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The Impact of Technology In Farming

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Abstract: *Assorted challenges are currently facing the global farming industry. Varying market demands, excessive cultivation of land, yield decreases due to pestilences, higher costs for production, and limited market access are a few challenges farmers are confronted with daily. Certain challenges (such as less than optimal soil management due to monocropping) are created by farming methodologies that can be modified by the farmer at relatively minimum changes to inputs and input costs. However, other challenges require the use of either new technologies or a greater implementation of technology based solutions in order to sufficiently address issues. This article discusses the growing significance of technology use in meeting current and future agricultural industry requirements and challenges.*

Keywords: *Agriculture, Technology, Supply Chain*

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I. INTRODUCTION

Food sustainability is critical for the safety and long term well being of any society. In relation to societal security, the agriculture industry within any civilization is critically important. Agricultural security involves, two categories of activities:

1. Activities necessary for attaining and sustaining adequate levels of food provision to meet the needs of the communities being served.
2. Activities required to protect the food supply.

Various implementation of different types of technology to address agricultural safety, security, and sustainability in the area of farming has increased noticeably. The level of knowledge of farmers in the area of food safety issues has also increased concurrently. Some observers might identify this as a metric for identifying the level of safety of food provided to those communities. Public health concerns, as they are related to food supply can focus on varying potential threats such as: proper nutrition, food shortage, diseases spread by food, and warfare using a society's food and water supply as a primary target for attack. The use of technology for normal activities by farmers and food handlers in order to address concerns, enhance quality, increase production, and increase safety is the focus of this article. One such example is using traceability technology as a means for monitoring food within various agricultural supply chains. However, there are many other examples. The remainder of this article discusses the intersection of the agriculture industry and technology, the current impact of technology on the industry, and potential impacts moving forward.

II. AGRICULTURE AND TECHNOLOGY

In an article on its webpage, the Bayer Group composes a timeline of the evolution of crop management, the implementation of technology in agriculture, and crop manipulation. Learning the evolution of farming promotes better activity within the research project such as: evoking questions that improve data collection and technology implementation, orchestrate deliverables and public dissemination.

In the 2000s, software and mobile devices became more prominent in helping farmers have better harvest. The Bayer Group states:

"Like many people, farmers started carrying mobile devices, which allowed them to stay connected to colleagues while in the field. This also meant they now had access to data needed while on-the-go, including the ability to place orders for seed or fertilizer at any time or in any place" (Technology In Agriculture, 2023).

The average age of a farmer ranges from 46 to 50 years old. After so many years of farming, overtime they may experience pains or aches within their body due to so many years of manual labor. The implementation of technology and/or mobile devices allows farmers to reduce the amount of manual labor they would need to do in order to gather feasible data and make proper adjustments within their crops if they need to.

Data is a key component when it comes to effective farming. Data will allow farmers to determine the number of crops they have, the progress of each crop, inventory, crop location, crops that have been harvested, etc.. As agriculture has advanced, engineers have produced technology that will be conducive to agriculture business. In 2015, data had revolutionized farming potential. The Bayer group states:

"Farmers make decisions based on the information they have on-hand, which is why data has helped them harness the power of information to make better-informed decisions that allow them to use resources more sustainably. The Climate Corporation's Climate FieldView™ platform is a digital platform that brings together data collection, agronomic modeling, and local weather monitoring, which gives farmers a better understanding of their fields. These tools allow farmers to plan for better harvests and make decisions that are better for the planet" (Technology In Agriculture, 2023).

The next section explains different ways in which technology has affected the farming industry.

III. SPECIFIC EXAMPLES OF TECHNOLOGY'S IMPACT ON THE FARMING INDUSTRY

Evolution of farming has played a big role in farming from mitigating ergonomic issues older farmers may face and may making it easier keep track of everything that is happening in your farm just by the touch of your device. In an article titled, "5 Ways Technology Is Changing Agriculture", Rebekah Shields details several ways technology has helped changed agriculture.

Online resources are the first change presented in the article. Shields states:

"The proliferation of internet technology has dramatically offered farmers unprecedented access to a wealth of valuable resources and tools to make farming easier. Notably, the internet has innumerable production and planning tools to help them forecast future crops. Additionally, the World Wide Web provides several farming forums that let them exchange ideas seek advice and participate in insightful discussions. These forums offer robust support groups that can help farmers without ever setting foot on the farm" (Shields, 2019).

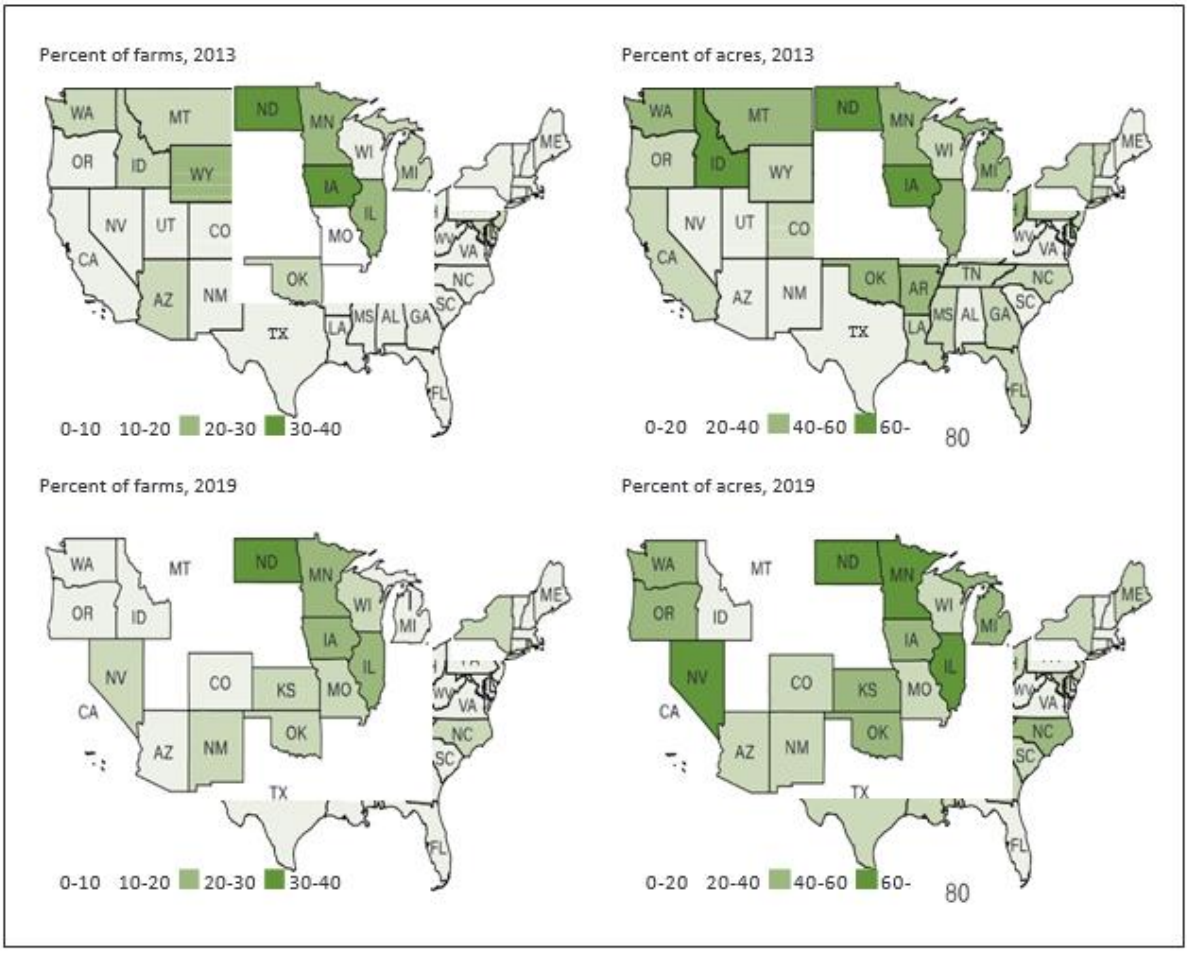
Increasingly, the utilization and significance of the internet has grown over time within agriculture operations. Now farmers can go online and research various information related to agricultural activities such as:

- More efficient ways to grow their crops,
- Technology that would be best to implement in small- or large-scale farms, and
- How to implement Good Agriculture Practice (GAP) within agricultural activities.

The use of technology (such as RFID, Radio Frequency Identification Technology) for tracing may allow farmers to effectively perform activities that track various points of data within farming supply chains such as: crop categories, planting, crop locations on farm, control systems being utilized, etc.. Some other examples of technology use on farms are now discussed.

Figure 1 shows displays the percent of total farm and ranching using GPS for farming operations. The figure is cited from the Economic Research Service of the United States Department of Agriculture's February 2023 Economic Information Bulletin Number 248.

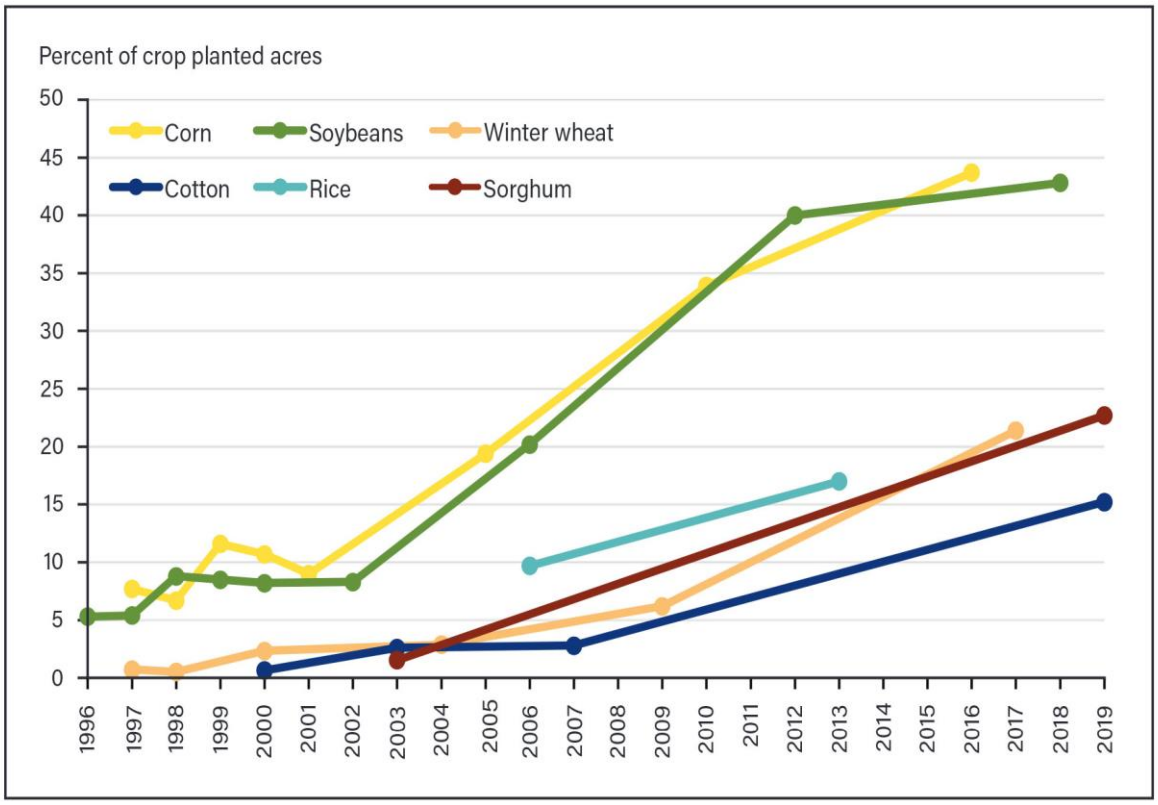
Figure 1: Percent of Total Farms and Total Farm/Ranch Acres Using GPS For On-Farm Production Activities, 2013 and 2019. (USDA, Economic Research Service and USDA, National Agricultural Statistics Service, 2013 and 2019 Agricultural Resource Management Survey (ARMS). (McFadden, Jonathan; Njuki, Eric; Griffin, Terry; February 2023))



McFadden et al state: "The top panels depict the percent of each State's total farms and total farm/ranchland, respectively, in 2013, with operators who indicated they used GPS for on-farm production activities. Similarly, the bottom panel depicts these percentages for year 2019. Data are not available for Alaska and Hawaii." (McFadden, Jonathan; Njuki, Eric; Griffin, Terry; February 2023)

Yield maps are a GPS based tool used in agricultural processes. They allow for depicting three-dimensional and chronological yield patterns. Figure 2 below presents the use of yield maps for selected crop types from 1996-2019.

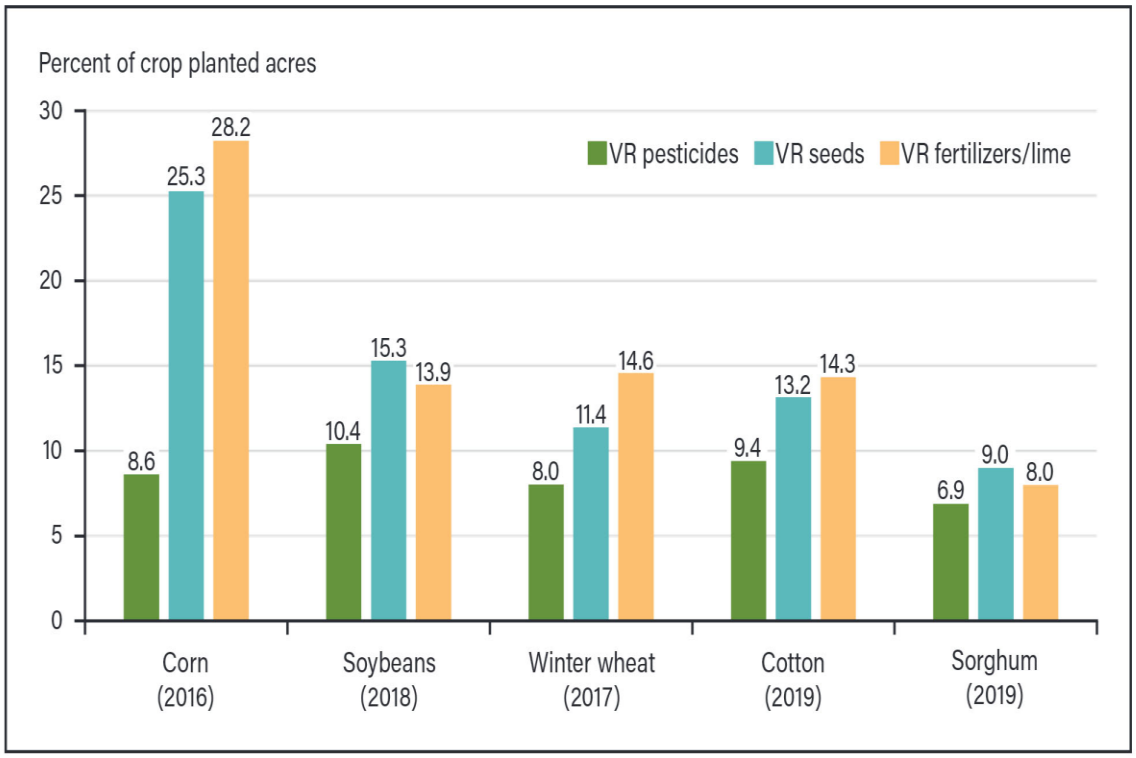
Figure 2: U.S. Farmers' Increasing Yield Map Adoption, 1996-2019 (USDA, Economic Research Service and USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey, Years 1996-2007, 2009-2013, 205-19. (McFadden, Jonathan; Njuki, Eric; Griffin, Terry; February 2023))



McFadden et al state the following: "Starting in 2015, the adoption of a yield map is considered to be the use of yield monitor data that were/will be used to create a map". (McFadden, Jonathan; Njuki, Eric; Griffin, Terry; February 2023)

Another technology used in farming operations is called: Variable Rate Technologies. "Variable rate technologies (VRT) are used by some farms for activities such as seeding, and applications of fertilizer, lime, and pesticides." (McFadden, Jonathan; Njuki, Eric; Griffin, Terry; February 2023). This is illustrated in Figure 3 below.

Figure 3: Percentages of Variable Rate Technology (VRT) Used On United States Crop-Planted Acres. (USDA, Economic Research Service and USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey, Years 2016–19. (McFadden, Jonathan; Njuki, Eric; Griffin, Terry; February 2023))

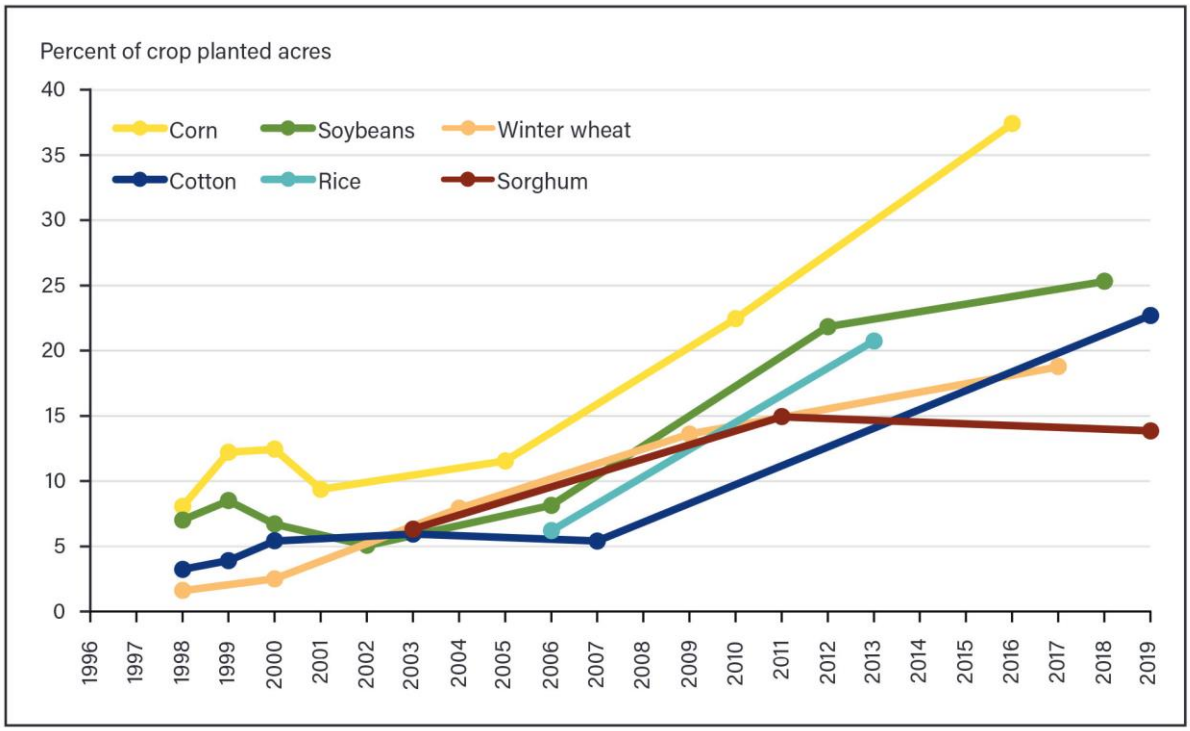


McFadden et al states, "VRT is commonly used for lime applications. However, due to survey question wording, variable rate (VR) fertilizer applications cannot be distinguished from VR lime applications. Data are not available for VR irrigation applications."

Varying usage rates for different crops with VRT are illustrated in Figure 4. McFadden et al state that,

> "Any VRT adoption is considered to be the use of a variable rate applicator for seeding, fertilizer/lime applications, or pesticide applications. The use of VR applicators for irrigation are not considered, as no data are available."

Figure 4: Variable rate technology (VRT) use: Substantial expansion from 1996–2019. (USDA, Economic Research Service and USDA, National Agricultural Statistics Service, Agricultural Resource Management Survey, Years 1998–2007, 2009–13, 2015–19. (McFadden, Jonathan; Njuki, Eric; Griffin, Terry; February 2023))



In her article, Rebecca Shields states that the use of mobile applications within farms have had a meaningful impact. They have altered the lives of farmers and agricultural field holders, for the better. Farmers have access to several mobile apps that can help them to collect information on their field farms, check the weather, and receive relevant updates. With farmers being provided details from mobile apps, they are smoothly transitioning from handling fields to creating farm maps and facilitating the use of drones. The software behind the apps gives more control when managing everything from strategy formulation to tracking progress. Mobile devices have been of great help to many farmers and how they move forward with their crops. As society progresses, technology usage will likely become a more mainstream way of farming. This will reduce manual labor for farmers.

Integrated farm management systems are discussed next.

IV. THE IMPACT OF RESHAPING AGRICULTURE WITH TECHNOLOGY

The concept of Integrated Farming is to approach agricultural operations within a farming business from total systems perspective. An integrated farm is a technology dependent operation that has the goal of attaining outputs that benefit stakeholders (i.e. both those within the system and those who are affected by the success of the system because they are dependent on the system as customers). Sometimes, the term sustainable farming may be associated with the concept. On the Agricology, the section titled Integrated Farm Management: A Guide, defines Integrated Farm Management as follows:

"Integrated Farm Management (IFM) is a whole farm business approach that aims to deliver more sustainable farming." It goes further to define IFM stating that, "IFM combines the best of modern technology with traditional methods to help deliver prosperous farming that enriches the environment and engages local communities." Similar to Integrated Farm Management, the term Integrated Farming Systems also describes a related concept.

"Integrated farming systems (IFS) entail a holistic approach to farming aimed at meeting the multiple demands (impart farm resilience, farmer livelihoods, food security, ecosystem services, and making farms adaptive and resilient, etc.). IFS are characterized by temporal and spatial mixing of crops, livestock, fishery, and allied activities in a single farm."(Venkatesh, Natesan, UmaKant, et al, 2022).

As stated in an article from the Global Ag Tech initiative website, "The adoption of an integrated farm management solution in the agriculture field can bring several opportunities to growers and can significantly improve agriculture services and contribute to its continued and systematic innovation." (Decisive Farming, 2019) The article is titled, "The Impact of Reshaping Agriculture with Technology". The process of farm management involves the use of technology across a broad range of activities including land management, crop rotation, fertilization, and data management.

"Technological development, such as the use of electronic systems and data transmission, has introduced radical changes to the agricultural working environment in recent years…"(Pivoto, 2018). The same article additionally states, "Given the persistent food shortage and population growth around the world, it is estimated that a 70% increase in world food consumption must be achieved from 2009 to 2050. The technologies linked to smart farming will be important in meeting this challenge of increased food production in the face of constraints such as climate change and other environmental issues." (Pivoto, 2018)

V. THE FUTURE OF TECHNOLOGY IN AGRICULTURE

Food preservation is another area that can be addressed by better use of technology within agriculture industries. Technology application may be applied to increasing crop yields in order to meet market demands. The technology can be applied for achieving the goal of increasing supply in general by increasing production volume. Production volume can be increased by decreasing losses. The amount of food loss due to insects and diseases is critical. One author states, "The Food and Agriculture Organization of the United Nations estimates that 20–40% of global crop yields are lost each year to pests and diseases, despite the application of around two-million tonnes of pesticide." (King, 2017)

An increasing use of pesticides may not be an adequate solution. A more efficient method for food product protection may need to be considered. More pesticide usage may not effectively address the issue. It may instead increase problems to farmers and their customers. Although it may seem counterintuitive, in fact, a reduction in the use of such chemicals may be more appropriate. "Intelligent devices, such as robots and drones, could allow farmers to slash agrichemical use by spotting crop enemies earlier to allow precise chemical application or pest removal, for example. "The market is demanding foods with less herbicide and pesticide, and with greater quality," says Red Whittaker, a robotics engineer at Carnegie Mellon who designed and patented an automated guidance system for tractors in 1997. "That challenge can be met by robots." (King 2017)

VI. SMALL-SCALE FARMS

The genesis of this study emphasizes implementing technology solutions within
Small-scale farms. Local small-scale farms occupy an essential in society in providing food to the communities which they serve. The National Institute of Food and Agriculture (NIFA) USDA website provides more insight about small scale farms and their role in our communities.

"More than 90 percent of farms in the U.S. are classified as small, with a gross cash farm income of $250,000, or less. These farms, most of which are family-owned and operated, confront considerable challenges due to current trends, such as increased movement into cities, an aging population, farm consolidation, and changing weather patterns." (NIFA USDA)

Though this may come as a challenge, this gives small scale farmers a better opportunity to expand their consumer base and have an even more profound impact within their communities than they currently possess. Technology solutions could also help small scale farmers with these issues allowing for more work to be done with less resources.

The article from NIFA states:

"Family and small farms are vital to our economy and well-being as a nation. Not only do they support the competitiveness and sustainability of rural and farm economies, they serve to:

- Protect and enhance natural resources and the environment
- Provide a nursery for the development of new enterprises and marketing systems
- Maintain rural populations" (NIFA USDA)

The work related to this study has revealed that when local grocery stores require small orders of produce, they place orders directly to local farmers. The supply from local farmers is vital to enabling normal operations to continue until lager shipments can be received. It is important to find solutions to help sustain

these small-scale farms not only for the sake of local communities economically, but also for other reasons including preserving the health, safety, and sustainability of individual communities.

VII. CONCLUSION

Historically, various technology solutions have had an important role in the agricultural industry. An article titled, "American Farm Machinery and Technology Changes from 1776–1990" discusses various technology developed for farming between the 1700s and 1900s (Bellis, 2021). The development and usage of technology within farming supply chains has only increased since the turn of the millennium. This current article has highlighted some key issues related to trends in technology usage in the farming industry.

Conflict of interest

There is no conflict to disclose.

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