Bridging the Gap: Accelerating Technology Adoption for Sustainable Food Production

Navigating the Path in Adopting Emerging Agricultural Technological Innovations

The Chicago Council on Global Affairs - Center on Global Food and Agriculture

October 2023

With climate change and growing populations, the world faces unheralded demands upon a safe, reliable, and sustainable food supply that nourishes a healthy global population without exhausting finite resources. In decades past, farmers and their supply chain partners have risen to food production challenges through the rapid adoption of technology and scientific innovation, vastly increasing the productivity of food systems. Overcoming today's agricultural challenges requires a similar step change in innovation.

However, a recent history of agricultural technological (AgTech) innovations that failed to achieve widespread consumer acceptance underscores the importance of consumer buy-in for technical innovation in agricultural production. We will need to apply key learnings and generate new strategies in rebuilding consumer trust of new technology in food production, streamline and coalesce processes that expedite innovation, and ensure new innovation is accessible and profitable for growers.

This white paper explores the current development, challenges, and potential of emerging AgTech innovations with the potential to radically improve the sustainability, profitability, and accessibility of US-produced food. This paper concludes with action recommendations designed to remove barriers and expedite the next generation of AgTech integration in US food production.

AP Photos

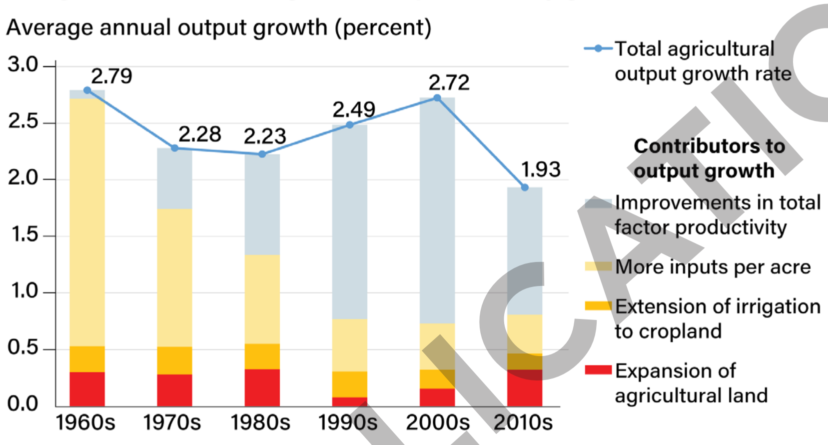
Why AgTech Innovation Is Needed

US farmers, ranchers, and fishers contribute nearly $330 billion[1] annually to the US economy ($750 billion when adjacent food-service and agricultural industries are included), providing nearly 90 percent[2] of the food purchased by US consumers. Additionally, the US agricultural system is essential to global food needs, supplying nearly 25 percent of the global grain market (corn, wheat, and rice) and contributing significantly to the global supply[3] of livestock products, tree nuts, fruits, and vegetables.

However, after decades of increasing productivity rates, the global agricultural output growth rate, i.e. the ability of farmers to produce more food while using fewer resources such as land and fertilizers, is falling.

Figure 1

Global agricultural output growth rate slowed over the past decade along with declines in agricultural productivity growth



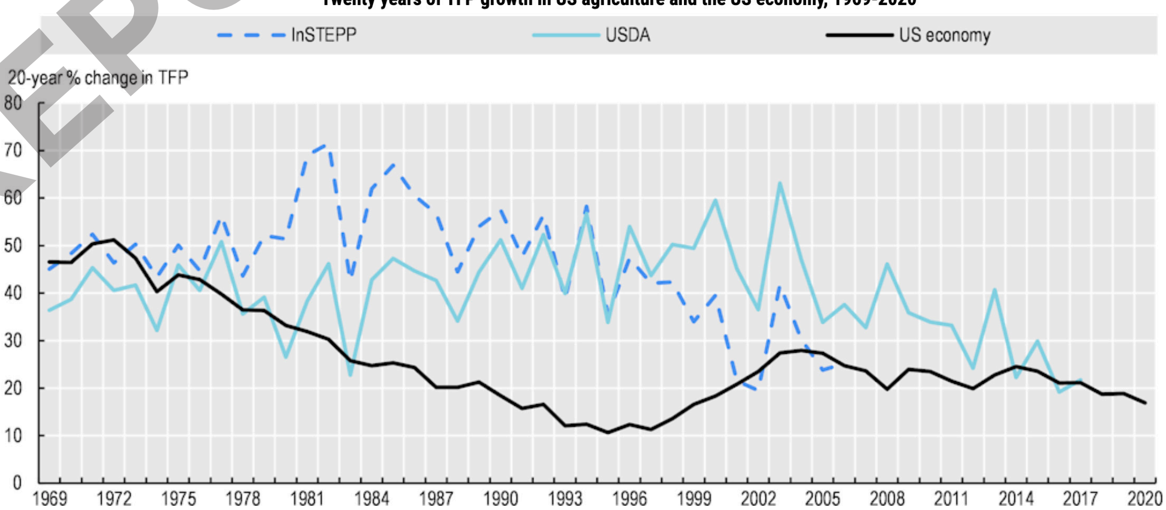
Source: USDA, Economic Research Service (ERS) using data from the ERS International Agricultural Productivity data product.

According to a 2022 USDA's Economic Research Service report[10] the global agricultural productivity rate has dropped to its lowest rate of growth in six decades, due to:

- Climate change-induced weather shocks like drought, extreme heat, or flooding.
- The rise of new pests and weeds resistant to traditional control methods.
- A slowing rate of new technologies with the ability to rapidly increase productivity.

Figure 2

Twenty years of TFP growth in US agriculture and the US economy, 1969-2020[10]



Source: Data are from USDA TFP series and InSTEPP MFP series. US economy is utilisation adjusted TFP from Federal Reserve Bank of San Francisco (2021).

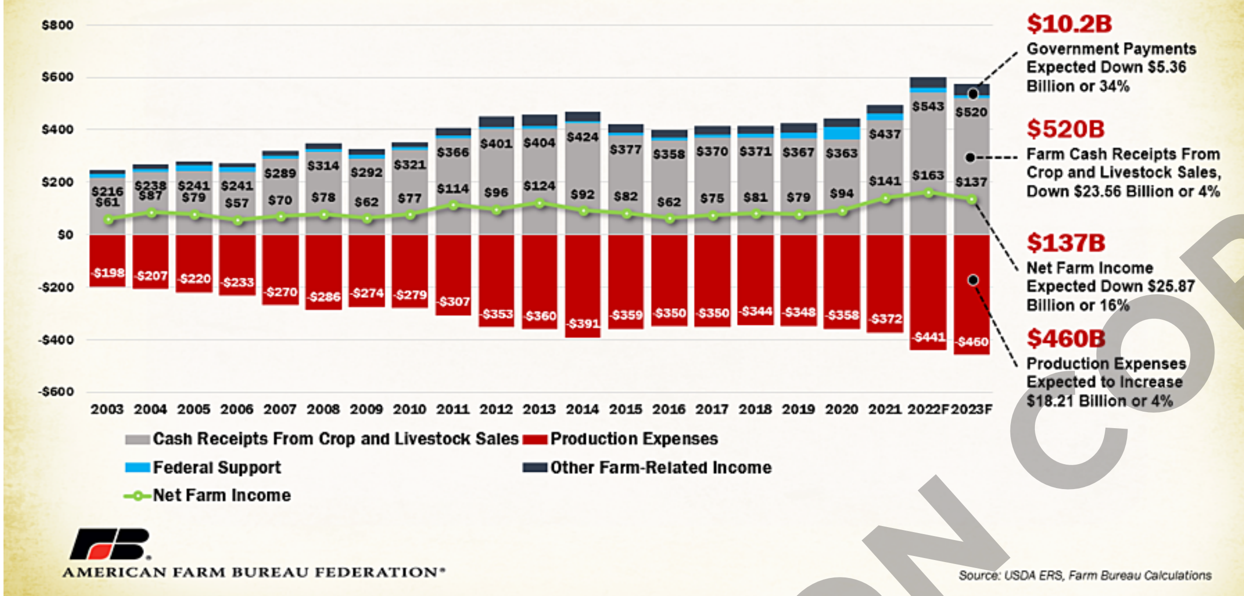


FIGURE 3: U.S. FARM INCOME AND EXPENSES[11]

U.S. Farm Sector Farm Income, Expenses and Net Farm Income, Billion Dollars

In US agriculture, the Total Factor Productivity growth rate, or the measurement of productivity efficiency calculated by how much output is produced from inputs, has declined significantly in the past 20 years.

But while agricultural productivity rates are trending downwards, the need for more food is trending up. Demographic projections estimate an additional 60 percent more food production[4] will be needed by 2050 to support a projected 9.3 billion global population.

Converting new land into agricultural productivity, a historical solution to producing more food, is not a sustainable option, jeopardizing native ecosystems such as forests and grasslands critical to maintaining species biodiversity and mitigating carbon emissions. Additionally, global water use, essential to food production, is projected to increase[5] between 20 to 50 percent by 2050 to support increasing populations. US agriculture consumes 80 to 90 percent[6] of our total consumptive water use (water that is drawn but not returned to its source), and globally, 70 percent of the world's freshwater supply[7] is used for food production.

Adding to the intensity of the problem, slowing crop productivity rates have been exacerbated by rising production costs, resulting in farmers struggling to operate within reliably profitable margins and contributing to the loss of farm businesses and farmland.

- Over the last 20 years, US farmer income levels have remained essentially stagnant. Even though farm cash receipts more than doubled so have production costs, according to the American Farm Bureau Federation.[11]
- Between 2007 and 2020[8] the US lost 200,000 farms and 22 million acres of farmable land was taken out of agricultural production.

All told, a new era of rapid innovation bolstering agricultural productivity is critical to future food security.

Challenges to the AgTech Adoption Pathway

Barriers exist at each step of getting innovations to market and achieving widespread consumer acceptance.

Prior to reaching the market, cost and affordability can prohibit the development of new technologies, especially considering recent high prices and underinvestment in agriculture R&D.

Restrictive regulatory processes can also slow down the adoption of agricultural technologies. At the adoption phase, implementers need the appropriate infrastructure and access to resources to utilize innovations at scale. Food system challenges often vary in unique contexts, and thus solutions must be locally available and adaptable.

Consumer Trust Matters

Although the American public trusts farmers as a group, ironically they do not trust farmers to farm, creating a potential barrier to the acceleration of AgTech adoption.

A 2020 American Farm Bureau survey[12] found that 88 percent of Americans trust farmers, but only one in five have a high level of trust in modern agriculture, with about half indicating skepticism in modern agriculture. This disconnect is attributed to an unrealistic and nostalgic view of farmers, a lack of education about modern farming techniques, a mistrust of 'Big Ag' companies and their motives, and concerns about the environmental and health impact of specific farming techniques.

Furthermore, many consumers mistrust or lack proper knowledge of agricultural technology. Consumers are also more likely to have expectations around the sustainable production of food than in the past. These views can limit market acceptance and opportunity to scale various innovations.

- In a 2018 study,[13] only 33 percent of survey respondents indicated that they "strongly agree" that they are confident in the safety of the food they eat, which is down from 47 percent in 2017.
- Only 24 percent of survey respondents indicated a "high degree of trust" in the food they eat and decreased to seven percent when only Generation Z responses were considered, according to a 2022 survey of 1,022 consumers.[14]

However, US and global consumers look to farmers and producers as potential leaders in global sustainability improvements, a key factor in their decision-making process which can lead to more acceptance of technology. A 2023 NielsenIQ study found that a high percentage of consumers indicated they are more interested in understanding production practices as a part of their purchase decision, and want to learn more.

- 55 percent of consumers are willing to try products produced through indoor vertical farming technology.
- 54 percent of consumers are willing to try products grown using regenerative practices, which is associated with environmentally sustainable farming practices.
- The number of environmentally-conscious consumers 18 to 35 years old is greater than all other age groups, and growing.

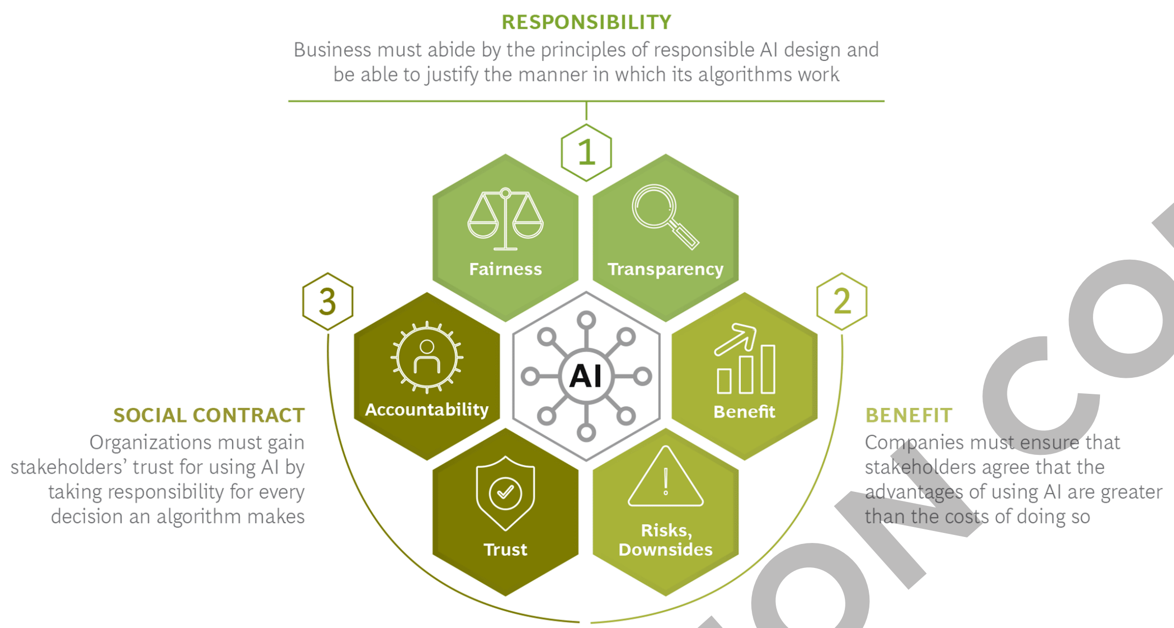
The Role of Consumer Social License in AgTech Innovation

Social license is a concept developed for gaining community acceptance of projects (such as a new building, a mining operation or a power plant) that also applies in the development and introduction of new technologies. In the case of technology, social license represents an implied contract between technology developers and society based on a set of underlying assumptions, such as trusting the new technology will be safe, fair, and beneficial.

Although it is important for social license to be granted during the early stages of development, social license can be lost either during the adoption process or long after technology has been diffused throughout society. Reasons include notable events, conflicting science, or changing values. For instance, autonomous driverless vehicles were on the path to generating social license until notable fatalities raised consumer concerns. And combustion engines, once widely accepted by society, are now losing social license due to the climate change impacts of fossil fuel use.

Figure 4

The Three Pillars of an AI Social License[17]



In AgTech innovation, there have been notable examples of social license barriers. For example, the failure of the developers of genetically modified crops to establish trust with consumers led to policy regulations, market influence and a 'NonGMO' labeling campaign.

- In 2004, Monsanto dropped the development of genetically modified wheat[15] due to US farmer concerns over endangering wheat exports to countries that had banned GM crops.
- In 2014, McDonalds announced[16] they would not purchase USDA-approved genetically modified potatoes developed by J.R. Simplot based on assessments of down-stream market consumer concerns,

Similar issues have occurred with consumer acceptance of glyphosate, an innovation that replaced less-effective and more toxic chemical herbicides and enabled the adoption of improved soil erosion and crop management practices (e.g reduced tillage practices) in US crop production.

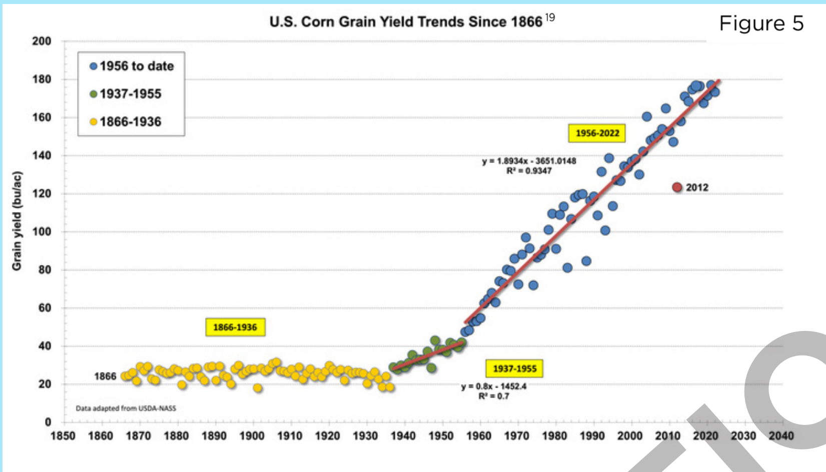
Grower-Focused Technology Versus Consumer-Focused Technology

When considering future AgTech adoption, it is noteworthy to differentiate between AgTech innovations that are primarily grower-focused versus technologies that prioritize consumer-focused innovations with benefits that consumers care about. For example, traits for drought-resistant crops are more grower focused, while traits related to nutrition, taste, and shelf-life are more consumer focused. Innovations in the past have primarily targeted farmer productivity and efficiency, but future innovations will need to ensure that the benefits will also appeal directly to shoppers. With gene editing, there is an opportunity to develop a product which combines traits that benefit both producers and consumers. For instance, Pairwise is developing a higher yielding, thornless blackberry (traits valuable for producers) that also will be seedless and consistently taste great (traits valuable for consumers). By positioning the interests of consumers at the center of AgTech innovation, there is an opportunity to increase public awareness and to defuse potential distrust of new technology in food production by focusing on and highlighting consumer-level benefits.

Case Study: US Corn Production - The Tremendous Potential (And Need) For AgTech Innovation

In the US 'Corn is King,' historically topping total value and land-in-production averages. In 2022, the US corn crop was worth $88 billion,[18] more than 32 percent of the US total cash crop receipts. Yet corn's position as a top US crop wouldn't be possible without a 100–year period of rapid technical and scientific innovation.

Figure 5

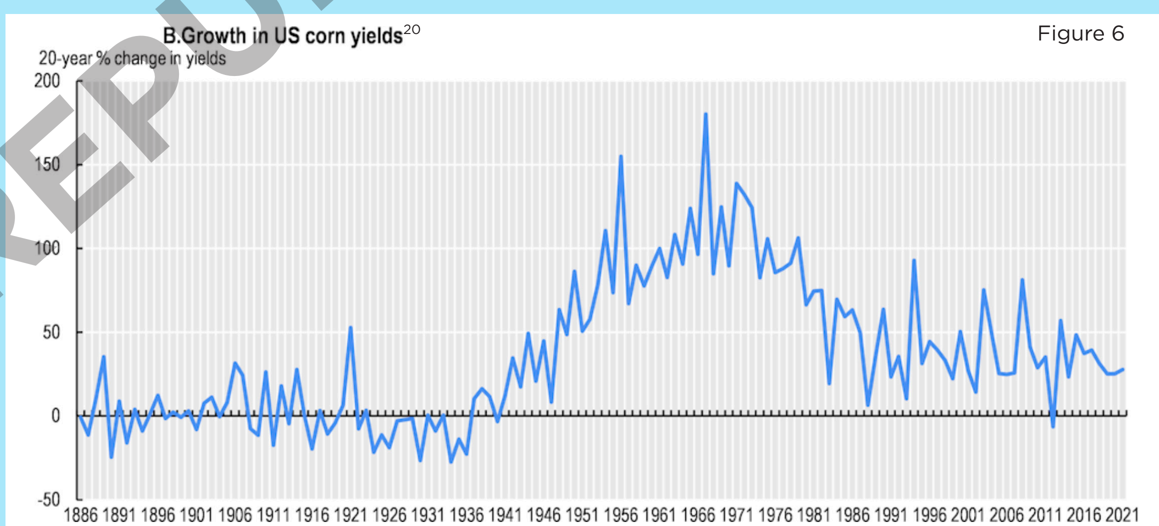


Between the 1930s and today, annual corn production increased by 590 percent,[20] from an average yield of 30 bushels an acre to 180 bushels. The productivity increase was due to an ongoing series of innovations, including improved genetics, agricultural mechanization, the advancement of crop protection products and nitrogen fertilizers, and improved soil and crop management practice. In the 1980s, the adoption of herbicide and pesticide-resistance transgenic traits added more predictability and reliability to corn production.

But, while overall annual US corn yields continue to grow at nearly two bushels per acre a year, the overall productivity gains have stagnated in the last 20 years.

When put in the context of growing climatic impacts on agricultural productivity and global population demand for more food, corn stands as an example of not only what can be achieved through innovation, but the dire need for a new boost of technological and science-based innovation in food production.

Figure 6



Source: Author's calculations based on data from USDA NASS Quickstats.

The Current State of Agricultural Innovation

The US agricultural sector has experienced remarkably rapid productivity increases, despite a widely held misconception that farmers are slow adopters of new technologies.

From 1947 to 2017, new machinery, growing practices, and greatly-improved crop and animal genetics led to US farm production nearly tripling over a 70 year period,[21] despite a 76 percent decline in farm labor and 26 percent decline in total land farmed during the same period.

Precision Agriculture: The Last 20 Years of US AgTech Innovation

Even though the overall productivity growth rates have slowed, the last 20 years of US agriculture has seen multiple AgTech innovations and ongoing adoption.

Technologies like Global Positioning Systems (GPS), Geographic Information Systems (GIS), aerial and satellite-based remote sensing capabilities, and data collection have enabled a new era of technology-enabled food production deemed "precision agriculture." Many US farmers today use technologies that allow them to adjust within inches their seeding, fertilizing, crop protection, and irrigation inputs allowing them to optimize their productivity while minimizing their inputs. Additionally, advances in biotechnology such as genetic modification of crops like corn, soybeans, and cotton have helped farmers reduce chemical pesticide use[22] while increasing yields and profitability.

- Between 2001 and 2016 the use of auto-steer and guidance systems on US row corn acreage increased from 5.3 to 58 percent.[23]
- In 2019, GPS-enabled applications were used on 40 percent of all US farm and ranchland acreage.
- At least half of large-scale US row crop farms rely on digitally-enabled yield maps, soil maps, VRT (variable rate technology), and/or guidance systems in their production systems.

Meanwhile, according to a 2022 McKinsey and Company global survey[24] of 5,500 farmers, 79 percent of North American (US and Canadian) farmers say they are already using or planning to adopt yield monitoring and mapping, and variable rate fertilizer applications; 77 percent are already or planning to adopt sprayer-section control technology; and 56 percent are already using or planning to adopt in-field soil sensors.

The AgTech Innovation Investment Ecosystem

Public and private investments into research and development (R&D) spur the development and adoption of AgTech innovation. Research supported by the USDA Economic Research Service (ERS) shows that every $1 invested in public agricultural research and development (R&D) from 1900 to 2011 generated $20 in benefits to the US economy, on average.

Table 1

Research applications from universities funded by AFRI

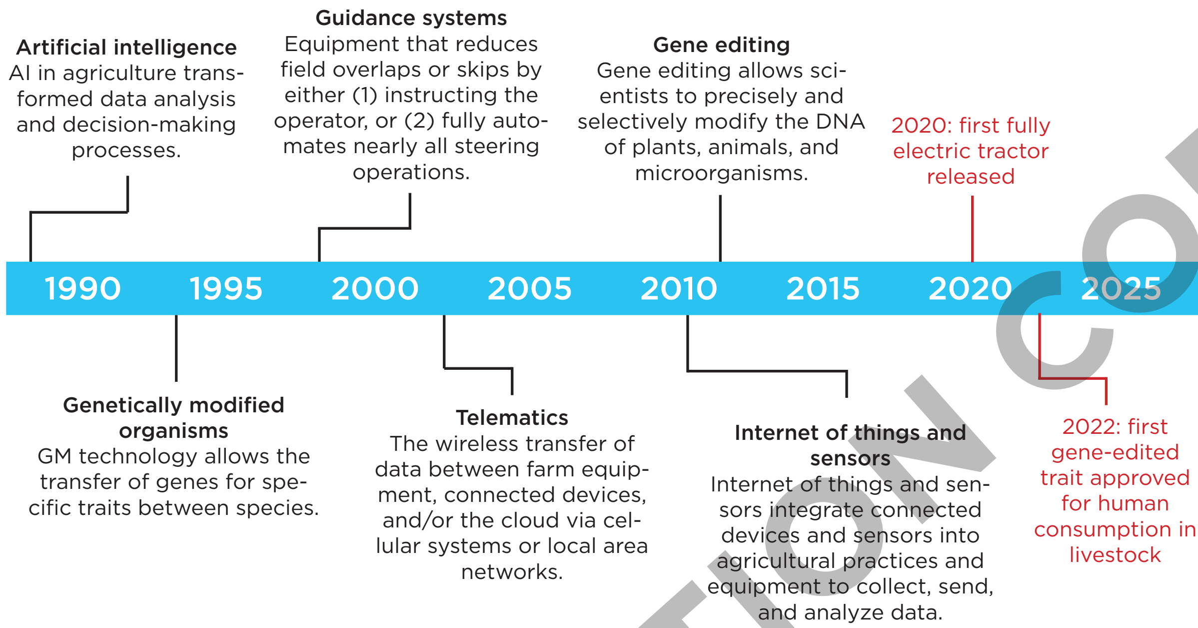
Less than half of research proposals from universities that are recommended for USDA funding are awarded due to congressional funding shortfalls.

Applications requested	2,787	$1.36 billion
Recommended for funding	1,614	$845 million
Awarded	719	$377 million

Source: AFRI FY 2020 Annual Review

Figure 7

30 Years of AgTech Innovation[29]



However, new innovation-enabled productivity gains lag years, sometimes several decades, behind initial R&D effort and US public agricultural expenditures in R&D have declined by about one-third since 2002[25] with those funding decreases impeding the ability to support domestic public research projects.

Private investment can offset public R&D investment. Over the past 20 years, global venture capital (VC) investment in agricultural and food tech has grown from practically nothing to a record-breaking $51.7 billion in VC investment in 2021.[26] The VC market is particularly important for supporting technologies at the startup level, helping foster the growth of innovation considered to be too risky and early stage for established agribusinesses to invest in.

However, the VC market cultivates high-value opportunities, generally investing in a limited set of areas with high potential for returns, such as technologies supporting major row crops. Smaller commodity crops and production areas with less likelihood of monetary returns do not experience the same level of VC investment or returns, even though they may be ripe for productivity gains with the potential of significant public benefits.

Private investments are also susceptible to market pressures. Agricultural and food tech investments in 2022 dropped by nearly 44 percent over 2021, following the same trend as declining global venture capital markets.

Critical Challenges AgTech Innovation Can Address

But what does a well-funded, innovative AgTech ecosystem fostering the productivity improvements needed to support a sustainable US agricultural system look like?

A resilient, sustainable food system solves the following critical challenges currently jeopardizing the future of US food security:

1) Nutrition Security

Nutrition security is a critical component of any successful food production system. Effective nutrition security ensures consistently available, accessible, and affordable nutritious foods promoting well-being, health, and preventing diet-driven diseases.

- Nearly 13 percent of US households were food insecure at some point in 2020,[27] a jump from 10 percent the year before.
- Only one in 15 US adults have optimal cardiometabolic health, an issue linked to poor nutrition diets and the rise of diet-related diseases including obesity and adult-onset diabetes.
- One in four US youth have prediabetes or are overweight. One in eight US youth have diet-related fatty disease.
- Only one in ten American adults eat the recommended daily amount of fruits and vegetables.[28]

To improve nutritional security, producers need technologies that support more nutritionally-dense crops, humanely-raised livestock, and agricultural products that are accessible and appealing to consumers. Innovations are needed for that improving food accessibility across all populations, including technologies that streamline and avoid waste and disruption in the supply chain as well as innovations supporting localized crop production in populations traditionally highly dependent on food imports.

2) Rural Livelihoods and Farmer Profitability

Resilient and thriving rural communities are integral to supporting a sustainable agricultural system. The rural communities surrounding and supporting agricultural lands need to be able to effectively improve their own social, economic, and environmental benefits.

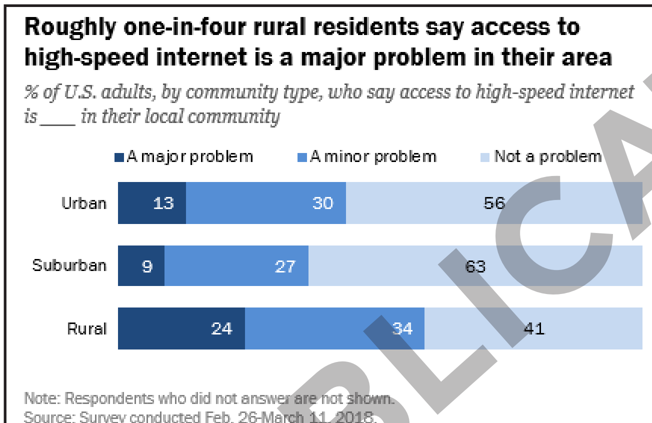


Figure 8

Poor economic conditions, including the lack of reliable, living wage employment, the inability to access benefits such as high-speed internet services, locally available health care, and nutritious food hamper the ability of rural, food-producing communities to support agricultural innovation at the local level.

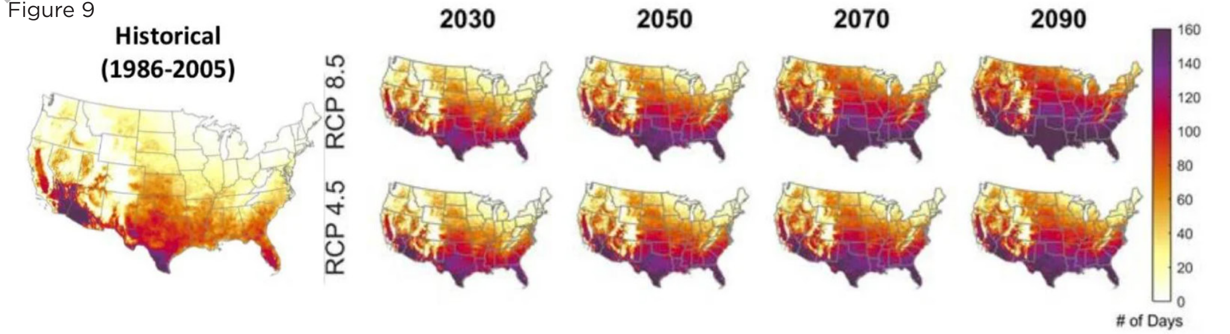
To foster successful AgTech adoption, agricultural production ecosystems need to be incentivized and supported to build an infrastructure that bolsters services and social growth at the community level.

3) Climate Change

Climate volatility — including prolonged droughts, flooding, and temperature extremes — are threatening the current and future productivity of US agricultural production. The 2018 Fourth National Climate Assessment[30] identified two key impacts of climate change on US agriculture as:

(1) Reduced US agricultural productivity.
(2) Degradation of US soil and water resources.

Figure 9



Projected increases in number of days over 90°F between now and 2090 according to two climate change scenarios. Even in the less severe RCP 4.5 scenario, there will be many more 90-degree days in important farm states such as Iowa, Missouri and Kansas. Map source: EPA report.[31]

Changing precipitation and temperature patterns will lead to increasing incidents and more severe droughts, floods, and temperature extremes, and will also contribute to rising pest, disease and weed management outbreaks.

In adapting to climate change, US producers need more climate-resilient crops and livestock, and more climate-resilient cropping systems that better utilize farmland and other inputs. They also need technologies that enable enhanced conservation of limited resources like water and topsoil without limiting productivity as well as new innovations in food production that mitigate the risk of weather extremes.

Emerging Technologies to Address Challenges

Three AgTech innovations – artificial intelligence (AI) including agricultural robotics, controlled environment agriculture (CEA), and gene editing (e.g. CRISPR) – have great potential for solving the problems of nutrition security, rural livelihoods, farm profitability, and climate change mitigation. While other innovations, such as sustainable packaging, quality control automation, and waste-reducing and climate-friendly operations, could enhance the entire agricultural supply chain, the advancement of these three technologies have the greatest potential for transformative change of the US food chain.

1) Artificial Intelligence Including Robotics

A broad spectrum of Artificial Intelligence (AI) and robotic applications, from automation to generative AI, will have great transformative impacts and affect all new technologies in agriculture.

Artificial intelligence (AI) allows machines to mimic human intelligence by acting upon information gathered in the process of executing tasks or making decisions and it spans multiple disciplines and application areas essential to agricultural production. AI in agriculture has progressed naturally out of the advancement of data collection and analytics in agriculture (i.e. digital agriculture).

How Artificial Intelligence Solves Key Agricultural Challenges

A general-purpose technology that fosters a wide range of innovations, AI enables innovation across almost every aspect of agriculture production, helping to solve numerous challenges including:

- Speeds up modeling used for breeding more climate-resilient crops and livestock.
- Rapidly analyzes vast data-bases of information, identifying new modes of action in chemical and biological processes useful for agriculture.
- Combines historical crop and soil data with real-time information such as satellite imagery and field sensors to help farmers know the most resource-effective time and to deploy the most effective tools to conduct tasks such as irrigation, fertilization, and pesticide application.
- AI-enabled autonomous machinery, including driverless tractors and robotic farm implements, can perform routine tasks at high-levels of precision, offsetting high labor costs and mitigating farm labor shortages.
- Generative AI can be used to facilitate agronomic education helping solve grower challenges leading to increased crop yields and quality and increased farm profitability.
- Can be used to prevent health and disease outbreaks in livestock production, ensuring a safer and more reliable supply of meat and dairy products while reducing producers' veterinary costs and improving animal productivity.
- Forecast inventory management, preventing supply chain disruptions and reducing food waste, benefits that help keep food affordable and accessible.

The Current State of Artificial Intelligence and Agricultural Robotic Adoption and Future Challenges

Artificial intelligence (AI) has already been deployed for at least a decade in agricultural product development and services, used for modeling of advanced breeding of crops and live-

stock, precision spraying and irrigation, and satellite-based information governing in-season agronomic responses. AI is used extensively in academic and private sector agricultural R&D, enabling faster and much more comprehensive analysis of datasets, particularly in genetics where enormous data sets must be explored to find traits that are of interest for breeding. Additionally, particularly in specialty crop production, high labor costs, and a lack of labor is driving the rapid adoption of AI-enabled automation for labor-intensive tasks such as weeding, thinning plants, and the harvest and transportation of crops.

The sheer complexity of Big Data in agriculture and the lack of legal and common operational frameworks, however, has impeded integration and poses a challenge to the most effective future use of AI in agriculture. In addition, farmer and consumer concerns pose a risk that the use of AI in agriculture will be constrained. Questions linger over requirements and liabilities related to data ownership and privacy, particularly when a mix of public and private entities are sharing data. Additional barriers include cybersecurity attacks (e.g. computer hacking of food system functions) and data interoperability (silos) between systems, entities, and institutions.

While growers are generally favorable to many aspects of AI on their farm, such as task automation, farmers remain skeptical of the accuracy of next-generation AI functions such as generative AI, and are concerned about the privacy of their data. Farmers and ranchers question how their data will be used, who will see it, and who profits from it? Farmers are also distrustful of the safety and efficacy of autonomous tractors and implements. Who is liable in the event of an error that impacts crop production or jeopardizes human safety? Additional barriers to AI integration from the grower perspective include high adoption costs and the lack of high-speed wireless networks in rural areas.

Consumers have a high awareness of what AI and automation is (unlike gene editing and CEA), but also have a general distrust of AI, a byproduct of their experience with AI in other industries and well-publicized failures, such as ChatGPT making up fictitious court cases.[32] The public is wary of how their personal food decisions and purchase data are collected, used, and monetized. They are also concerned that AI decisions will favor morally unethical choices, either by design or through unconscious bias incorporated in AI systems. What prevents AI from sacrificing environmental resources for high yields? Or favoring 'Big Ag' over smaller, less tech-enabled farmers? The elimination of agricultural jobs due to AI-enabled automation (ag robotics) is also a well-cited public concern.

2) Controlled Environment Agriculture

CEA is a set of application tools in which part, or the entire, process of plant growth occurs in an environment wholly or partially sheltered from the environment.

For the purposes of this paper, CEA applications concentrate on crops grown in 'soilless' environments, eliminating the need for arable land for crop production. Examples include high-tech glass greenhouses (permanent, glass-covered structures with climate control that may be combined with artificial light) and vertical farms or indoor farms (wholly indoor production systems with total climate control, including complete light control using artificial lights and with plant-growing structures typically stacked vertically for dense configuration).

How CEA Solves Key Agricultural Challenges

As an alternative to the traditional outdoor production for food products, without the need for soil, CEA solves multiple food issues prevalent in agriculture, including:

- Ensures food production despite climate extremes.
- Conserves water, especially for heavily water dependent crops such as salad greens, berries, and fresh vegetables, and in highly water-scarce regions.
- Unlocks new opportunities for food production in environments previously not conducive to growing food, such as urban areas or in regions where weather extremes have made agricultural production unsustainable.
- Increases productivity while reducing resource use through the use of automated, precision-controlled growing systems.
- Mitigates the risk of global supply chain disruptions impacting food availability by allowing localized food production.
- Is a reliable, year-long source of highly nutritious, but perishable, seasonal crops such as salad greens, tomatoes or berries, improving consumer accessibility to nutrient-dense, healthy food sources.
- Reduces the transportation cost and fossil fuel impact of transporting food.
- Creates new, high-skilled jobs in horticulture, technology, software, engineering, marketing, and sales.

The Current State of CEA Adoption and Future Challenges

CEA adoption is experiencing two simultaneous trends and sectors: (1) a mature, multi-billion dollar, hi-tech glass greenhouse value chain and sector reaching its peak of technological innovation, and (2) an emerging, early-stage vertical ag/indoor farm sector dependent on artificial light control. In the former, unit costs of production enable reasonable prices for today's consumer, whereas in the latter case high unit costs are a barrier to adoption, at least in part due to the very large energy requirement.

In the United States, a period of hype and investment in CEA startups began in 2016, resulting in nearly $6 billion invested. However, early investor support imploded in 2022 with a series of high-profile bankruptcies, lay-offs, and company closures. Early stage, tech-focused investors who anticipated emerging value in CEA hardware innovations were not prepared for the steep capital intensity of scaling production facilities. Promises of 100-times productivity gains, 'Farmer-in-the-Cloud' (FaaS) and robotic crop management innovations have yet to emerge as functional and economically-viable solutions. Combined with a downturn in the economy, higher interest rates, and rising energy costs, CEA operations in both greenhouse and vertical/indoor farm categories are struggling to raise capital despite growing demand for indoor-grown crops like tomatoes and leafy greens.

Despite high profile CEA failures in the United States, there are market indicators pointing to clear signs of future potential. Successful indoor farm operations have been established in Canada, Japan, and Singapore. Additionally, new funding opportunities are emerging for CEA projects in the Middle East and Asia.

To support CEA adoption, consumers need to clearly understand the benefits of CEA-grown food products, including improved sustainability, longevity, taste, dependability, and regional food security as well as the industry must continue to innovate to address the remaining major hurdle associated with high energy costs. Differentiating CEA-grown versus traditionally-grown foods in the marketplace will help CEA operators build relationships with retailers and create value in the category.

3) Gene Editing

Gene editing and other genetic innovations are key to optimizing production using less water, land, and pesticides while ensuring a product that is resistant to drought, pests, and other biotic and abiotic risks.

Gene editing is a method of selective breeding that allows for precise DNA changes in plants or animals by removing or altering existing genetic material. Gene editing is different from genetic modification (GM), or transgenic technology, which introduces DNA from a different organism into the genetic code of a plant or animal, because it only works within an organism's existing genetic structure.

Multiple methods[33] can be used for gene editing, but iterations of CRISPR-based technologies offer the most potential for rapid agricultural innovation as they are faster, less expensive, and more reliable than other methods of genetic modification.

How Gene Editing Solves Key Agricultural Challenges

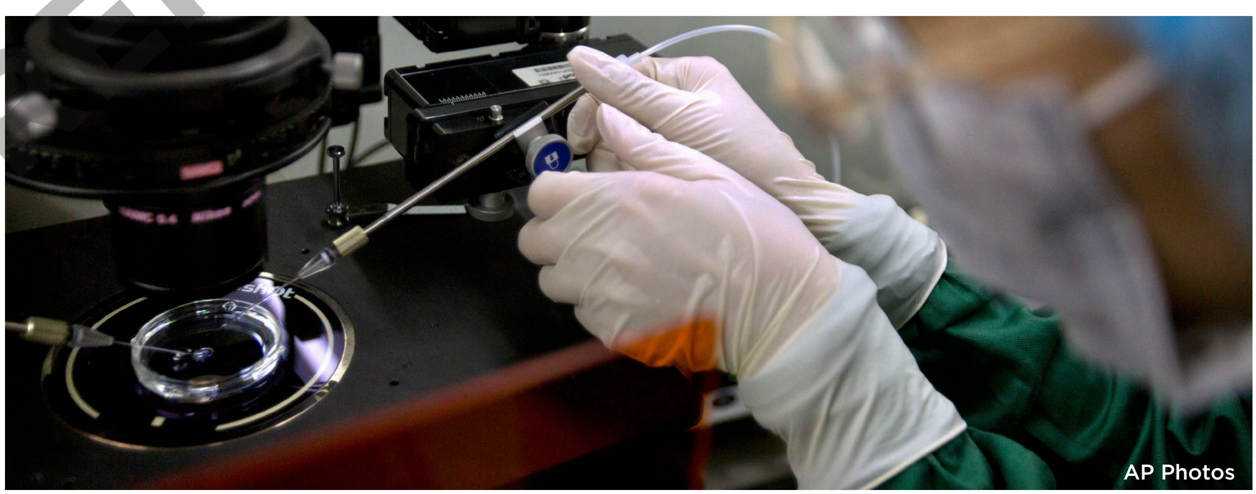
- Gene editing offers multiple pathways to solving agricultural challenges including:
- Plant cultivars and livestock that are more resilient to abiotic stresses such as drought or extreme temperatures.
- Improved resistance to diseases and pests.
- Increased productivity by enhancing photosynthetic ability in plants or feed to weight gain conversion processes in livestock.
- Improved nutrient value in crops.
- Increased flavor, palatability, and storage life of food products.

The Current State of Gene Editing Adoption and Future Challenges

The current state of integration of gene editing in US agriculture has been impacted by regulatory policy as well as public confusion about the process of gene editing and a conflation of gene editing with genetic engineering (transgenic) biotechnology.

In the United States, gene editing is regulated by a Coordinated Framework structure consisting of three agencies: the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA) and USDA. The Coordinated Framework is tasked with ensuring the human health and environmental safety of biotechnology products in plants, animals, and food products. Set up in 1986, before the advent of genetic engineering, the Coordinated Framework structure[34] has been widely criticized for not being applicable to genetic engineering or gene editing technologies, creating a regulatory framework that is expensive and difficult for technology providers to navigate.

In 2018, USDA announced[35] they would not regulate gene-edited plants if the end product "does not regulate or have any plans to regulate plants that could otherwise have been developed through traditional breeding techniques as long as they are not plant pests or developed using plant pests," accelerating market commercialization of gene edited plant-based foods. In animal production, however, gene editing has not been separated from genetically engineered (transgenic) processes and is still tightly regulated under the auspices of the FDA.


AP Photos

In June 2023,[36] EPA announced that it will, like USDA, exempt gene-edited plants with changes that could be achieved through conventional breeding from an in-depth review. However, for all plants gene-edited to resist pests and pathogens, the agency will require developers to submit data showing the plants will not harm humans or the ecosystem. Industry experts worry this new rule could slow innovation and discourage conventional breeders from adopting gene-editing.

A quagmire of international regulations governing genetically modified and gene edited food products have also conspired to dampen US integration of gene edited crops under the concern that gene edited crops may face export restrictions. In 2018, the European Union (EU) issued a ruling that gene edited plants would fall under the same laws governing transgenic plants. However, a proposal[37] to deregulate gene edited crops was introduced in the EU in July of 2023.

Opponents of genetically modified crops have confused the public on the difference between genetic engineering and gene editing. For instance, the Non-GMO Project argues that gene edited crops or animals are fundamentally no different than genetically engineered (transgenic) food products, posing potential health and environmental risks. The consumer backlash against genetically engineered (transgenic) crops has dampened and continues to threaten the potential of securing, and maintaining, social license for gene editing in US agricultural production.

Case Study: Pairwise Conscious™ Greens

Transparency and Appealing to Consumer Desires to Build Trust in AgTech Innovation

Pairwise is a food and ag startup that uses gene editing to build new crop varieties. In 2022, Pairwise launched 'Conscious™ Foods,' a consumer-focused brand with a commitment to public-facing transparency and education about the process and benefits of gene editing.

Pairwise's market research indicated that while the majority of the US public does not know much about gene editing, when they are given information they tend to view gene editing positively and that public perceptions are shifting toward a more positive view of new technology in food. This is especially true of younger adults. A Pairwise consumer survey showed that 77% of Gen Z adults are "likely to try food grown with technology."

Pairwise Consumer Field Tests

In the summer of 2022, Pairwise participated in public events in Seattle, Washington, Palo Alto, California, and Austin, Texas. They served over 6,000 samples of a salad blend developed using gene editing to improve flavor while retaining high levels of nutrition and freshness. In addition to samples, consumers were given information via brand ambassadors, booth signage and access to QR codes for additional information about how gene editing was used to develop the salad mix.

Result: Out of more than 3,000 consumer surveys completed after eating a salad less than one percent of respondents indicated anything negative about the use of gene editing or technology in food. Some survey respondents noted they were enthusiastic about finally being able to taste foods developed using gene editing technology.

The Pairwise experience shows that transparent, clear communication about how technology is used in food production to directly benefit consumers is an effective way to generate trust and gain social license for technological innovation. As the company moves the salad greens toward retail stores, the Conscious™ Greens packaging contains a voluntary icon that reads, "Better Flavor by CRISPR" in addition to QR codes that helps consumers learn more, noting that 79 percent of produce buyers want more information on gene edited produce.

Policy Recommendations

The food system is multi-layered and complex, with numerous and overlaying touch points of economic, societal, and environmental impacts. "Fixing" the food system by means of accelerated AgTech innovation is thereby similarly complex, requiring a harmonization of messaging and the building of alliances across the industry, including public, private, and academic stakeholders.

The following policy recommendations aim to break-down barriers and solve issues between consumers and farmers for the advancement of a more sustainable food supply. These recommendations are meant to be actionable, leaning into current public initiatives and private sector momentum, and to identify key stakeholders and partners for the purposes of building a groundswell of support for AgTech innovation as a pathway to a more resilient and sustainable food system.

Calls to Action

1) Increase Public & Private R&D Funding for Climate-Smart AgTech Solutions

With a long, often multiple decade, lag-time between the onset of R&D investments and eventual productivity gains, the amount invested today in AgTech innovation, including both public and private investments, will chart the course of future productivity. To bolster struggling innovation, the public and private sectors must increase R&D investment levels.

- **Increase Investment into the Climate-Smart Commodities Initiative.** In 2022, the Biden administration allocated $3.1 billion to 141 selected public and private projects under the USDA's Partnerships for Climate-Smart Commodities,[38] an initiative to expand markets for US-grown climate-smart commodities and support climate-smart commodity production. Additional financial commitment will ensure these projects come to fruition and the impacts of successful projects can be expanded.

- **Making Funding Agricultural Research a Priority in Farm Bill Updates.** The Farm Bill is reauthorized every five years and includes funding appropriations, generating opportunities for new R&D funding commitments for agricultural research at land-grant universities and other public sector institutions. For funding priorities specific to the 2023 Farm Bill reauthorization see the joint report from the Chicago Council on Global Affairs and the Farm Journal Foundation entitled *Prioritizing Agricultural Research in the 2023 Farm Bill.*

2) Modernize Agricultural Agencies in Preparation for Technological Innovation and Consumer Expectations for Tranparency

For the food industry and agriculture to be most effective, US regulatory agencies governing agriculture must be able to keep up with the pace of innovation. Agency and regulatory processes not structured to accommodate the rapid pace of technological development delay and even prevent AgTech innovation. A clearly communicated regulatory and agency framework that is predictable and efficient is a crucial component of gaining social license for innovation adoption and inspiring R&D investment and entrepreneurship.

- **Coordinated Framework for Consistent Policy Formation Among Agricultural Governing Agencies.** A coordinated framework among all regulatory bodies overseeing food and agriculture is critical for ensuring consistency. Commit and build an infrastructure for innovation based on a shared set of principles, developed and applied across all regulatory agencies governing food and agriculture, including EPA, FDA, and USDA.

- **Reverse EPA's regulatory decision on gene editing.** EPA's recent gene editing regulatory announcement is inconsistent with USDA's exemption on gene-edited plants. EPA's regulatory decision will stifle innovation, decrease competition, and make commercialization of gene edited products possible only for companies with significant resources. By disproportionately impacting small- and medium-sized entities – particularly in fruits, vegetables, and other small acreage crops – EPA's burdensome regulations will more directly impact these companies as well as public sector scientists working to develop innovative crops. The new regulation will unintentionally limit the diversity of choices available to farmers and limit the overall utility of these critical tools. Congress should reassess and potentially reverse EPA's decision on gene editing regulations.

- **Keep Agriculture at the Table For Regulatory Discussions.** Agriculture needs to be at the table for regulatory discussions that can impact agricultural innovation, for instance, AI regulations. In 2020, the National Science Foundation and USDA's National Institute of Food and Agriculture established seven new AI institutes across America to accelerate research into AI.[39]

3) Harmonize Data Standards to Build Grower and Consumer Trust

Unlocking the promise of AI in agriculture needs regulatory attention to data privacy. Farmers who give up data will need to be protected from predatory practices and legal liabilities while opportunities for data sharing will need to be preserved. Consumers need to be able to trust that their food purchase data will be used responsibly.

- **Explore Data Sharing.** Explore the use and feasibility of a data repository for AgTech stakeholders similar to Figshare,[40] an online open access platform for sharing academic research. Figshare includes a structure of community best practices, standards for persistence, provenance and discoverability while maintaining the ability to share multiple types of files and research documents and ensure work is properly cited and credited.

- **Leverage the Climate Smart Initiative to Develop Data Standards**. The ongoing Climate Smart Initiatives creates an opportunity for the USDA to spearhead the development of new ag-focused data standards, creating a structure that supports the sharing of data and creates value between public agencies, NGOs and private sector partners.

- **Establish Structure for Voluntary Data Use.** Agricultural data is fragmented and not easily accessible, and will need to be FAIR (findable, accessible, interoperable, reusable) to be able to be useful. The Foundation for Food and Agriculture Research[41] is exploring ways to establish a voluntary data use rights structure for agriculture that would apply in both the public and private sectors.

4) Advance Legislation Providing Financial Support to Accelerate Farmer Tech Adoption

Legislative efforts supporting AgTech innovation have already been made but are languishing in the political process. Stalled legislation should be reviewed and a new multi-stakeholder effort made to influence their adoption.

- Support the Precision Loan Act. The Precision Loan Act[42] was introduced in 2021 to the US Senate by Senators Deb Fischer (R-NE) and Amy Klobuchar (D-MN). The bill would allocate financing for precision agriculture technology, making technology and climate mitigation more accessible to farmers. Farmers could also "retrofit existing equipment with new technology," helping to reduce overall waste. A twin bill was introduced to the US House in March of 2023 by Representatives Jimmy Panetta (D-CA) and Randy Feenstra (R-IA).

5) Multi-Stakeholder Commitment Increasing Transparency and Education to Consumers About Tech Innovation in Food Production

Generating consumer trust, i.e., consumer social license, in AgTech innovations requires an ongoing, multi-stakeholder and multi-layered approach, including committed efforts from public agencies, NGOs, academia, industry groups, innovation developers, agribusinesses and food manufacturers. All stakeholders in the food system have a critical role with educational outreach and transparency to the public about AgTech innovation, focusing on the benefits that engage consumer interest and trust.

- Develop a Sustainable Food Seal. A "sustainable food seal" standardizing a food product's eco-score and using comparable metrics involving all parts of the food value chain – from farm to fork – would reduce consumer confusion, build transparency and offer the opportunity to validate practices and empower stakeholders to support a more sustainable food supply chain. For more information on recommendations specific to the sustainable food seal, see the Chicago Council on Global Affairs report entitled *Bridging the Gap: A Sustainable Food Seal.*

Conclusion

Food is a basic necessity of life and the ability to grow food is a foundational element of human civilization. Thanks to innovation, US growers have been phenomenally successful in increasing food productivity rates, especially in the past 100 years. But between climate change and growing global populations, the US and global agricultural systems face unprecedented challenges jeopardizing food production. The planet's resources are finite. We must find ways to use those resources more efficiently and sustainably.

Globally there is building momentum up and down the food value chain, from farmers to consumers, in support of practices growing more, healthier food while conserving critical resources and reducing the environmental footprint of agriculture.

Technology innovation offers a clear and proven pathway to achieving the goals of agricultural sustainability and resiliency. But change does not happen in a bubble. Developing, adopting, and integrating AgTech innovation requires a complex set of stakeholders and systems built to support and facilitate new technologies. Farmers will need to be incentivized to adopt new technologies, and consumers need to be able to trust that innovations will be safe and beneficial for them, as well as the community and ecosystem in which they live.

While we have barely skimmed the surface of the complexity of AgTech innovation, the recommendations generated from this paper are designed to help generate momentum for bridging the gap between food producers' needs for better solutions and consumers' trust in the food supply, and for ensuring the integration of AgTech innovation for a more sustainable and resilient future food system.

Endnotes

1 Hatfield, Jerry, and Gene Tackle. "Agriculture." National Climate Assessment. Accessed October 30, 2023. https://nca2014.globalchange.gov/report/sectors/agriculture.

2 "Close to 90 Percent of U.S. Consumers' Food and Beverage Spending Is for Domestically Produced Products." USDA ERS - Chart Detail, 2018. https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=88950#:~:text=In%202016%2C%2087.3%20percent%20of,Chile%20or%20wines%20from%20France.

3 "Agricultural Trade." USDA ERS - Agricultural Trade, May 8, 2023. https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/agricultural-trade/#:~:text=The%20leading%20U.S.%20agricultural%20exports,are%20major%20U.S.%20trade%20partners.

4 Graziano Da Silva, José. "Feeding the World Sustainably." UN Chronicle, June 2012. https://www.un.org/en/chronicle/article/feeding-world-sustainably#:~:text=According%20to%20estimates%20compiled%20by,toll%20on%20our%20natural%20resources

.5 "The Future of Water: Water Insecurity Threatening Global Economic Growth, Political Stability." Global Trends 2040. Accessed October 31, 2023. https://www.dni.gov/index.php/gt2040-home/gt2040-deeper-looks/future-of-water.

6 "U.S. Water Supply and Distribution Factsheet." Center for Sustainable Systems, 2023. https://css.umich.edu/publications/factsheets/water/us-water-supply-and-distribution-factsheet#:~:text=Agriculture%20accounts%20for%20the%20largest,total%20U.S.%20consumptive%20water%20use).&text=Of%20the%20118%20Bgal%2Fd,is%20lost%20to%20consumptive%20use.

7 "Water in Agriculture." World Bank, October 2022. https://www.worldbank.org/en/topic/water-in-agriculture.

8 "The Number of U.S. Farms Continues Slow Decline." USDA ERS, March 2023. https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=58268.

9

10 "World Agricultural Output Growth Continues to Slow, Reaching Lowest Rate in Six Decades." USDA ERS - World Agricultural Output Growth Continues to Slow, Reaching Lowest Rate in Six Decades, 2023. https://www.ers.usda.gov/amber-waves/2022/december/world-agricultural-output-growth-continues-to-slow-reaching-lowest-rate-in-six-decades/.Clancy, M. "Is Technological Progress in US Agriculture Slowing?" Artificial Intelligence in Science : Challenges, Opportunities and the Future of Research. Accessed October 31, 2023. https://www.oecd-ilibrary.org/sites/43d900ce-en/index.html?itemId=%2Fcontent%2Fcomponent%2F43d900ce-en.

11 Munch, Daniel. "2023 USDA Farm Income Forecast Erases 2022 Gains." American Farm Bureau Federation,

2023. https://www.fb.org/market-intel/2023-usda-farm-income-forecast-erases-2022-gains.
12 Moore, Terri. "Public Attitudes about Farmers and Farming: A Golden Opportunity." American Farm Bureau Federation, January 2020. https://www.fb.org/focus-on-agriculture/public-attitudes-about-farmers-and-farming-a-golden-opportunity#:~:text=Farmers%20enjoy%20one%20of%20the,leaders%20in%20the%20retail%20sector.
13 "A Dangerous Food Disconnect." Food Integrity. Accessed October 31, 2023. https://www.foodintegrity.org/wp-content/uploads/2018/01/CFI_Research_8pg_010918_final_web_REV2-1.pdf.
14 "Bridging the Food Trust Gap: College of Food, Agricultural and Natural Resource Sciences." University of Minnesota College of Food, Agricultural and Natural Resource Sciences, March 3, 2022. https://cfans.umn.edu/news/bridging-food-trust-gap.
15 "Monsanto's Genetically Engineered Wheat Scandal Is No Surprise." Forbes, June 5, 2013. https://www.forbes.com/sites/forbesleadershipforum/2013/06/05/monsantos-genetically-engineered-wheat-scandal-is-no-surprise/?sh=68ed9f601ea8.
16 "McDonald's Isn't Loving Simplot's GMO Potato." The Lewiston Tribune, November 16, 2014. https://www.lmtribune.com/northwest/mcdonalds-isnt-loving-simplots-gmo-potato/article_91c7f55e-cda1-5fa9-8292-cde572331cbc.html#:~:text=%22McDonald%27s%20USA%20does%20not%20source,called%20the%20%22Innate%22%20potato.
17 Candelon, François, Rodolphe Charme di Carlo, and Steven Mills. "Why AI Needs a Social License." BCG Global, February 22, 2023. https://www.bcg.com/publications/2022/why-a-social-license-is-needed-for-artificial-intelligence.
18 "Corn, Soybeans Accounted for More than Half of U.S. Crop Cash Receipts in 2022." USDA ERS, August 31, 2023. https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=76946.
Nielsen, R.L. (Bob). "Historical Corn Grain Yields in the U.S." Corny News Network, February 2023. https://www.agry.purdue.edu/ext/corn/news/timeless/yieldtrends.html.
19
20 Clancy, M. "Is Technological Progress in US Agriculture Slowing?" Artificial Intelligence in Science : Chal lenges, Opportunities and the Future of Research. Accessed October 31, 2023. https://www.oecd-ilibrary.org/sites/43d900ce-en/index.html?itemId=%2Fcontent%2Fcomponent%2F43d900ce-en.
21 Njuki, Eric. "A Look at Agricultural Productivity Growth in the United States, 1948-2017." USDA, March 5, 2020. https://www.usda.gov/media/blog/2020/03/05/look-agricultural-productivity-growth-united-states-1948-2017#:~:text=Agriculture%20stands%20out%20among%20U.S.,almost%20none%20of%20output%20growth.
22 Klümper, Wilhelm, and Matin Qaim. "A Meta-Analysis of the Impacts of Genetically Modified Crops." U.S. National Library of Medicine, November 3, 2014. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4218791/.
23 Njuki, Eric, Jonathan McFadden, and Terry Griffin. "Precision Agriculture in the Digital Era: Recent Adoption on U.S. Farms." USDA ERS, February 2023. https://www.ers.usda.gov/publications/pub-details/?pubid=105893.
24 Fiocco, David, Vasanth Ganesan, Maria Garcia de la Serrana Lozano, and Hussain Sharifi. "Agtech: Breaking down the Farmer Adoption Dilemma." McKinsey & Company, February 7, 2023. https://www.mckinsey.com/industries/agriculture/our-insights/agtech-breaking-down-the-farmer-adoption-dilemma#/.
25 Nelson, Kelly P., and Keith Fuglie. "Investment in U.S. Public Agricultural Research and Development Has Fallen by a Third over Past Two Decades, Lags Major Trade Competitors." USDA ERS, June 6, 2022. https://www.ers.usda.gov/amber-waves/2022/june/investment-in-u-s-public-agricultural-research-and-development-has-fallen-by-a-third-over-past-two-decades-lags-major-trade-competitors/.
26 "Agfunder Global AgriFoodTech Investment Report 2023." AgFunder, 2023. https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2023/?download=true.
27 "Key Statistics & Graphics." Food Security in the U.S., October 25, 2023. https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-u-s/key-statistics-graphics/.
28 "Only 1 in 10 Adults Get Enough Fruits or Vegetables." Centers for Disease Control and Prevention, February 16, 2021. https://www.cdc.gov/nccdphp/dnpao/division-information/media-tools/adults-fruits-vegetables.html.
29 Njuki, Eric, Jonathan McFadden, and Terry Griffin. "Precision Agriculture in the Digital Era: Recent Adoption on U.S. Farms." USDA ERS, February 2023. https://www.ers.usda.gov/publications/pub-details/?pubid=105893.
30 Olson, Carolyn, Tracey Farrigan, Michael A Grusak, and Mark Boggess. "Fourth National Climate Assessment: Chapter 10: Agriculture and Rural Communities." NCA4, 2018. https://nca2018.globalchange.gov/chapter/10/.
31 "Climate Change and Agriculture." Union of Concerned Scientists, March 20, 2019. https://www.ucsusa.org/resources/climate-change-and-agriculture.
32 Brodkin, Jon. "Lawyers Have Real Bad Day in Court after Citing Fake Cases Made up by Chatgpt." Ars Technica, June 23, 2023. https://arstechnica.com/tech-policy/2023/06/lawyers-have-real-bad-day-in-court-after-citing-fake-cases-made-up-by-chatgpt/#:~:text=Lawyers%20fined%20%245K%20and,chatbot%20%22gibberish%22%20in%20filings.&text=A%20federal%20judge%20tossed%20a,intelligence%20tool%20made%20by%20OpenAI.
33 "CRISPR in Agriculture." CRISPRpedia, May 16, 2023. https://innovativegenomics.org/crisprpedia/crispr-in-agriculture/.
34 "About the Coordinated Framework." The Unified Website for Biotechnology Regulation. Accessed October 31, 2023. https://usbiotechnologyregulation.mrp.usda.gov/biotechnologygov/about/about.
35 "Secretary Perdue Issues USDA Statement on Plant Breeding Innovation." USDA. USDA, March 28, 2018. USDA. https://www.usda.gov/media/press-releases/2018/03/28/secretary-perdue-issues-usda-statement-plant-breeding-innovation.
36 Stokstad, Erik. "EPA Decision to Tighten Oversight of Gene-Edited Crops Draws Mixed ..." Science, June 2, 2023. https://www.science.org/content/article/epa-decision-tighten-oversight-gene-edited-crops-draws-mixed-response.

37 “European Green Deal: More Sustainable Use of Plant and Soil Natural Resources.” European Commission, July 5, 2023. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/IP_23_3565.
38 “Partnerships for Climate-Smart Commodities.” USDA. Accessed October 31, 2023. https://www.usda.gov/climate-solutions/climate-smart-commodities.
39 Peppers, Faith. “USDA-NIFA and NSF Establish Nationwide Network of Artificial Intelligence Research Institutes.” National Institute of Food and Agriculture, August 26, 2020. https://www.nifa.usda.gov/about-nifa/press-releases/usda-nifa-nsf-establish-nationwide-network-artificial-intelligence#:~:text=Learn%20more%20about%20the%20USDA,discoveries%20that%20solve%20societal%20challenges.
40 “About Figshare.” Figshare. Accessed October 31, 2023. https://knowledge.figshare.com/about.
41 “About FFAR.” Foundation for Food & Agriculture Research, December 8, 2022. https://foundationfar.org/about/?gclid=CjwKCAjw5_GmBhBIEiwA5QSMxDPW2OQ44x5-d7rHspXCzW2sDQ09enZWVq3B8TRxsFft-a-4ZU_QoxoCPysQAvD_BwE.
42 “Klobuchar, Fischer Introduce Bill to Expand Farmers’ Access to Precision Agriculture Equipment, Climate-Friendly Technologies.” U.S. Senator Amy Klobuchar, September 17, 2021. https://www.klobuchar.senate.gov/public/index.cfm/2021/9/klobuchar-fischer-introduce-bill-to-expand-farmers-access-to-precision-agriculture-equipment-climate-friendly-technologies.

Acknowledgements

The Chicago Council convened a Roundtable on AgTech Adoption on June 26, 2023, to bring together groups representing consumers, farmers and AgTech innovators to deepen understanding of how to accelerate AgTech adoption on US farms and throughout the agricultural supply chain, including current consumer expectations and perceptions of trust and regulatory and economic barriers. We identified areas of opportunity, considered how policy and private sector actions can be unified to support AgTech integration and proposed recommendations for actionable steps forward for stakeholders. We thank the Center on Global Food and Agriculture Advisory Board members Francesca DeBiase, Sally Rockey, and Paul Schickler for serving as Co-Chairs for the Roundtable.

The Chicago Council would also like to thank the following individuals who participated in the Roundtable discussions: Mary Boote, Chief Executive Officer, Global Farm Network; Brett Brohl, Managing Partner, Bread and Butter Ventures; Suresh DeCosta, Director of Food Safety, Lipman Family Farms; Vonnie Estes, Vice President of Innovation, International Fresh Produce Association; Sarah Davidson Evanega, Director, Stakeholder Engagement, Pairwise; Marco Ferroni, Chairman, Vertical Future; Jennifer Goldston, Founder and CEO, AgTech PR; Neal Gutterson, Partner & Chief Technology Officer, Radicle Growth; Aimee Hood, Head of Regulatory and Scientific Engagement, Bayer Crop Science; Rob Larew, President, National Farmers Union; Steve Marshall, Global Engineering and Data Sciences Leader, Vice President, Cargill Research and Development; Raina Nelson, President and CEO, Westfalia Fruit North America; Philip Pardey, Professor of Science and Technology Policy, University of Minnesota; Garland Perkins, Senior Manager of Innovation and Sustainability, Oppenheimer Group; Chris Samuel, Head of Global Communications, U.S. Soy; Kevin Schwartz, Chief Executive Officer, Managing Partner, Paine Schwartz Partners; Shari Westerfeld, Vice President U.S. Sustainability Customer Engagement, Zoetis; and Peggy Tsai Yih, Managing Director of the Center on Global Food and Agriculture, Chicago Council on Global Affairs.

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