it was kind of beaten into my head in terms of being way too expensive for the benefits, the older of my two sons, who now run the company with one of their sisters, I became a believer in it. The benefits of it, amazing how it gets, in our case, a train to show up on time, figuratively speaking, how much it costs, but the benefits have always been there. Anymore I do not argue. I just say how much and we do it. Of course, it is not my decision anymore.

We still, though, today, in touching base, have to fend off from across the world people trying to take your technology, and for no real good reason, disrupt it, run it, ransom it, all that.

I want to use that as kind of what we deal with before we heard much about AI. I would like to ask Mr. Krishnan and Dr. Hindman your opinion, what the main worries would be when we take something as wholesome as agriculture and to see what we want to do with it, what would you see as being the biggest risks, in your mind, of how we apply AI to agriculture and not to have a maleficent end result in the process of doing it? We will start over here.

Mr. KRISHNAN. It is a great question. I think AI is just like any other technology or toolkit. It has pros and cons. It can definitely increase productivity, as you saw in your business, but also increase disparity between small producers or large producers or people with access to those high value revenues and people who do not, people that have high sensor penetration and people that do not on farm.

I think data has become this raw material for these algorithms to make them more valuable or productive and more profitable. I think a lot of what we have talked about today around data privacy, data ownership, cyber, are very critical. I think the biggest thing, whether it is in AI or in ag tech is really trust and transparency I think they are very important, and a lot is in the details and nuances. I really encourage maybe an expert working group to really tackle the issues around data ownership, data privacy, and data protection.

Senator BRAUN. Thank you. Mr. Hindman.

Dr. HINDMAN. Yes, I think, it is relatively easy to get a machine learning model to be 80 percent accurate. It is much harder to get it to be 99, 95 percent accurate, and the difference between those two is the difference in data. It is how much data you have, the quality of that data that is used to train the model.

Data is the currency of artificial intelligence. It is what powers it. It is what makes it go. For an example, in the See & Spray application that we produce, where we are discriminating between weeds and healthy crops and spraying only the weeds, we created a dataset that is an image catalog, effectively, of millions of images of weeds at all different growth stages and different light conditions across corn, soy, cotton, across the southern part of the U.S. to the northern part of the U.S.

This dataset is very, very valuable. It is what gives us the ability to discriminate a weed in the machine learning model across the geography of the United States in those three crop production systems. If you think about the value of that data, one of the things that keeps me awake at night is the threat actors that you mentioned having access to it so that they can go create something very, very similar without putting the effort into collecting the information that was necessary to produce it.

Senator BRAUN. Thank you. Mr. Janzen, since you deal with the farmers in your practice and the industry itself, especially from the perspective of farmers, they need every tool they can get to nurse that extra dollar per acre out of a tough, tough business. We talked about that a little bit earlier. What are they saying that they are looking forward to out of it, and what risks are they talking about that might be associated with it?

Mr. JANZEN. Yes, thank you, Senator Braun. I would say that what they really want to see is return on investment, and they are always very reluctant, I think, to give over data to a lot of the companies that want to use it for, whether it is farm management system or training AI models. If they know that they are going to get at least an equal amount of value back in return for giving that data over, then I think it is worth it to them.

Farming is their livelihood, and so that is why I think they have a reason to be skeptical of just turning over all this information about their livelihood to third parties unless there is that trust there.

Senator BRAUN. I think that is a good point because my feeling is that is the toughest small business in the whole spectrum of enterprise to run, inherently low margin in an increasingly concentrated industry. Any leg up they can get, they need it, and ROI may be the best way to measure that.

Thank you.

Chairwoman STABENOW. Thank you very much. Senator Luján.

Senator LUJÁN. Thank you, Madam Chair, and thank you to our Ranking Member for this hearing.

Dr. Earles, in your testimony you discussed research into how farms and workers can utilize AI technologies to monitor livestock, help provide nutrients, predict climate, and control irrigation. Yes or no, is there a work force ready to fully develop and operate these technologies so that farms across the Nation can fully benefit?

Dr. EARLES. Thank you. I think that is a great question. It really depends on which crop we are probably talking about, but across the board I would say that the work force is probably not as there in specialty crops, for example, as it may be where we have much more manual labor, and so there are a lot more difficult types of tasks humans are doing. I think maybe we are closer on the front

where we already have major penetration and mechanization, so in some of the row crops and things like that, where maybe there is less manual labor.

I think that is probably the biggest differentiator in my mind of what drives readiness for the work force.

Senator LUJÁN. I appreciate that, and Madam Chair, I think that is just a reminder that the Committee not lose sight of the human component here as well as this conversation continues to grow.

Dr. Earles, California has a large Spanish-speaking population, as does New Mexico. Are efforts being made to make AI-enabled agricultural technologies easy to use by non-English speakers?

Dr. EARLES. Yes, I will speak from an example in this case. I think if someone is not doing this, then the technology is not going to penetrate the market.

Senator LUJÁN. Would you repeat that?

Dr. EARLES. Yes. I think if there is not an effort to make Spanish-first or at least bilingual in these tools, especially in specialty crops where we have predominantly Spanish-speaking workers, then the tools are unlikely to succeed. I have seen this firsthand in grape and wine industry, where people building tools internally are Spanish mode first.

Senator LUJÁN. Dr. Hindman, would you agree with that?

Dr. HINDMAN. I would.

Senator LUJÁN. Is Deere doing it?

Dr. HINDMAN. We do from an operations perspective in all of our equipment. The ability to operate the equipment exists in multiple language, Spanish being one of them.

Senator LUJÁN. To operate. What about the AI component of all the smart stuff you all build into your tractors and farm equipment?

Dr. HINDMAN. What we build into the tractors to this point has been largely visual. It is machine learning image recognition, so it is language agnostic, in a sense.

Senator LUJÁN. I appreciate that, and I look forward to learning more about that.

Mr. Krishnan, you firm helps identify and develop AI technologies in the agricultural sector. How can companies like yours work with Congress and other government agencies to ensure that full diversity of American farmers and farm workers have a say in the development and deployment of AI agricultural technologies?

Mr. KRISHNAN. Thank you for that very important question.

Our hope is AI can improve and democratize access to information, networks, and knowledge, and create a more level playing field. In order to do that you need to have smart policy and partnership with the private sector.

Senator LUJÁN. I appreciate that very much. Dr. Hindman, there have been several conversations, questions around broadband connectivity and the importance of access, especially along the last acre, which I am proud to be working on with Senator Fischer, talking about last-acre connectivity. The idea here is to expand network connectivity across farmland and ranchland to ensure our rural communities and smaller farms can benefit from emerging technologies.

You have deployed precision agricultural technology, Deere has, that allows for plant level management. Now yes or no, does every rural community in America have access to the wireless networks needed to support that level of precision ag?

Dr. HINDMAN. It does not.

Senator LUJÁN. How important is it to expand connectivity to allow that to occur?

Dr. HINDMAN. Ultimately important.

Senator LUJÁN. I appreciate that. Madam Chair, this is a question that I know many of us have been asking, especially those of us who represent more rural areas and more rural communities. With the commitments that were made with the Bipartisan Infrastructure Bill with broadband, there was a commitment made that everyone was going to get connected. All of that was going to happen. As a former utility commissioner I pay attention to the filings at the FCC, and there are several of those companies that have been submitting those filings. One of them, I think, used an adage of, well, what about someone that lives down a longer road? What if it is too expensive to connect them? I thought that was the idea of the bill.

I live down a long dirt road. I am sure a few of us do. It is just one of those reminders that if we are going to live up to the promise, especially in this particular space, of AI to help food production, improve profits for farmers and producers across the country, they need to have that simple technology that takes advantage of spectrum to be able to utilize these tools. I hope that is something else that we can impress up.

Dr. Hindman, with Deere—and I appreciate your response to the threat actors having access to data. Now my question is, does Deere sell the data that they collect? Do they profit? Do they use a third party? Or does Deere keep that information just to themselves for their own product improvement?

Dr. HINDMAN. We do not sell it. We are approached routinely by others who would like access to it. Our response is you have to go get approval from every farmer who has data that you are interested in.

Senator LUJÁN. I want to thank you for that. I know that that is a tough decision, but especially as you are protecting the intellectual property, behavior, whatever it may be, or the confidence with those users as well. I just want to thank Deere for that and for your response here.

Thank you, Madam Chair.

Chairwoman STABENOW. Thank you very much Senator Luján. Let me just say that they used to say that it was too expensive to put the farmer at the end of the road into telephone or electricity, and somehow we managed to do that. I could not agree with you more. Senator Thune.

Senator THUNE. Thank you, Madam Chair, and just as a followup to Senator Luján's comments on some of these, there are tens of billions of dollars available, and yet I met last week, or the week before, with our independent telephone co-ops in South Dakota, and not a single one was applying for any of that money, partly because of all the regulations and red tape and requirements that have been attached to it. You have got to hire certain types

of people. You know, the unions had their say in that. We are a right-to-work State. We do not have that kind of work force. Then, of course, there is all the climate requirements you have to prove.

Yes, there are a lot of places in South Dakota, like the State that you represent, New Mexico, that desperately need that connectivity, and there are companies that are willing to invest and put money into it. That, to me, was pretty striking, that not a single one of them was going to apply for that funding because it just did not make sense for them economically.

Let me come back, and I am going to try and combine several questions here into one, Dr. Griffiths. I think it is really important, and there is a bipartisan bill that I am working on that is focused on putting the right guardrails in place for the highest impact AI systems while also, at the same time, allowing for innovation. I think that is an important balance we have to strike.

What I believe is important, as we think about that, that we keep innovation in it but we also know that there are riskier applications that are going to need a little bit, at least some amount of guardrails around it. Could you give a few examples of—and you mentioned this in your testimony—how new AI systems, the tools are being used to benefit agriculture? Second, what some of those risks are and why Congress needs to establish at least a light touch approach with respect to guardrails for AI deployment. Then you also mentioned the threat of unfriendly nations asserting themselves into U.S. agriculture, and maybe touch briefly why it is important for the U.S. to lead in innovation on artificial intelligence to stay ahead of some of those unfriendly nations that are also trying to deploy it in ways that would perhaps be detrimental to us.

Dr. GRIFFITHS. Thank you, Senator, for the complex question. Well, first of all, in terms of how AI is being used, we have talked a lot about that today. Precision agriculture or precision farming, precision ranching are being incorporated to improve yield, cut down on data processing and inform better farming practices. Examples include autonomous farming, the use of self-driving tractors, robots for crop inspection and crop harvesting. I am not an agricultural specialist so I am learning the vocabulary of agriculture. Autonomous systems used for spraying, et cetera.

A number of agricultural startups are leveraging the power of data to use AI to better inform practice, and I do believe that with some of the recent developments in artificial intelligence technologies the cost of entry is lowering, not so much for the large data to train AI systems, but then once you have got the AI system available you can apply it to your own environment at a much lower expense.

I think there are a lot of things that we can do. There is the individual field and the individual herd, if you like, that you can manage, but now you can go up a level and talk about how do you optimize the use of land, how do you optimize—we have talked about soil health and things of that kind. All of those are better informed by AI.

In terms of establishing guardrails, I do believe very strongly in a lighter touch than heavy-duty regulation because the moment regulation gets too much, innovation shrinks, naturally. The United States has always had a lighter touch on regulation than

other parts of the world, particularly, for example, Europe, which has its AI framework.

I think it is important that we ensure that innovation can occur, but at the same time that we can have these guardrails to help mitigate risks. I know the beginnings of this have already started with companies volunteering efforts to make sure that they are appropriately secure, and hopefully that will continue and then hopefully the Senate and the House will begin to put some of these lighter guardrails in place. I do think under-regulation would put the industry and the public at risk, so it is that nuanced balance between how much regulation is sufficient. Involving the agricultural producers and providers and technologists in the conversation I think is going to be very important.

Then in terms of unfriendly nations, we do get concerned that tends to be the high end of cybersecurity that I worry about on a regular basis. It keeps me up at night. The United States has a lead in artificial intelligence. It has the lead in the high end research activities. It has the advantage in the high end chips that are a piece of the infrastructure needed to do high end AI research.

Some other countries are very interested in this, some because they want to use it for good, others because they do not wish us well. I do think that the United States needs to stay in a lead role, and then we might see unfriendly countries, or let's say less friendly countries, perhaps they will become fast followers of whatever we produce. Whatever we produce, they are going to take up as quickly as they can and mimic and deploy on their own.

I do think it is important to maintain that research edge. It is what I believe has kept the United States in the lead for many, many decades, and I think it is important that investing in research in AI applications across multiple sectors is going to be very important.

We are really talking about one of the 15 critical infrastructures in the United States. Agriculture is a critical infrastructure. It came quite late to the area of cybersecurity, if I might say. I think 2015 we finally saw the first USDA report on that. I think it is important to bring the agricultural sector into this world very, very quickly to advance the benefits of AI, which is moving very, very quickly, and is going to need the various infrastructures that exist, including 5G, and at the same time making sure we protect that infrastructure so the United States can stay one or two generations ahead of much of the rest of the world. It is the only way we are going to be able to move ahead.

Senator THUNE. It has been remarkable just the progress we have already made in precision agriculture and what that has done on yields and just productivity in our country and how that has improved the bottom lines of agriculture but also, as I mentioned earlier, makes us more competitive globally.

Very quickly here—I see Senator Sullivan here—let me ask Mr. Hindman. When we think about precision ag technologies now that are utilized, how important is it that we, as policymakers, take a tech-neutral approach with respect to broadband deployment?

Dr. HINDMAN. I think it is very important. I think the reality is to connect the last acre requires a different solution than to con-

nect the last household, and in precision agriculture it is that last acre that is important.

Senator THUNE. Thank you. My time has expired, Madam Chair. I might submit some questions for the record, but thank you all.

Chairwoman STABENOW. Absolutely. Thank you so much. Senator Fischer, I almost did not see you. Senator Fischer is next, and then Senator Hoeven.

Senator FISCHER. I didn't want to get in the way——

Chairwoman STABENOW. That was very courteous.

Senator FISCHER. Thank you, Madam Chair, and thank you to our witnesses today. I appreciate you being here.

I am glad to see this hearing today on how we can leverage technology to help our producers. Farmers and ranchers have been using precision agriculture technology to improve yields, reduce inputs, and optimize water usage. There are more ways that we can boost access to these tools right now.

I have written several bills that focus on expanding access to advanced technologies and ensuring farmers and ranchers can fully utilize the benefits of precision ag technology. My Precision Ag Loan Program would provide dedicated financing for precision ag technologies. My PRECISE Act would leverage existing conservation programs to increase access to precision ag technologies. My Last Acre Act would expand network connectivity across farm and ranch land so these technologies can work reliably in the field. These bills have received broad stakeholder support. I appreciate the love this panel has shown these bills today, and I thank many of my colleagues here on this Committee who have joined me as cosponsors on those bills.

Just last week, the Joint FCC-USDA Precision Ag Connectivity Task Force voted to include both the PAL Act and the Last Acre Act as part of their final recommendations.

We know that precision ag technologies give producers the ability to monitor and decrease their use of inputs, like fertilizer and water, while still producing safe, high quality crops. For example, precision agriculture's ability to optimize water usage is enormously important, particularly for our western States. Nebraska, for example, has 8.6 million acres of irrigated cropland, the most in the whole United States.

Dr. Griffiths, in your written testimony you describe some of the benefits of precision agriculture. Would you please expand on the economic and environmental benefits that can be gained through the use of precision ag technologies?

Dr. GRIFFITHS. Yes. Thank you. Basically, the technologies allow much more specific information to be provided to the farmer or the rancher. As a result, they can use their resources sparingly, only when and where needed. That is basically why costs are reduced.

Also, AI can allow us to identify and develop plants can be harvested more frequently so that you could actually potentially have two crops per year rather than one. I know there is a lot of research on the bio side of agriculture that is looking at how to develop these new crops and products and new things that you can grow. Same thing in animals, where we are doing that kind of research as well.

Basically that is what AI allows us to do.

Senator FISCHER. Thank you. Despite the benefits that we have discussed here today, producers continue to face challenges adopting new precision ag technologies, and that is mostly due to the high cost and the lack of connectivity in rural areas.

Mr. Hindman, I appreciate your testimony supporting the inclusion of my precision ag package in the farm bill. As a technology developer, can you explain some of the financial challenges facing producers in adopting these advanced technologies, and then second, even if producers can acquire the technology, what barriers prevent them from being able to fully leverage the precision ag technologies on their own farm?

Dr. HINDMAN. Sure. Yes, the technologies that we are talking about—you know, graphical processing units, cameras, et cetera—are expensive technologies to start with. I think the first barrier is that initial cost of the technology, and that is a barrier to entry for some growers at some sizes into the market.

Which is, I think, why it is important for these new-to-world type of technologies for us to not just work on the technology development but the business model that accompanies it. We can shift the business model to make it more amenable to smaller farmers and pay-for-use type of mechanisms, those sorts of things. The business model I would expect to shift over time as well.

Your second question, Senator, is a connectivity question, pure and simple. There are fundamentally technologies, and an increasing number of them, that will be in marketplace—they are in the marketplace today and will be in the marketplace in the future—that are connectivity dependent, connectivity ubiquitously throughout whatever the field is that the farmer happens to be using.

Senator FISCHER. Not just building to building, to be able to connect there. We have got to be able to look again at that last acre if we are truly going to make a difference.

Dr. HINDMAN. Acre-based, not household-based.

Senator FISCHER. Exactly. Thank you. Thank you very much.

Chairwoman STABENOW. Thank you very much, Senator Fischer. I just want to thank you for all your work in this area. Senator Boozman and I were just talking about that, the importance of having your work become part of what we are doing in the farm bill, so thank you very much. Senator Hoeven.

Senator HOEVEN. Thank you, Madam Chair. Thanks to you and the Ranking Member for calling this meeting today. I appreciate it very much. Thanks to all of our witnesses.

Senator Klobuchar and I have introduced bipartisan legislation to increase the loan limits, modernize loan limits for the Farm Service Agency Farm Loan Programs. We did that before the last farm bill and made that part of the farm bill. We are looking to do that again.

Do all of you agree that we need to modernize those lending programs, increasing the loan limits, which would include not only the direct loans but also the guarantees and subordinations? I would welcome comments from any and all of you, unless they are in the negative.

[Laughter.]

Mr. KRISHNAN. I will be in the very positive. Thank you, Senator, for your question. I think particularly on the topic of AI in ag tech,

as agriculture goes from data poor to data rich, it is not just about sensors and Internet of Things and getting the farm super connected. I think we can use that data to provide new risk and lending solutions to farmers, particularly as the U.S. business model goes from more rented acres as opposed to owned acres. I think it is really important.

Senator HOEVEN. Anybody disagree with that? Anybody want to add to it? Is there anything specific you want to see in these lending programs?

Mr. KRISHNAN. I think just allowing for private sector involvement. Fintech has gone to small business, has gone to many other parts of our economy, to the consumer, but has not yet gone to agriculture, and there is a really interesting opportunity to provide more competition and products and services from fintech overall to the agriculture sector.

Senator HOEVEN. Would you also agree that it is very important for beginning farmers that we have these programs available, and that they are adequate to meet the needs?

Mr. KRISHNAN. They provide a ladder to acquire working capital, to acquire farmland, and to bringing new generational farmers into the system.

Senator HOEVEN. Right, because we need to bring in your people and the capital barriers are significant with modern agriculture. You would agree with that?

Mr. KRISHNAN. Absolutely.

Senator HOEVEN. Then in North Dakota we have a project called Grand Farm, which is conceptually to be an autonomous farm, where we are using AI and precision ag and all these incredible developments to develop a farm that is highly automated. In essence we say autonomous, although, of course, it would never be fully. Really to be on the cutting edge of the development of precision ag. John Deere is involved, as are many other, Microsoft. Many leading companies are involved in this incredible effort.

Tell me, from each of your perspectives, how do you think you can bring resources to bear to help these kinds of efforts like Grand Farm? Since John Deere Controls has a major development office in Fargo, maybe you would start.

Dr. HINDMAN. Sure. I think it is important. Grand Farm is a really good example of painting a picture of the future of what agriculture can be and to do it in a location that allows growers to see it sort of in their own backyard. I think that is incredibly important. It also provides an ecosystem where multiple entities, public and private, can collaborate on solutions within the context of a public farm that I think paints an interesting and compelling picture for the future.

Senator HOEVEN. Who else? What other ideas can you bring, either from higher ed or from the business world?

Dr. GRIFFITHS. I think it is a great idea to actually demonstrate what can be done. I think that will allow for sort of people to understand that it is available and to have some understanding of how it works and what it costs.

We have had a slightly different approach, mainly because we do not have a Grand Farm Initiative. We have used virtual reality to demonstrate what that kind of precision agriculture could do. It is

on a somewhat limited basis, but we are able to bring people in and demonstrate that you could be driving an autonomous vehicles, you can be riding in an autonomous vehicle. It can be doing all these things for you in the future, and give them a sense of it that way.

Senator HOEVEN. Dr. Griffiths, what is the most important thing that we can do include in NIFA funding this year?

Dr. GRIFFITHS. I think many of the things we have talked about—support for ongoing research and development, loans to farmers so that they can really get up and running and reduce the cost of entry for those small, independent farms.

Senator HOEVEN. Is there anything we should do in terms of the NIFA funding that you would recommend that could make it even more effective, I mean other than, I am sure, increasing the dollars. Are there recommendations you have regarding NIFA specifically, or anyone else?

Dr. EARLES. I might add one thing to it. In the NIFA funding one interesting piece to me is that across all of the different topics that you will see within NIFA, which is a lot, right, within AFRI, for example, there is an opportunity for AI to be embedded in almost every one of those.

I think it is a cross-cutting technology, so how we can make it a cross-cutting type of opportunity I think is really important.

Senator HOEVEN. Yes. As the Chairwoman said, adding AI to the language in the right way, both to give you the authorities but also so that we are careful in its development. I would echo her thoughts on that.

Thanks to all of you. Thanks, Madam Chair and the Ranking Member.

Chairwoman STABENOW. Thank you so much. This has really been a terrific discussion, very helpful, and we have lots more to do. We look forward to working with you going forward. This is really important to our work in supporting future innovations. We know that agriculture is all about innovation, and that is how our farmers have been able to effectively feed the world with the most abundant, lowest cost, safest food supply in the world, which is what we all have.

We have covered a lot of ground today. It is our responsibility, on the Committee, to ensure that America continues to lead the world in agricultural innovation, and I know that Senator Boozman joins me in strongly supporting that effort, to get that done. We look forward to working with every member of the Committee as we draft a strong bipartisan farm bill. This has been very helpful to us today.

The record will remain open for five business days, and the hearing is adjourned.

[Whereupon, at 11:48 a.m., the hearing was adjourned.]

A P P E N D I X

NOVEMBER 14, 2023

J. M. Earles, PhD
Senate Committee on Agriculture, Nutrition, and Forestry
November 14, 2023

Testimony of

J. Mason Earles, PhD
Assistant Professor, Viticulture & Enology; Biological & Agricultural Engineering
CO-PI and Lead of Agricultural Cluster, AI Institute for Next-Generation Food Systems
University of California, Davis

Before the U.S. Senate
Committee on Agriculture, Nutrition, and Forestry

On

Innovation in American Agriculture: Leveraging Technology and Artificial Intelligence
November 14, 2023

Good morning, Chairwoman Stabenow, Ranking Member Boozman and Members of the Committee. I'm happy to be here today to discuss the topic of leveraging technology and artificial intelligence for innovation in American agriculture.

My name is Mason Earles and I'm an Assistant Professor at the University of California, Davis. I'm also a Co-PI and Agricultural Production Cluster Lead at the USDA funded National AI Institute for Next Generation Food Systems, along with a Co-Founder and CEO of an emerging agricultural technology startup called Scout. Prior to joining UC Davis, I worked as a Data Science Engineer at Apple, and before this I studied fundamental and applied plant physiology. Today, my lab at UC Davis sits at the crossroads of agriculture and artificial intelligence, or AI. I lead a team of engineers, computer scientists, and biologists who are making AI-enabled sensing systems that aim to help agricultural producers manage more precisely, efficiently, and sustainably. However, I'm not here just to talk about what we do in my lab but I want to more broadly discuss the rapidly

growing trend of AI and technology in agriculture and food systems, and the role of research institutions in spurring such innovation.

We're sitting here today because of unprecedented advancements in hardware and software which have massively expanded the capacity of AI computer programs to learn from complex real-world data like what we see in agriculture and food systems. Before going any further, however, I would like to define "AI" using a relevant example. Put simply, an AI is a computer program that takes in one or more inputs, like an image, audio recording, or table of data, and outputs some prediction or physical action. As an example, let's say we input into our computer program thousands of images taken from a camera mounted on a tractor weeding implement in a carrot field and we want the AI to predict if an invasive weed, such as nightshade, is present in the image; which could in response trigger a precise herbicide spray application. We typically train these AI computer programs by showing them many examples of inputs with "correct" outputs. In our carrot versus nightshade example, this means that a human first categorizes which images do or do not have nightshade – literally clicking "yes" or "no" on a screen. The AI computer program then repeatedly tries to predict which images contain nightshade versus carrots and is penalized for incorrect predictions. Once training reaches a desired performance target, this AI can then be used to automate the detection, and potentially spraying, of nightshade based on input images without the need for human categorization. This is just one of many, many possible examples of the growing number of current and potential applications of AI in agriculture and food systems.

At the AI Institute for Next Generation Food Systems, our team of more than forty researchers across six national institutions aims to accelerate critical solutions to big challenges in the food supply chain, from crop breeding and farming to food processing and nutrition. Imagine if AI could bring together genomic and sensor data to uncover novel molecular patterns to enable

plant breeders to discover more flavorful and nutritious strawberries. Now, imagine those same strawberries growing in a field where hundreds of cheap, paperclip-sized soil sensors are measuring nutrient and water stress, and wirelessly sending data to a drone that flies overhead each day. After harvest, these strawberries are transported to a processing facility that rapidly samples washwater to rule out the presence of *E. Coli* pathogens using AI-enabled microscopy. Finally, a consumer points their phone at their plate which uses AI to estimate the macro- and micronutrients of the strawberries and every other ingredient they're about eat. Critically, the socioeconomic and ethical risks of introducing AI tools across the food supply chain, such as data privacy and security, and potential effects on labor must be considered. Our researchers and industry partners at the AI Institute for Next Generation Food Systems are investigating each of these topics, among many others. We see ourselves as one of the world's leaders in research, development, and commercialization of such novel open-sourced AI-based solutions in food and agriculture. We do this through a three-pronged strategy of multidisciplinary science, industry engagement, and workforce development.

Such a massive effort and innovation is made possible by more than $20M in funding provided over five years by USDA's NIFA as part of NSF's National AI Institutes. In fact, four additional National AI institutes focused on food and agriculture are funded by USDA NIFA, totaling more than 30 research institutions and industry partners across America. These National AI institutes are working on programs that aim to relieve labor shortages via AI-driven robotic harvesters in tree crops, monitor the health and stress of livestock using AI-enabled sensors, and predict climate and crop risk by building AI-accelerated models that could eventually be used to precisely control irrigation and nutrient emitters. Each of these AI Institutes is focused on tech transfer and meeting industry needs, with partners including dairy producers, soybean farmers,

chemical and agricultural machinery producers, among others. Thinking to the future of our workforce, in 2021 more than 161,000 undergraduate and graduate computer science degrees were awarded in the U.S. alone. While we don't have exact numbers, a very small fraction of these students ends up working in the agricultural and food sector. This needs to change. Building on these accomplishments and to keep America as a global leader in agricultural innovation, I strongly encourage the Committee to continue, and even expand, funding for these National AI Institutes among other funding sources provide through the USDA that focuses on AI solutions for food and agriculture. I believe that this is how we will accelerate more research innovation and industry collaboration, and create a wider funnel for motivating more computer science and engineering students to solve the big challenges in the agricultural sector via AI and new technology.

Testimony of Sanjeev Krishnan

Chief Investment Officer and Senior Managing Director, S2G Ventures

Before the Senate Agriculture Committee

Innovation in American Agriculture: Leveraging Technology and Artificial Intelligence

November 14, 2023

Chairwoman Stabenow, Ranking Member Boozman and Distinguished Members of the Senate Agriculture Committee, including Senator Durbin from my adopted home state of Illinois, I am Sanjeev Krishnan. I am a founding member and Chief Investment Officer of S2G Ventures, a direct investment firm that has been focused on sustainable food and agriculture solutions and technologies since 2014. I appreciate the invitation to share my perspective on how agricultural and food technologies have translated into value for the American farmer and consumer. I applaud the leadership of the Committee in convening today's hearing and, as always, for its thoughtful consideration of the risks, challenges and policy opportunities on the road ahead. This conversation is particularly timely as we begin to see the broader integration of artificial intelligence (AI) into commercialized agricultural technologies, and as U.S. farmers adopt these technologies at an unprecedented rate.

I help lead a team of more than 40 talented and passionate sector experts and investors focused on identifying promising technologies, companies and entrepreneurs across the food, agriculture, oceans, seafood and clean energy sectors. Today, we manage $2 billion of capital and our portfolio includes investments in more than 90 companies.[1] This includes companies at

[1] https://www.s2gventures.com/our-portfolio

the "seed" stage – meaning the company is taking its first steps to translate a promising concept into a viable product and business strategy – all the way through to companies listed on public markets, with proven products, extensive infrastructure, and demonstrated viability and impact.

At S2G, we seek out opportunities that produce financial returns and positive impact, including many that benefit U.S. farmers, ranchers and rural communities. We are based in the Midwest and deploy capital that creates jobs and returns in the Heartland. Nearly all of our portfolio companies are either headquartered in or maintain significant business, commercial, manufacturing and production, research and development, or other operations in the United States. In fact, our portfolio either operates, manufactures or distributes in every state represented by the Members of the Senate Agriculture Committee, including Alabama, Arkansas, Colorado, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Nebraska, New Jersey, New Mexico, New York, North Dakota, Ohio, Pennsylvania, South Dakota and Vermont.

Over the course of my career, I have worked at various investment platforms, including CLSA Capital Partners, IFC (World Bank Group), Global Environment Fund and JPMorgan, and have served on a variety of advisory and corporate boards. Traditionally, venture capital is oriented around identifying and investing in winning companies believed to have long-term growth potential to generate a financial return in the relatively short-term. Throughout my career, however, I have been as interested in finding opportunities at the intersection of investment, sustainability and health, and innovation, in what is referred to as "tough tech." It's called tough tech because these sectors – including agriculture and food – often receive disproportionately

low investment and are less well-understood, with opportunities and challenges that cannot be solved through a single app, a consumer device or lines of software code. Tough tech requires patience and a longer-term investment approach to develop new ideas and learnings to tackle system-wide opportunities.

This tough tech philosophy drives S2G and is reflected in how we diligence investments and support our portfolio companies. We don't just write checks. We ask what problem needs to be solved and seek to understand how individuals experience it. What does the consumer in Iowa see, in terms of price and quality? What is a farmer in Michigan or a rancher in Colorado experiencing on the ground? How are communities in Mississippi impacted?

Using a systems perspective, we evaluate challenges in food and agriculture and, in partnership with farmers and food system stakeholders, we identify and invest in the missing pieces and needs. Rather than picking one technology, approach or product as a "winner," our investments span the entire agriculture and food supply chain, from how products are grown to the ingredients in our food to how consumer behavior is changing. This enables us to construct a portfolio based on a systems understanding of industry, while increasing our ability to create synergies between portfolio companies. As a result, much of our portfolio is in the "in-between" spaces across the supply chain where the needs are both most pressing and not currently being met with adequate financial support. This includes investments in less headline-grabbing, though incredibly impactful, innovations in agricultural inputs, new crop traits, on-farm technologies and techniques, and new financing and merchandising solutions. These innovations enable

farmers to derive more value from their land in a less intensive way and de-risk farming in an increasingly volatile operating environment - all while meeting global demand for food.

In practice, this might look like identifying a durable consumer trend. We would then consider investments not only in new consumer products, but also in companies using machine learning to rapidly develop improved seed genetics that pair desirable ingredient attributes, such as better texture and flavor or improved nutrient density, with crop performance. We would also look at what farmers need to plant this crop, such as tools that more precisely measure soil health co-benefits and enable farmers to profit from them; less intensive ways to nourish crops that could further stack environmental benefits and profit potential; the infrastructure to take crops from the farm field to finished products; and fintech solutions that help de-risk the transition to a new crop. We also support our ecosystem by making introductions, sharing knowledge and generating leads for our network with the goal of increasing access to capital industry-wide. That includes spurring deeper conversations and building relationships that will drive meaningful impact and return on investment for the entire food and agriculture system, not only our individual investments or portfolio companies.

It is from the combination of this experience and system-wide perspective that I draw from in my comments to the Committee:

> **The journey of the American farmer is a remarkable story of hundreds of years of continuous innovation and transformation.** Tech and, increasingly, artificial intelligence build on that tradition. They offer a unique toolkit to rapidly accelerate

breakthrough solutions and significant per-acre value generation opportunities. While these technologies and their applications and implications are just beginning to emerge, American agriculture's history is rooted in a strong legacy of embracing and rapidly adopting innovation. The impacts of these roots can be seen in the ways that productivity and markets have shifted and evolved over time.

Today, farmers are drowning in data, but not in solutions. The power and promise of data have long been a topic in agriculture. We now have aggregated data points from sensors, machinery and many other sources. The new wave of solutions is rooted in improving the quality of that data and better utilizing data to drive better, faster, more efficient and precise solutions. To varying degrees, these solutions will be able to account for, automatically adapt to, and moderate the negative impacts of the high level of variability in weather patterns, in the soil, in commodity prices, and other global and local factors that drive volatility. This also represents a new frontier of deriving value from on-farm data.

AI is not magic, nor is it a replacement for the foundation on which the agriculture system is built: a trusted community. Ag technology and AI can, however, be powerful co-pilots to further strengthen that trust, if deployed thoughtfully and responsibly.

Public policy plays a critical role. Realizing the full potential of tools ready to deploy today will rely on enhancing or building programs that support – or do not unnecessarily hold back – scaling. Federal loan guarantees and other financing opportunities offer

security to the developers of nascent technologies that, once they are at scale, offer a public good in the form of improved sustainability or profitability. Developing innovative financial instruments will continue to be an important area for public-private partnership. Finally, improving data quality and sharing will become increasingly critical with emerging applications of AI. The public and private sectors each have roles to play in avoiding duplicative work and focusing limited resources on filling data gaps, while protecting privacy, supporting the farmer and building tools that account for the full diversity of the food and agriculture system.

A Legacy of Continuous Innovation and Transformation and the Anthropology of Market Change

For more than 10,000 years, agriculture and food systems have been at the forefront of adopting innovations that have transformed societies and economies. In the more recent history of American agriculture, these trends have only accelerated as farmers have adopted and adapted the new "toolkits" enabled by the science and innovation of the day into productive solutions that feed not just our nation but the world.

Innovations in the late 18th and early 19th centuries, including the development and widespread deployment of the steel plow, laid the foundation - and drove the need - for a higher degree of control over crop nutrition and pest management. Through the 20th century, the scientific revolution - and concurrent global population boom - drove the development of synthetic fertilizers, higher-yield crops, improved irrigation and better machinery, all in service

of further increasing yields and reducing inefficiencies in the agriculture system to meet booming food and fiber needs. Digital agriculture and precision farming built upon this foundation, beginning with the application of GPS technology to agriculture in the early 2000s, and has now expanded to include integration of big data and analytics - from an array of sources, including drones, satellite imagery, remote sensing and more - to support on-farm decision making.

This ongoing embrace and adaptation of broad innovation to the specific needs of agriculture underpins the leadership of American agriculture on the global stage. America feeds the world, exporting more than $200 billion worth of agricultural products to customers around the globe, a figure that has steadily increased for the past 25 years.[2] Alongside our crops, we export our on-field machinery, our seeds, our fertility, crop protection and biological products, and the sophisticated land management practices and know-how that enables food security around the world. Agriculture productivity, production and food security are essential elements of our national security, and global food security depends on American leadership.

Leveraging Artificial Intelligence as the Next "Toolkit" to Solve 21st Century Challenges in Agriculture – And Better Utilize Farm Data in a Way that Directly Benefits Farmers

American agriculture has existed for centuries in a state of constant transformation and evolution, which has built the critical foundation of necessary experience, adaptability and resiliency as we enter a new era of food system transition. The past few years have shown us the

[2] https://www.ers.usda.gov/topics/international-markets-u-s-trade/u-s-agricultural-trade/u-s-agricultural-trade-at-a-glance/

signature calling cards of the next century: an unknown future economic and geopolitical order; a new generation of consumers; increased volatility in the factors that impact productivity from access to labor; volatility of input and output commodity prices; and increasingly, extreme weather patterns and climatic events. As in the past, a new toolkit of solutions well-suited to adapt to and overcome the rising challenges of the food system transition has emerged: artificial intelligence (AI).

AI is projected to transform nearly every industry in the world over the next decade. The power of new classes of AI models, combined with the advancements in and economics of creating massive amounts of data to feed into models, means that we will see dramatic shifts in how we use AI to augment and advance the ways we do things today. While difficult to project, McKinsey estimates that this will create over $4.4 trillion in new value in the economy across sectors.[3] In the coming years, hundreds of billions of dollars will be spent developing data, training models and building products around AI.

AI also has the potential to provide breakthrough new solutions and generate significant value in agriculture, offering innovative solutions to improve crop yields, optimize resource utilization, enhance overall farm management and more. We are just now at the beginning of unlocking the potential of AI in agriculture, and the pace of development we may see in these areas will be staggering.

[3] https://www.mckinsey.com/mgi/overview/in-the-news/ai-could-increase-corporate-profits-by-4-trillion-a-year-according-to-new-research

At the core of this development, however, is data. The most powerful and effective AI solutions will be those that have access to the best data and have developed the most effective ways to translate that data into appropriate training sets that feed AI models.

One of the most common pieces of feedback we hear – via S2G portfolio companies that partner directly with farmers and through our own direct engagement with farmers and agriculture and food system stakeholders – is that, thanks to the technological advancements of the past five to 10 years, farmers now have access to an astonishing amount of data. The agriculture and food system is still in the relatively early stages of digitization. The average farmer generates an estimated 500,000 data points every day and, by 2036, the amount of data generated daily is expected to increase by 800 percent.[4]

Despite this rapidly growing amount of data, the connection today between that data and trustworthy decision tools remains lacking, limiting our ability to access and apply actionable insights based on the information collected. Improving the quality of data collected and aggregated in agriculture, and using AI to analyze, synthesize and apply that data through existing and future agricultural technologies could have immediate implications on many aspects of agriculture, including enabling farmers to fully act on real-time changes across many fields that are changing every day.

For example, fresh water is becoming an increasingly scarce resource in the United States. Just last year, the California Department of Water Resources provided financial

[4] https://blogs.idc.com/2022/10/12/the-problem-potential-and-promise-of-a-data-revolution-in-agriculture/

incentives of up to $2.5 million per farm to fallow fields in “critically overdrafted basins,” meaning areas where drinking water wells have gone or are in jeopardy of going dry.[5] A 2023 United Nations report on the economics of water found that global demand is expected to outstrip supply of fresh water by 40 percent by the end of this decade.[6]

AI presents an opportunity to better address this challenge, particularly when paired with the right high-quality data and intuitive decision tools and apps. AI could enable farmers to significantly increase production, using the same amount of water. This will be made possible by driving the dynamic daily decisions around irrigation with powerful AI that can incorporate millions of data points in real-time, optimize risk versus reward, and even take into account societal goals around water conservation.

According to U.S. Department of Agriculture estimates from 2019, realizing the full potential of digital agricultural technologies at scale, including building the requisite infrastructure, could create $47 - $65 billion annually in additional gross benefit to the U.S. economy.[7] These figures, developed just five years ago, now likely underestimate the scale of potential future benefits given the emergence and rapid ongoing integration of AI into ag technologies.

There are numerous specific use cases where AI can deliver gains in efficiency, productivity and sustainability for farmers and society, including:

---

[5] https://www.cbsnews.com/sacramento/news/ca-program-pays-farmers-fallow-fields-preserve-water/
[6] https://turningthetide.watercommission.org/
[7] https://www.usda.gov/sites/default/files/documents/case-for-rural-broadband.pdf

Precision Agriculture: AI-powered systems can analyze vast amounts of data from sensors, drones and satellites to provide farmers with real-time insights into crop health, soil conditions and weather patterns. This would further enable farmers to make more precise decisions about irrigation, fertilization and pest control, leading to reduced waste, increased yields and improved environmental sustainability.

Disease and Pest Detection: AI algorithms could identify early signs of plant diseases and pests by analyzing images and videos captured from fields. This timely detection would allow farmers to take early action to prevent the spread of diseases and protect their crops, reducing yield losses and improving overall crop health.

Robotic Harvesting and Automation: AI-powered robots are being developed to automate various tasks in agriculture, such as harvesting, weeding and pruning. These robots can work tirelessly and precisely, potentially reducing labor costs, improving efficiency and enabling farmers and farmworkers to focus on other higher-skilled and less labor-intensive tasks.

Livestock Monitoring and Management: AI systems could monitor the health and behavior of livestock, providing farmers with valuable insights into animal welfare and productivity. This information could be used to optimize feeding strategies, detect early signs of illness and improve overall herd management.

Predictive Analytics and Market Insights: AI algorithms can analyze historical data, market trends and weather patterns to predict future crop yields, prices and demand. This information could help inform decisions about planting, marketing and financial planning.

AI-powered Agricultural Drones: AI-equipped drones can be used to monitor crops, collect data and apply pesticides and fertilizers with precision. These drones would cover large areas efficiently, reducing environmental impact and improving crop health.

Ag Technology and Artificial Intelligence Can Support and Strengthen Community and Enhance Trust

As the Committee well knows, American agriculture is rooted in trust. Ag technology tools – further enhanced by artificial intelligence – have the potential to build community in agriculture and create and expand connections in a way that complements the existing network of trusted advisors in agriculture. I believe this will play out in multiple ways but want to spotlight two particular examples today.

The first is artificial intelligence's ability to make existing ag technologies better and more effective at doing what they say they can do. Certainly, there are powerful tools available today. Farmers and agricultural stakeholders also have a healthy skepticism as a natural consequence of being presented with technologies and tools that have claimed to do it all but

have failed to deliver. I believe that the application of artificial intelligence could: a) further improve and refine existing technologies and approaches; b) help stakeholders verify the impact of technologies and practices with clear, accurate and high-quality data; and c) enable stakeholders to truly weed out ineffective approaches and focus resources and time on options that work best for the conditions on their operations.

And, while it may sound counterintuitive, I believe ag technology, data, analytics and AI have an important role to play in strengthening human relationships and our ties to our communities – particularly the trust between the farmer and their network of advisors.

For example, AI can almost instantly intake, analyze and identify patterns in all research ever conducted and all aggregated on-farm data ever collected on, for example, sheath blight in rice. Enhanced by their own experiences on the ground, a certified crop advisor or independent agronomist can use AI to offer more precise advice and actionable insights more quickly to a farmer in Arkansas battling a crop disease. AI takes the burden off those advisors or agronomists to intake and synthesize this same information. AI-powered chatbots and virtual assistants – paired with the expertise of the existing system of trusted farmer advisors, including certified crop advisors, independent agronomists and ag retailers – could provide farmers with real-time advice and support, answering questions about crop management, pest control and market trends. These tools would be particularly valuable for farmers in remote areas or with limited access to agricultural experts.

Policymakers Have a Critical Role to Play in Positioning U.S. Agriculture to Maximize the Benefits of Ag Technology and Artificial Intelligence – and Establishing Thoughtful Guardrails

There are multiple opportunities for the federal government to ensure the leadership position of the U.S. in ag tech and solidify it as a global leader in AI for agriculture, while continuing to protect and support farmers and agricultural system stakeholders.

I would be remiss if I did not acknowledge that along with tremendous potential benefits of ag tech, the future ubiquity of AI also raises difficult questions about how to ensure these technologies are safe and equitable, particularly as more and more decisions are made with the assistance of or directly by AI. At this point, the future prevalence of AI throughout our lives, industries and economies is inevitable. The key will be to ensure that the right balance is struck between human control and oversight and leveraging the immense power of AI to change our world for the better.

There is a tremendous amount of innovation already happening. To succeed and scale, we need to take a systems approach to continue developing these solutions - including through private capital investment, government and public sector investment, philanthropic funding and other creative, collaborative delivery mechanisms.

While not an exhaustive list, there are several areas that, based on what I see and hear in my role, I recommend the Committee explore further as it considers thoughtful policies and

programs that can support the further scaling of the ag tech commercially available today, as well as how best to use policy tools to facilitate the productive application of AI to further enhance and improve those technologies, while protecting stakeholders and ensuring that the benefits of ag tech and AI are equally distributed. These include:

- **Harnessing the Potential of AI in Agriculture Effectively and Responsibly:** AI is driven by data, and fundamental questions about data ownership in agriculture must be fundamentally addressed. In agriculture, the conversation around protecting data privacy and confidentiality and ensuring that farmers maintain and derive value from ownership of their on-farm data has been ongoing. Again, while information security and protection concerns did not arrive with AI – nor are these concerns elevated by AI in a unique way – these conversations should expand to include applications in AI as they continue to emerge.

  In addition, ethical guidelines for AI development and deployment in agriculture will be important to ensuring that AI systems do not perpetuate biases, are transparent in their decision-making processes, and are accountable for their outcomes. This could involve developing industry standards for data collection, usage and transparency to ensure that AI systems are reliable, ethical and do not harm the environment or market dynamics. In addition, a set of benchmarks to validate the claims of AI-powered services could further support accuracy and transparency, and act as an important tool in building trust. Finally, engaging in international collaborations to share knowledge, best practices and regulatory

frameworks related to AI in agriculture can help harmonize standards and promote global food security and farmer profitability.

- **Promoting Data Sharing Standards and Initiatives:** Encouraging the sharing of agricultural data among farmers, researchers and AI developers while ensuring data privacy and security will be critical to leveraging the power of new, innovative agricultural technologies and AI to the benefit of farmers. This could be facilitated through the establishment of agricultural data cooperatives or platforms that aggregate data while protecting individual privacy. AI could also be a powerful tool in enhancing federal customer service, such as using AI techniques to replace paper-based and lagging analytics. Increasing funding for AI research, specifically in the domain of agriculture, could further spur necessary innovation for farmers. This could include grants for land-grant universities, public-private partnerships and incentives for startups developing AI solutions for agricultural challenges.

- **Boosting Digital Infrastructure and Investing in Digital Literacy, Particularly for Small Farmers:** Improving rural digital infrastructure can help ensure that farmers, especially those in remote areas, have access to the high-speed internet required to take advantage of new agricultural technologies, including AI. In addition, programs to train farmers and agricultural workers in AI and related technologies could involve partnerships with educational institutions, online courses and on-site training programs. Programs to specifically support

small and marginalized farmers in adopting AI technologies could involve subsidized access to AI tools, financial assistance and technical support.

Conclusion

Chairwoman Stabenow, Ranking Member Boozman and Members of the Committee, I commend you on your leadership in convening this hearing. I believe that we are at a critical moment for farmers and ranchers, rural communities, innovators and entrepreneurs, and for the food and agriculture system as a whole. This is an incredible opportunity to leverage and direct the power of artificial intelligence, with appropriate guardrails and protections in place, to make technologies, programs and practices across the food and agriculture system work better, faster and more efficiently to improve our lives in innumerable ways. By stepping up now and taking on the mantle of leadership, we have the opportunity to control, direct and optimize that future to the benefit of the American farmer, the American consumer and the global food and agriculture system. Thank you for the opportunity to share my perspective and I look forward to responding to questions.

# # #

Testimony of Dr. José-Marie Griffiths

before the United States Senate Committee on Agriculture, Nutrition, and Forestry on

"Innovation in American Agriculture: Leveraging Technology and Artificial Intelligence"

Tuesday, November 14, 2023

Dr. José-Marie Griffiths
President
Dakota State University
820 N. Washington Ave.
Madison, SD 57042

Introduction

Chairwoman Stabenow, Ranking Member Boozman, and Members of the Committee, thank you for the opportunity to testify about leveraging technology and artificial intelligence (AI) to drive innovation in American agriculture.

I am Dr. José-Marie Griffiths, President of Dakota State University (DSU) in Madison, South Dakota. At DSU, we are training the next generation of professionals in emerging technology fields such as AI, cyber, and quantum computing. My career has focused on research, teaching, public service, corporate leadership, economic development, and higher education. I have served appointments to the National Security Commission on Artificial Intelligence (NSCAI), National Science Board, President's Information Technology Advisory Committee, and several other federal commissions and committees.

South Dakota is one of the nation's top agricultural states. As a leading research institution for technology education, DSU views agriculture through the lens of innovative applications in cyber, AI, and how to move the industry to the next phase of growth. In collaboration with South Dakota State University (SDSU), the state's leading agricultural institution, we are working to engage in collaborative research through a precision agriculture cyber (CyberAg) partnership; SDSU brings the data generated by precision technologies and DSU brings the cyber and AI expertise.[1] The CyberAg partnership is made possible by a $1.25 million investment from the South Dakota Legislature to begin to develop undergraduate and graduate curricula, engage in research, and provide outreach programming and communication to address agriculture security threats.

At DSU, our mission is to grow future technology talent and help them find rewarding employment inside South Dakota and in other key cyber markets, even beyond the mainstay tech hubs of Silicon Valley and Washington, D.C. We are only one of ten universities nationwide to hold all three Centers of Academic Excellence in Cybersecurity designations from the National Security Agency (NSA). Our innovative R&D campus facilities and public-private partnership models empower students to immediately enter the cyber workforce upon graduation. One such example is the Dakota State University Applied Research Corporation (DARC) which operates and manages the Dakota State University Applied Lab (DSU-ARL).

We currently have a 99.7 percent overall job placement rate that is supporting a skilled talent pipeline of recent undergraduate and graduate students who are ready to address some of the toughest challenges and exciting opportunities posed by AI and emerging technologies.

The Challenge

As a sector, agriculture has evolved tremendously over the past 100 years. Technology is now being leveraged to drive farming equipment, predict crop health and optimize yields, and monitor the entire produce supply chain from seed to stomach.

We must ask ourselves, what does an increase in connectivity and a heavier reliance on technology mean for the future of agriculture? There are tremendous opportunities, and with that,

[1] Amazing Madison. Governor signs bill supporting CyberAg partnership initiative.

there are also risks. With each connected tool or vehicle, the potential attack surface grows, providing multiple entry points for bad actors.

By discussing how to best leverage technology and AI for innovation in agriculture, we can consider the benefits to modern practices, the impact on the cyber threat landscape, and what further research is needed to reach full innovative potential.

Benefits and Considerations for Precision Farming

Modern farming, often referred to as "precision agriculture" or "precision farming," has come a long way from the traditional practices of the past. This transformation has been made possible with the integration of cutting-edge technologies including AI, robotics, cloud computing, smart sensors, and actuators.

The U.S. Department of Agriculture (USDA) has reported a substantial increase in the adoption of precision technologies in agriculture since the mid-1990s. For example, auto-steer and guidance systems are now used on over 50% of U.S. acres planted with crops like corn, soybeans, winter wheat, cotton, rice, and sorghum. This is up from roughly 10% of planted acres or fewer in the early 2000s.[2]

The increased adoption of AI signifies its transformative potential in the U.S. agriculture sector. When embedded in connected systems, AI technologies enable the widespread collection of vast amounts of data from crops and livestock through satellites, drones, sensors, and robots, which in turn help lower costs and improve yields and production.[3]

Potential Impacts

The Senate Committee on Agriculture, Nutrition, and Forestry published statistics that show farm production expenses are projected to be record-high in 2023 at nearly $500 billion, up by 28% or $87 billion.[4] Today, agricultural producers are constantly seeking innovative ways to lower such costs and improve productivity and yields. AI presents incredibly promising solutions for these needs.

For example, autonomous tractors, combines, or other farming equipment with integrated AI technology, such as the auto-steer and guidance systems previously described, can help reduce the cost of labor and other operating costs, as this machinery can work tirelessly without the constraint of human fatigue. The combination of AI and precision agriculture could reduce the operating costs of corn, soybean, and wheat production in the United States by 26%, 31%, and 31%, respectively, on a per-acre basis.[5]

---

[2] McFadden, J., Njuki, E., and Griffin, T. February 2023. Precision Agriculture in the Digital Era: Recent Adoption on U.S. Farms. USDA Economic Research Service.
[3] Halverson, T., Rimal, B., and Wang, Y. June 30, 2023. Cybersecurity in precision agriculture: Safeguarding America's connected fields. Infosecurity Magazine.
[4] U.S. Senate Committee on Agriculture, Nutrition, and Forestry. May 9, 2023. Revisiting Farm Production Expenses.
[5] Maguire, D. August 2, 2023. Will the Convergence Between Artificial Intelligence and Precision Agriculture Lower Farming Costs? ARK Invest.

Additionally, successful crop cycles are critically dependent on technology. AI's predictive capabilities allow valuable insights on crop health, market demand, and weather patterns using both historical and real-time information. This empowers agricultural producers to make informed decisions in optimizing fertilizer, watering, and other practices for better crop yields and profitability.

Recommendations
While there is a vast potential for AI and digital technology in farming today and in the future, many of these digital tools have significant up-front costs, repair or replacement expenses, and annual user fees. These costs can present a barrier to adoption for farmers, making USDA's conservation programs that provide technical or financial assistance to farmers seeking to implement digital agriculture technologies increasingly critical. Continued support for these programs is essential to ensure the sustainable growth of AI in agriculture as we usher in a new era of innovative farming solutions.

Cyber Security and Intelligence Risks to Address
There is a real need for stronger cyber security protections to safeguard U.S. agriculture and critical infrastructure that power our national food supply. Looking through the lens of cyber security, the deeper we embed AI into internet-connected farming machinery, vehicles, and devices, the more vulnerable these systems become to cyberattacks.

On September 1, 2021, the FBI released a notification report sounding the alarm on cybercriminals increasingly targeting the food and agriculture sector due to the rise in adoption of smart technologies and the internet of things (IoT).[6] For reference, six attacks against grain cooperatives occurred in the fall of 2021.[7] In early 2022, two agriculture related attacks occurred that temporarily disrupted seed and fertilizer supply.[8] Later that year, the FBI reported a total of 48 ransomware attacks targeting the food and agriculture industry during 2022.[9] The increasing frequency of attacks on this sector further underscores the national and economic security risks that need to be addressed.

Intellectual property (IP) confidentiality risk is another consideration which has come up in my conversations with both public and private stakeholders regarding agriculture technologies. As AI applications are rapidly developed and deployed, IP confidentiality is essential to protect and prioritize further development of leading innovations in the field.

Furthermore, a heightened concern for cyber and national security involves the acquisition of land by unfriendly nations, especially in sensitive areas or close proximity to critical infrastructure and agricultural areas. Of particular significance is the safeguarding of seed vaults or banks, which are often overlooked as critical infrastructure but are essential as a vital resource. These vaults play a crucial role in the agriculture industry, serving as the starting point for both the supply and food chains within the sector.

---

[6] FBI. September 1, 2021. Private Industry Notification.
[7] Reed, J. September 14, 2022. Ransomware attacks on agriculture potentially timed to critical seasons. Security Intelligence.
[8] Michigan Farm News. April 22, 2022 FBI Alert: Ag ransomware attacks timed to critical seasons.
[9] FBI. 2022 Internet Crime Report.

Presently, China possesses 380,000 acres of U.S. land.[10] In 2021, a Chinese company acquired land near a Grand Forks, North Dakota Air Force base, sparking concern among lawmakers.[11] This raises apprehensions about China having the capacity and capability to control the U.S. food and energy supply, as well as highly sensitive sites that can influence markets and impact critical infrastructure. As geopolitical tensions escalate, it becomes crucial to secure our land for the sake of our national security.

Potential Impacts

The consequences of heightened cyber security risks accompanying the deployment of AI in agriculture are too significant to overlook. Failure to adequately secure our systems invites hacking attempts on interconnected farming machinery and platforms. This could result in the manipulation of computing in farm equipment, control over water sources, fertilization, treatment of seed stock, and other vital systems. Potential outcomes could include substantial disruptions and harm to livestock, crop health, and the risk of disrupting entire ecosystems and supply chains.

Additionally, the foreign ownership of land near U.S. critical infrastructure, sensitive sites, and farmlands introduces the risk of foreign surveillance, attacks on critical infrastructure such as power, water, and chemical plants, and/or the potential theft of IP—an expensive and challenging setback from which to recover. The consequences are severe, with the Commission on the Theft of American Intellectual Property reporting annual losses of up to $600 billion.[12] This staggering figure is unsurprising, given the numerous cyberattack surfaces inherent in distributed research.

Recommendations

Limited awareness among agricultural producers and stakeholders regarding cyber threats increases their vulnerability and reduces the likelihood of implementing appropriate security measures. It is essential for farmers and agricultural stakeholders to engage actively with and reference the Food and Agriculture Sharing and Analysis Center.[13] This proactive involvement will significantly decrease the risks posed to their operations and contribute to enhancing overall industry security.

The Cybersecurity & Infrastructure Security Agency (CISA), collaborating with the Food and Drug Administration (FDA), the United States Department of Agriculture (USDA), and the Department of Homeland Security (DHS), provides a valuable resource known as the Food and Agriculture Sector-Specific Plan.[14] However, given the substantial changes and technological advancements in the industry since its 2015 publication, an update to this plan is imperative. This

[10] Bustillo, X. and Hanzhang Jin, C. June 26, 2023. China owns 380,000 acres of land in the U.S. Here's where. NPR.
[11] China owns 380,000 acres of land in the U.S. Here's where. NPR.
[12] Badders, T. February 22, 2023. Intellectual property theft: A threat to the U.S. economy and national security. Telos.
[13] Starks, T. May 24, 2023. The food and agriculture industry gets a new center to share cybersecurity information. The Washington Post.
[14] FSA, USDA, and DHS. 2015 Food and Agriculture Sector-Specific Plan.

would serve as a pivotal and relevant resource for the evolving landscape of the agriculture industry.

Increased research in this field holds the potential to proactively prevent cyberattacks. Collaborative efforts between industry and academia can drive innovation and devise preemptive solutions. Notably, the partnership between South Dakota State University (SDSU) and Dakota State University (DSU) is actively exploring vulnerabilities in the agricultural sector, simulating potential attacks, and scrutinizing the security of autonomous vehicle sensors and systems. Supporting additional research within specific cyber practices is crucial to effectively mitigate risks in the evolving landscape of agricultural cyber.

While layered defenses and zero-trust strategies, including solutions like multi-factor authentication (MFA), are vital to safeguard infrastructure in high-risk environments like food production centers and even research institutions, the escalating threats to IP indicate further innovation is necessary to counter determined adversaries who work to find ways to bypass or hack these defenses.

Importance of Sustained Research

Agricultural research, particularly in the realm of AI, is crucial for the sustainability and development of the agriculture industry. This research leads to the creation of new technologies and improved policies that enhance agricultural productivity and resilience.

Collaboration between industry and academia is vital to effectively disseminate AI knowledge and technology. Leading universities like SDSU and DSU are actively engaged in AI research for agriculture, exploring advancements and vulnerabilities associated with AI adoption. Specific projects are focused on investigating sensor technology, vehicles, and GPS systems. Other universities, such as Purdue, have received grants to establish AI Institutes dedicated to climate-smart agriculture and forestry, a prime example for academia's capabilities.[15]

Potential Impacts

Specific research projects between SDSU and DSU include efforts to ensure agricultural data confidentiality and integrity to improve data privacy and secure GPS data integrity from satellite to the cloud. Other projects are designed to develop secure cyber infrastructure for precision agriculture. The proposed integration involves four critically important areas: cyber issues, precision farming data analysis, a portal for agricultural producers, GIS data analysis, and optimization. Full integration of these components will result in new and secure cyberinfrastructure based on resilient networks, optimized energy consumption, and reliable communications. This research has the potential to reduce risks and contribute to the future of the agriculture industry.

The National Institute of Food and Agriculture (NIFA) supports AI and agriculture research, particularly in areas such as agricultural systems, engineering for crop and soil monitoring using technologies like machine learning, remote sensing, satellites, drones, and precision methods.[16]

[15] Purdue University. Purdue receives $500,000 grant as part of new AI Institute focusing on climate-smart agriculture and forestry.
[16] USDA National Institute of Food and Agriculture. General information on artificial intelligence activities.

Additional investment in research is essential for the advancement of smart agricultural systems. Furthermore, research focused on AI applications to aid decision-making by farm, forest, and ranch managers is crucial to sustain and advance the future of the agriculture industry.

Recommendations

According to the Artificial Intelligence R&D Interagency Working (IWG) group, key areas of focus for federal coordination and collaboration on AI include making long-term investments in fundamental and responsible AI research, ensuring the safety and security of AI systems, developing shared public datasets and environments for AI training, and testing, measuring, and evaluating AI systems through standards and benchmarks to expand public-private partnerships to accelerate AI advancements.[17] Effectively addressing these key areas of focus is crucial for advancing agricultural research and the collaboration needed to further fuel the industry.

In line with the USDA's Urban Service Centers and the U.S. Economic Development Administration's (EDA) recent Tech Hubs Program aimed at boosting the technological ecosystem for the U.S. to achieve global leadership, similar hubs or regions should be established for research in AI and agriculture. These designated areas could play a crucial role in advancing our understanding and implementation of AI in agriculture. Moreover, they have the potential to generate a significant number of jobs, ranging from hundreds to thousands, fostering both technological innovation and economic growth, particularly for rural areas like South Dakota.

Supporting research on AI's role in agriculture is critical to ensuring the industry's security and growth. It is also crucial for our nation's innovation and national security, addressing industry challenges and fostering economic growth.

Conclusion

The U.S. has a critical opportunity to advance the deployment of AI to further innovate the agriculture sector while also helping address the very real cyber risks and challenges associated with a growing attack surface. There are crucial steps that academia, in partnership with industry and federal agencies, can take to ensure the safe, responsible, and effective use of AI. The important thing to remember is that the industry has been automating and innovating within the agriculture industry for decades. While the deployment of AI across agriculture is a transformative shift, it is nothing we can't be prepared for.

While this is a complex undertaking that will involve many different players at all levels of both the public and private sectors, we must move forward by addressing the cyber risks and advancing the crucial role of academia in devising research-driven solutions to the agricultural system. Academia has a critical role to play in advancing the next generation of AI literate talent equipped to help the agriculture industry move into the next phase of growth and development.

Chairwoman Stabenow, Ranking Member Boozman, and Members of the Committee, thank you again for this opportunity. I also want to thank our leaders in South Dakota, including Senator Thune, Senator Rounds, Representative Johnson, and Governor Noem for their continued

[17] NITRD. Artificial Intelligence R&D Interagency Working Group.

innovative leadership to drive South Dakota into a new era of innovation. DSU looks forward to continued collaboration with the Committee to help further devise solutions to agriculture's most pressing challenges and ensure that the power of AI can be harnessed to its full potential.

###

Dr. José-Marie Griffiths is the President of Dakota State University in Madison, South Dakota. Dr. Griffiths has spent her career in research, teaching, public service, corporate leadership, workforce and economic development, and higher education administration with a special focus on work in STEM fields. She has served in presidential appointments to the National Science Board, the President's Information Technology Advisory Committee, and the U.S. National Commission on Libraries and Information Science. She was also a member of the National Security Commission on Artificial Intelligence.

Testimony of

Jahmy Hindman
Senior Vice President & Chief Technology Officer
Deere & Company
Moline, Illinois

Committee on Agriculture, Nutrition & Forestry
United States Senate

November 14, 2023

Good morning. My name is Jahmy Hindman, senior vice president and chief technology officer for John Deere. On behalf of Deere's 80,000 employees worldwide, I want to thank the Committee for the opportunity to address you here today.

John Deere is dedicated to assisting customers in meeting the increasing global demand for food, fuel, shelter, and clothing. We tackle challenges like limited land, water, and rural labor by leveraging technology, including artificial intelligence, to empower growers to achieve higher productivity with fewer resources. This approach allows farmers to accomplish more with less while improving their economic and environmental sustainability.

Deere currently connects over 650,000 machines around the world using terrestrial cellular networks. This allows data generated during farming tasks like planting and harvesting to be sent to the cloud for analysis. The insights gained from this analysis help optimize a farmer's current tasks, such as improving logistics, and contribute to enhancing future farming seasons. A common concern regarding farmers' data is ownership, and we are unequivocal on this matter: John Deere customers retain control over their data, including how it is collected, stored, processed, and shared. That said, we also believe that the valuable insights that can be derived from this information will play a crucial role in meeting our industry's collective objective of sustaining a growing global population.

Farmers use these same connections to deliver data-driven instructions back to their machines, such as prescriptions for applying different rates of fertilizer to different parts of a field, navigation information used to auto-steer machines, and input specifications like seed and fertilizer. These network services are offered to farmers through partnerships with third-party companies, allowing farmers to have greater flexibility in choosing the services based on their own preferences and needs. However, it's vitally important to address connectivity challenges in rural areas, including in-field connectivity, to fully unlock the benefits of technology for farmers.

In addition to connecting our products, we have significantly increased the computing capability embedded within our products. This allows for more advanced control and enables a unique "plant-level management" capability, where each plant can be

nurtured to achieve its optimal potential. Our self-propelled sprayers, for example, feature 9 graphical processing units and 36 cameras. These cameras can scan a distance of 120 feet at a speed of 12 miles per hour. Through artificial intelligence, they analyze images to identify weed pixels, allowing precise herbicide application only where necessary. This See & Spray™ technology is not some futuristic vision, it is already in the field: in 2023, U.S. farmers achieved an impressive 61% reduction in contact herbicide usage across 275,000 acres of corn, soy, and cotton in 2023, saving approximately 2 million gallons of herbicide.

But reducing herbicide use is just the start of AI's potential in agriculture. For instance, we have integrated the same graphical processing units with stereo cameras in our autonomous tillage solution. This application of artificial intelligence allows us to identify obstacles in the fields, prompting the fully autonomous tractor and tillage tool to pause and await further instructions from the farmer, who may be engaged in other, higher-value tasks. This solution directly addresses labor scarcity, especially during critical agricultural periods such as harvest and planting. In the past two growing seasons, this AI technology facilitated autonomous operations on approximately 45,000 acres of corn and soy in North America. As rural-urban migration continues, AI-powered solutions like this one become even more essential to U.S. farm productivity.

Additionally, we leverage the power of AI to train models using our technical assistance data. This enables us to promptly address customer or dealer machine issues, ensuring swift problem resolution. AI allows us to efficiently identify similar issues across a machine population and expedite solutions for affected customers. As a result, the impact duration during crucial agronomic timing windows is significantly reduced.

The future of U.S. agriculture is being built today with tools that enable data-driven decision-making by farmers. Artificial intelligence plays a crucial role in unlocking the value of that data and turning it into actionable insights in the field. But we need your help.

U.S. Farmers would benefit greatly from incentives to help them acquire the precision technology needed to do their jobs more effectively and sustainably. As you deliberate the upcoming Farm bill, I urge you to consider such proposals as the PRECISE Act, and

the Precision Ag Loan Act, that would expand eligibility for USDA conservation and loan programs to include the adoption of precision technologies. Further, bills like the Last Acre Act are essential for farmers to fully leverage the benefits of AI and precision technologies.

Putting these technologies in the hands of America's farmers not only improves productivity and profitability for growers, but also enables them to produce enough food, fuel, shelter, and clothing to sustain the growing world population. And that benefits us all.

Thank you.

Testimony of
Todd J. Janzen, President
Janzen Schroeder Agricultural Law LLC

Before the

U.S. Senate
Committee on Agriculture, Nutrition and Forestry

Washington, D.C.

November 14, 2023

Innovation in American Agriculture: Leveraging Technology and Artificial Intelligence

Good morning, Chairwoman Stabenow, Ranking Member Boozman, and members of the Committee. My name is Todd J. Janzen, I am the president and law partner with Janzen Schroeder Agricultural Law, LLC, a law firm based in Indianapolis, Indiana that serves the needs of America's farmers, ag technology providers, and agribusinesses. I also serve as the Administrator of the Ag Data Transparent project, which is an industry effort to build transparency, simplicity and trust into contracts between farmers and agricultural technology providers.

Farming in the United States has always been a story about technology. John Deere commercialized the steel plow over 175 years ago, which allowed for the Great Plains to be planted to food crops. Since then, we have seen many revolutions in agriculture—the internal combustion engine led to the tractor replacing the horse; the combine harvester replaced the threshing machine; commercial plant breeding led to consistently improved genetics and increased yields.

Today we are at the beginning of another large technological revolution in agriculture. I think of this transformation as the digitalization of farming. A modern farm generates enormous amounts of data: yield data, soil data, weather data, livestock data, financial data, etc. What has changed today is that farmers have various digital tools available to collect, manage, analyze, and share this agricultural data. While farmers once kept track of this information on paper notebooks and ledgers, today agricultural data has, for many farmers, moved to cloud-based data storage devices. With this technological change comes many possibilities for increased production from smaller environmental footprints. But there are also some concerns.

Today I will discuss: (1) how farmers use digital agricultural tools; (2) some of farmers' concerns about sharing their agricultural data with technology providers; and (3) how artificial intelligence (or "AI") is arriving on the farmstead.

1. How Farmers Use Digital Agricultural Tools

There are a number of different ways that modern farms collect, use and share agricultural data. The entrants in the market include both legacy agricultural companies that have added digital tools and new, start-up entities. Here are some examples of ways that farmers interact with digital platforms:

A. **FMIS Platforms.** There are many whole-farm management tools, commonly referred to as Farm Management Information Systems (FMIS). These are designed to help farmers manage all aspects of the farm, from making agronomic decisions to recording grain and livestock sales, to benchmarking farm production with similar operations.

B. **IoT Monitoring Platforms.** On the opposite end of the spectrum, there are many remote sensors used on farms that allow farmers to monitor specific tasks on the farm. These sensors are connected to the internet, commonly called Internet-of-Things or "IoT" platforms. An example would be an in-field irrigation sensor that links to an online platform that allows the farmer to monitor on his or her phone. Other examples include remote pest and soil sensors and connected livestock, such as a digital collar on a dairy cow that keeps track of the cow's eating, milking, and standing.

C. **Aerial Imagery.** Aerial imagery is more available to farmers today than at in any point in history. There are a number of digital platforms that allow collection of multi-spectral imagery from satellites, drones, and traditional fixed-wing aircraft. Farmers use these platforms to monitor crop and field conditions throughout the year.

D. **Robotics.** We are seeing the arrival of robotics on the farm in ways that seemed like science fiction twenty years ago. John Deere sells a fully-autonomous tractor that can be monitored by a farmer by his or her cell phone. Lely Corporation sells a robotic milking machine that can milk hundreds of cows per day without any human involvement.

E. **Crop Marketing and Trading Platforms.** There are online platforms available today that allow farmers to market, sell, and trade their crops and livestock products online. These platforms also allow traceability of commodities, which was nearly impossible in the old paper record days. Combyne is a good example of a platform that allows farmers to market and trade grain online.

F. **Connected Machines.** Nearly all modern agricultural equipment--tractors, combines, planters, etc.—either is remotely connected to the internet or has the ability to connect.

These machines generate a lot of data that is useful to the farmer, the equipment dealer, and the original equipment manufacturer (OEM).

G. **Precision Agriculture.** The ability to collect a lot of data from farmers has allowed the increased use of precision technologies. There are many platforms today that use agricultural data to generate field "prescriptions" for precise application of fertilizer, seed, pesticide application, and irrigation.

H. **Carbon Platforms.** In the last few years, numerous companies have started offering farmers the opportunity to monetize soil carbon sequestration on their farms by verifying such activities using agricultural data. These companies then sell the sequestered carbon as offset credits to other industries.

2. Concerns with Agricultural Data Sharing

Many farmers have embraced digitalization by using agricultural data tools on the farm. However, polls taken of farmer attitudes about these ag data products shows a consistent reluctance and apprehension. Below are some of those concerns and how the industry is attempting to address them.

A. Farmers' Concerns.

One of the more recent polls was by Trust in Food, a Farm Journal Initiative ("Trust in Food"), which surveyed 610 farmers for a 2021 report titled: "Farmer Perspectives on Data 2021".[1] The survey highlights a few of farmers' concerns with ag data collection and use by technology providers.

Lack of Trust

Trust is consistently ranked as farmers' biggest concern with sharing agricultural data. 73% of farmers stated that they do not trust private companies with use of their ag data. 58% of farmers stated that they do not trust federal, state, or local government offices with use of their ag data.

Privacy Concerns and the Loss of Control

Ag data is representative of a farm's livelihood. When asked about the greatest barriers to sharing ag data with technology providers, two areas in the Trust in Food survey jumped off the page. First, 69% of farmers surveyed stated that they feared sharing ag data would lead to

[1] https://www.trustinfood.com/wp-content/uploads/2021/05/Farmer-Perspectives-on-Data-2021.pdf

increased government regulation. Second, 69% of farmers surveyed also stated that privacy concerns were one of the largest barriers to adoption.

Interestingly, when asked whether ag data should be as tightly secured as "family health records," 87% of farmers agreed.

These concerns arise from a fundamental legal truth about ag data—there are no laws that specifically protect farmers' privacy and security concerns. Ag data is not typically "personally identifiable information," such that it would be protected by state laws which prevent misuse of personal information like name, address, and phone number. Nor does ag data fit into a class of data that Congress has chosen to protect legally, such as medical information (HIPAA). Finally, ag data does not neatly fit into existing legal protections for intellectual property, such as patents, trademarks, or copyrights. Ag data ultimately may be deemed a trade secret under existing state and federal trade secret laws, but that will depend upon whether courts interpret existing statutes to include information such as agronomic data.

Overly Complex Technology Legal Agreements

When American Farm Bureau surveyed farmers in 2016, 59% percent of farmers indicated they were confused about whether current legal agreements allowed technology providers to use their ag data to market other services, equipment, or inputs back to them. Zippy Duvall, president of Farm Bureau, said at the time: "You should not have to hire an attorney before you are comfortable signing a contract with an ag technology provider."

The more recent Trust in Food survey indicated that there is still a lot of room for improvement in simplifying legal agreements with technology providers. The third largest barrier to adoption (after fear of regulation and privacy concerns) was a "lack of training and understanding," with 52% of respondents indicating this was a problem.

My experience as a lawyer working in this area confirms that this is a real problem for farmers. Contracts from the technology industry have been widely repurposed for use with farmers, such as end-user license agreements, privacy policies, and terms of service. A farmer seeking to compare two similar products today might find that they are governed by two very different sets of contracts.

This only adds to a farmer's confusion. If we want to make technology easy to embrace and use—and we do—then we need to simplify the contracts farmers sign when implementing new ag data technology on the farm. Contracts that no one reads and understands set the stage for problems down the road.

B. Existing Industry Efforts to Address Farmers' Concerns

The Privacy and Security Principles for Farm Data

American Farm Bureau, National Farmer's Union, and national commodity organizations for corn, soybeans, wheat, and sorghum, led an effort in 2014 to establish fundamental principles for companies working in the ag data space. These organizations held a series of meetings where roundtable discussions occurred among industry stakeholders, such as John Deere, CNH Industrial, AGCO, Bayer Crop Science (at the time, Monsanto), Corteva (DuPont Pioneer and Dow AgroSciences), Beck's Hybrids, and many others. The culmination of these efforts was the drafting of the "Privacy and Security Principles for Farm Data," also known today as ag data's "Core Principles."

The Core Principles address thirteen key elements related to ag data. These include:

- Education
- Ownership
- Collection, Access and Control
- Notice
- Transparency and Consistency
- Choice
- Portability
- Terms and Definitions
- Disclosure, Use, and Sale Limitation
- Data Retention and Availability
- Contract Termination
- Unlawful or Anti-Competitive Activities
- Liability & Security Safeguards

The Core Principles have been widely embraced by the U.S. agricultural industry and have even served as a model for many other countries trying to create guidelines for proper agricultural data collection, use and sharing.

Ag Data Transparent[2] Certification

Having the Core Principles in place was a great starting point for the ag data industry to address farmers' concerns with ag data privacy, use, and control. However, the Core Principles are only guidelines, and only valuable if companies incorporate the Core Principles into their contracts with farmers. Therefore, following the release of the Core Principles, several farm groups and industry stakeholders worked together to create an independent verification tool that could help farmers determine if ag tech providers are abiding by the Core Principles. The verification is called the Ag Data Transparent certification, which entails a simple three-step process:

- Participating companies must answer 11 questions about how they store, use, and transfer ag data.
- The 11-question answer form is reviewed by an independent third party (Janzen Schroeder Ag Law) for transparency and completeness.
- If the evaluation is acceptable, the company is awarded the "Ag Data Transparent" seal of approval for use on its future marketing materials.

Companies that undergo evaluation and are approved as "Ag Data Transparent" may then use the seal of approval on their websites and in marketing materials. To date, over 40 companies have completed the evaluation and been approved as "Ag Data Transparent." The list of companies that are currently certified include those on this chart:

[2] www.agdatatransparent.com

Ag Data Transparent Certified Companies, November 2023.
Source: www.AgDataTransparent.com

The Ag Data Transparent process addresses farmers' three main concerns with ag data. First, the process instills trust. No company submits its contracts to a voluntary evaluation unless the company is willing to revise its contracts, as necessary, to bring them into compliance with the Core Principles. Second, loss of control is addressed by requiring tech providers to obtain farmer consent before transferring data to third parties. Finally, farmers' complexity frustration is addressed by condensing all of a tech provider's contracts into a 11-question form that answers the questions farmers want to know. The Ag Data Transparent process makes contracts better.

The Ag Data Transparent effort is governed by a non-profit corporation, the Ag Data Transparency Evaluator Inc. The corporate bylaws create three classes of directors: (1) Farm organizations that are made up of farmer-member organizations. The farm organizations are American Farm Bureau Federation, American Soybean Association, National Corn Growers Association, National Farmers Union, National Sorghum Producers, National Association of Wheat Growers and National Potato Council. (2) Ag technology providers that participate in the Ag Data Transparent certification are the second class of directors. (3) The organization also allows for organizations who align with the Ag Data Transparent's mission to be supporting

members. To date, these include McCain Foods, EMILI Canada, AGree Coalition (Meridian Institute), NASA Acres, Farm Credit Canada, and the National Ag Producers Data Cooperative.

Janzen Schroeder Agricultural Law LLC serves as the administrator of the program and conducts the evaluation reviews.

Creation of a Model Ag Data Use Policy

Our law firm, together with a committee from the Ag Data Transparent organization, has also developed a model Ag Data Use Agreement that we provide to companies looking for the best practices to manage farmers' ag data.

From my standpoint, the Ag Data Transparent effort has helped drive more technology providers into creating data use policies. Thus, the effort has paid dividends even for some companies that have not participated in evaluations because it has caused them to rethink how they are contracting with farmers.

3. The Arrival of AI in Agriculture Data Platforms

The agricultural retailer Farmers Business Network (FBN) recently unveiled "Norm[3]," an artificial intelligence (AI) advisor for FBN farmer-members. Norm is built off of OpenAI's ChatGPT language model and trained using agronomic data. Norm will allow FBN's farmer-members to use its query tool to obtain agronomic advice. Norm is likely the first dedicated artificial intelligence platform designed specifically for farmers, but it will not be the last. AI is on the rise in agriculture as it is elsewhere. Before AI technology becomes widespread, we should take some time to consider what AI is, how AI platforms might benefit agriculture and other industries, and consider what might go wrong to avert potential problems.

A. What is AI technology as it relates to farming?

First, some basics. AI stands for "artificial intelligence." According to Dr. Anastasia Lauterbach, contributor to *The Law of Artificial Intelligence and Smart Machines*, AI should be thought of as "narrow" AI or "general" AI. Narrow AI is focused on solving a particular task. When we talk about "machine learning" (ML) that is generally what we are talking about. ML involves a

[3] https://www.fbn.com/norm

computer using vast amounts of data to make a decision—but not just any decision but to continue to make better and better decisions. ML allows the computer to learn from its past decisions.

General AI is what we have been talking about more recently. According to Dr. Lauterbach, general AI is similar but seeks to mirror the behavior and capabilities of a human to solve problems. What we are seeing now with ChatGPT and other technologies is "generative" AI, which is a type of general AI that can generate new content that never existed. Generative AI like ChatGPT uses information from vast amounts of data that is publicly available, creating original content in response to inquiries from users.

B. How farmers can use AI tools.

Much of farming involves analyzing vast amounts of data to make informed and better decisions for future crop years and, in the case of livestock producers, using that information to increase milk production on dairies, egg production on poultry farms, and meat production. It is easy to envision how AI might be helpful in increasing plant and animal production.

For example, when a farmer asks *what variety of corn should I plant this year?* The market is saturated with seed companies and brands, each featuring dozens of unique varieties of No. 2 yellow corn (the most common feed corn). No human agronomist could reasonably analyze every possible variety and determine which might be best for a specific field, given the soil profile, weather predictions, pest predictions, anticipated weed pressure, the availability of irrigation, etc. AI, on the other hand, when equipped with the right training data, could do that. AI would also be free from the inherent biases that humans bring. No seed salesman is going to recommend seed from a competitor.

The same could apply to a modern dairy farm when the producer asks *which cows should I breed this year with which bulls?* Modern dairy farms often have hundreds or thousands of milking cows. Not surprisingly, there are many companies that offer their bulls for breeding and promise great results. And it may surprise many that not all dairy cows are the same. Some live productive lives longer, are more resistant to illness, and better suited to different climates (dairies exist everywhere from sunny, hot Florida to northern Wisconsin). AI could be trained on all of this data and make breeding recommendations for the dairy farmer.

In some areas, we are already seeing narrow AI used successfully on the farm. John Deere has introduced "See & Spray"[4] technology for its commercial sprayers. For those unfamiliar, modern sprayers are tractors with large liquid storage tanks used to hold fertilizer or pesticides. With spray booms up to 120 feet wide, these machines can cover hundreds of acres in a day. See & Spray is revolutionary, however, as it uses sensors to spot weeds and differentiate those weeds from desirable crops. The spray nozzles are then turned on only when a weed is sensed under the nozzle. Spray applicators only use pesticides on the weed and do not have to broadcast over an entire field. This sort of technology is only possible with machine learning, as the equipment must be trained with vast amounts of data to distinguish good plants from bad.

C. What might go wrong with AI?

Putting aside the Hollywood doomsday predictions of AI becoming so intelligent it decides to destroy humanity for the good of the planet, there are other more immediate and realistic concerns with AI in agriculture. AI is only as good as the data that trains it. If the training data is corrupt or skewed by a company to increase shareholder value, such decisions could create problems. Imagine a seed company figures out what data an AI tool like ChatGPT is using to make farming decisions and that company starts flooding the internet with false reports about its seed—data that we (as humans) never find through search engines, but AI zeros-in on the data. That seed company could skew the AI results to favor its products. Just as companies today use various tactics to game search engine optimization (SEO)—making sure they appear on page 1 of Google searches—we could see corporate marketing departments try to game AI systems to skew product recommendations in their favor.

Remember, too, that AI has to make mistakes in order to learn what is correct. This means mistakes will be made, on the farm and elsewhere, on the road to the future. Will AI platforms also retain liability for these failures? This seems doubtful.

D. What are some of the legal implications for AI?

Companies that are wanting to use general AI to expand services to farmers should do so with cautious oversight. Privacy has long been a big concern for farmers when it comes to their

[4] Learn more about See & Spray at: https://www.deere.com/en/sprayers/see-spray-ultimate/

agricultural data, as evidenced by the interest in the Ag Data Transparent organization. AI tools have the ability to violate the privacy walls that companies establish for their human users. Any company creating an AI tool should ask: does the platform have the right to access confidential information and, if so, are the safeguards to prevent release of confidential information? A farmer may provide confidential agricultural data to an AI platform and not realize that information will not only be used for recommendations for his farm but for others too.

Companies using AI tools should clearly license the ag data used to train models. A clear license not only addresses the farmers' concern with transparency but also protects the AI developer from claims later on that training data was not obtained lawfully.

On a broader sense, companies should also make sure that AI platforms respect the rights of ownership of data, copyrights, and other forms of intellectual property (IP). Currently, only humans or companies can legally create or own intellectual property. What happens when AI uses proprietary information to create new, derivative content? Who will own the resulting IP? And even more concerning, is the AI platform owner liable for violations of IP laws?

Companies trying to maximize the benefits of AI tools should also consider the ethical complications. Is it ethical—or worse, fraudulent—for companies to attempt to fool AI platforms into making decisions that may not be based upon accurate data but instead based upon false data published to skew AI results in the company's favor? Can a marketing department flood the internet with exaggerated claims about the company's products in order to trick AI platforms into believing the (false) hype. I don't know of any laws that address this scenario of intentionally misleading AI to generate inaccurate results.

Conclusion and Policy Considerations

Ag technology, ag data, and AI are all very broad subjects with a host of issues for farmers. For policymakers, I offer a few considerations to help with policy development.

When it comes to new technologies on the farm, **policy should focus on leveling the playing field and not stifling innovation.** The Ag Data Transparent project is a good example of this principle. The Ag Data Transparent certification does not recognize the right or wrong way to

collect and use data, but instead recognizes companies for being *transparent* about how they use data.

Transparency should always be the focus of any data collection platform, regardless of whether the collector is a private company or government regulator. Transparency does not mean such information should be publicly available, but that farmers should know what information is being collected from them and how it will be used. This is also important with AI tools. Farmers should know whether their data is being used for AI training when signing up.

There is room for improvement of data collection at USDA. The Agriculture Innovation Act (S.98)[5] is an example of a bill that seeks to modernize USDA's collection and use of data. USDA data has long history of collecting farm data for various programs, but much of that data is siloed within these agencies and therefore not valuable to policymakers and researchers. The Act envisions an update to USDA data collection, creating a secure data center that would allow stakeholders and researchers access to anonymized data collected by USDA.

Todd J . Janzen
President, Janzen Schroeder Agricultural Law LLC
8425 Keystone Crossing Ste. 111
Indianapolis, IN 46240
janzen@aglaw.us
(317) 855-9920
www.aglaw.us
www.agdatatransparent.com

[5] Learn more about the Agriculture Innovation Act at: https://foodandagpolicy.org/wp-content/uploads/sites/17/2022/05/Agriculture-Innovation-Act-One-Pager.pdf

QUESTIONS AND ANSWERS

NOVEMBER 14, 2023

U.S. Senate Committee on Agriculture, Nutrition, and Forestry
Innovation in American Agriculture: Leveraging Technology and Artificial Intelligence
November 14, 2023
Questions for the Record
Mr. Sanjeev Krishnan

Senator Reverend Raphael Warnock

1. Many farmers are open to ag tech innovations that could help optimize their returns and minimize financial risk, but upfront costs pose a major barrier to adoption.[1]

    a. How are ag tech companies addressing some of the financial barriers that farmers face to adopting ag tech?

    Addressing financial barriers directly can help to make agricultural technologies more accessible to individual farmers. In addition, the ongoing improvement and evolution of the overall ag tech operating environment can help to drive broader costs savings and improve economic security across the agricultural system. This includes focusing on quality of data over volume of data, interoperability of data between solutions and financing tools, and tech-enabled economies of scale benefits.

    By improving the quality of aggregated data – rather than only amassing a large quantity of data – ag technology companies can deliver better and more personalized solutions that better meet the needs of farmers. This, again, would save time, resources and other hidden costs, and maximize the value delivered through better, faster, more efficient and precise solutions. To varying degrees, these solutions will increasingly be able to better account for, automatically adapt to, and moderate the negative impacts of the high level of variability in weather patterns, in the soil, in commodity prices, and other global and local factors that drive volatility and farmer costs.

    Improving the quality of aggregated data collected can also create an equitable foundation that accounts for all historically excluded farmers, while also welcoming a new generation of farmers. With the proper infrastructure, ag technology, enhanced by AI, has the potential to support equity by reducing human biases. Better data can help to improve personalized solutions for small and mid-sized farmers, historically underserved farming populations, and other groups that would benefit from more targeted solutions. Better data also offer an incredible opportunity to make farming more accessible by democratizing

[1] https://www.mckinsey.com/industries/agriculture/our-insights/agtech-breaking-down-the-farmer-adoption-dilemma

financing platforms, increasing data sharing and access to toolkits and accelerating digital literacy efforts.

This expanded focus on quality over sheer quantity of data and a trend towards offering actionable insights also represents a new frontier of deriving value from on-farm data. To that end, interoperability will be critical in enabling farmers to derive more value from data pulled from many different on-farm sources. Ensuring that ag technologies can integrate with one another in a more seamless way will improve the farmer experience and, again, save time and other hidden costs associated with managing these technologies while maximizing the economic value of the insights delivered. Interoperability is also valuable in pricing risk and optimizing outcomes for farmers, enhancing the connection between new solutions and lending models and other innovative financial products that can support adoption. This can help to lessen the costs, risks and barriers associated with adopting new practices and solutions and complementary farm management software and technologies that can further enhance impact.

As these ag technologies continue to scale, further enhanced by AI, costs may naturally come down as companies achieve economies of scale, with the lower manufacturing and operational costs that come as scale and demand increase. In addition, tech-enabled scale has the potential to deliver more significant benefits even beyond those typically realized as economies of scale are achieved. For example, many ag technology companies are offering a wraparound solution set that, combined, presents a more scalable business model that thus becomes more accessible to farmers across size, geography, crop type, profitability profile and more. In addition to potentially bringing costs down, improving economies of scale also has the potential to enable ag tech companies to enhance the customer experience and streamline customer support. This would make it easier and less time intensive for farmers to manage these technologies on farm and reduce the hidden costs associated with time spent implementing and troubleshooting technologies on farm. Some companies are also exploring risk-sharing or outcome-based pricing models for new technologies, which have the potential to reduce upfront costs by offering shares in longer-term value streams, such as ecosystem services credits, offtake agreements, or transitioning to organic production and the associated premiums that such products typically command.

b. What resources are available to farmers to evaluate scientific and technical claims made by ag tech suppliers?

Today, the resources available to farmers to assess and evaluate ag technologies lie on four prongs. Likely foremost for most farmers is through word of mouth – hearing what a neighbor has experienced, or through a farmer's extended community, like watching a video presenting the pros and cons by someone with

experience with a product or service on social media or other digital platforms. In addition, information from leading land grant universities can support farmers with unbiased data from field trials, often conducted over the course of several years, enabling performance comparisons across diverse growing and weather conditions. Ag retailers, certified crop advisors, and university extension agents are a trusted source of advice, often based on hyper-local information they've gathered from their own communities and testing they've done in field trials. The developers and suppliers of these ag technologies, of course, also provide information directly to farmers. And the U.S. Department of Agriculture works with farmers, ag retailers and other stakeholders – for example, through farm bill-funded initiatives like Conservation Innovation Grants – to further scale the testing of new technologies and approaches and expand the body of evidence demonstrating the environmental, financial and social impacts of new tools.

Further developing and scaling unbiased third-party mechanisms and approaches to complement existing efforts to evaluate the efficacy of ag technologies will be critical, particularly as we learn to better leverage AI's ability to make existing and future ag technologies better and more effective at doing what they say they can do.

Certainly, there are powerful ag technologies and tools available today. Farmers and agricultural stakeholders also have a healthy skepticism as a natural consequence of being presented with technologies and tools that have claimed to do it all but have failed to deliver. The application of artificial intelligence could further improve and refine existing technologies and approaches; help stakeholders verify the impact of technologies and practices with clear, accurate and high-quality data; and enable stakeholders to truly weed out ineffective approaches and focus resources and time on options that work best for the conditions on their operations.

Farmers, researchers, ag tech and AI developers, and other stakeholders should work together to develop a set of benchmarks to validate the claims of ag technologies and AI-powered services. Doing so would further support accuracy and transparency, and act as an important tool in building trust. Likewise, increasing federal funding for ag tech and AI research, including grants for universities, public-private partnership and incentives for start-ups focusing on AI solutions for agriculture, can also help to expand the pool of verified data and information available to assess the impact of these technologies.

2. New precision agriculture technology is presenting farmers with enormous potential to increase their yields while decreasing their need for manual labor. However, a joint report from the U.S. Department of Agriculture (USDA) and the Federal Communications Commission (FCC) found that some farmers do not have access to these new technologies. Many farmers, especially small and historically underserved farmers, are concerned that they may get left behind if the barriers of adoption are not lifted.[2] My bill,

[2] https://www.fcc.gov/sites/default/files/precision-ag-report-11102021.pdf

the *Promoting Precision Agriculture Act*, aims to lift one of these barriers to make sure that precision agriculture technologies can work together and work for all farmers. This bill will direct USDA and the FCC to develop better interconnectivity standards for precision agriculture.

What is the importance of interconnectivity standards in ag tech?

Along with tremendous potential benefits of ag tech, the future ubiquity of AI also raises questions about how to ensure these technologies are safe, equitable and deliver the best possible outcomes for farmers, particularly as more and more decisions are made with the assistance of or directly by AI. At this point, the future prevalence of AI throughout our lives, industries and economies is inevitable. The key will be to ensure that the right balance is struck between human control and oversight, and leveraging the immense power of ag tech and AI to deliver on its full potential and change our world for the better.

Against that backdrop, interconnectivity and data interoperability standards will be critical as the food and agriculture system looks to deploy and manage new precision agriculture technologies and solutions at a large scale, while protecting stakeholders and ensuring that the benefits of ag tech and AI are equally distributed. The foundation of interoperability is the ability to exchange and make use of data across agricultural technologies and systems – not only enabling these technologies to seamlessly "talk" to each other, but also giving farmers a wider array of options in the technologies they choose to implement on farm. Strong interconnectivity and interoperability standards will, by their nature, also enhance competition and farmer choice.

Taking a step back, expanding access to rural broadband is fundamental to supporting connectivity. We urge Congress to keep ensuring consistent nationwide access to high-quality internet as a top priority. S2G portfolio companies have been able to overcome the connectivity barrier, but it required a considerable investment of time, energy and resources that not all businesses have the capacity to make. Imagine how much stronger and more robust rural small businesses, start-ups and farms could be if we eliminated the connectivity barrier and allowed those companies to focus on innovating, growing and scaling. We need a coordinated federal strategy – supported by the efforts of the private sector – to truly solve this issue. We urge Congress to prioritize funding to address broadband infrastructure gaps and incentivize telecommunications companies to bring fundamental connectivity to all communities.

Digital technologies can also speed the ongoing modernization of the food and agriculture supply chain, making it more resilient against disruptions – but again, only if internet access is universal.

We also encourage Congress to consider additional steps to encourage stakeholders to prioritize interoperability and interconnectivity. For example, the

federal government could play a critical role by creating incentives, such as financial rewards or regulatory benefits, to facilitate the development and widespread adoption of such standards.

In addition, establishing clear guidelines and frameworks for the use of AI in agriculture, including standards for data collection, usage and transparency, can help to ensure that AI systems – and the ag tech tools they help to enhance – are reliable, ethical, and do not harm the environment or market dynamics. The scope of such standards should include the use of data from multiple and diverse sources to ensure that ag tech and AI systems do not perpetuate biases, are transparent in their decision-making processes, and are accountable for their outcomes. These standards should also include the development of different classes of datasets and datapoints, to ensure that stakeholders can easily assess the quality and viability of data against their specific needs.

○