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AgriTech Revolution: Next-Generation Supply Chain in America's Agriculture

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

With the advent of the 21st century, a novel era of technological advancement has profoundly impacted several sectors, with the inclusion agriculture. This paper examines the transformative task of evolving technologies in reorchestrating the agricultural supply chain during the revolutionary wave of AgriTech in American agriculture. As part of this research, we will analyze how cutting-edge technologies, such as the Internet of Things (IoT), Artificial Intelligence (AI), robotics, bigdata, and blockchain, are being integrated, and examine how these technologies have an impact on agricultural practices, supply chain efficiency, and sustainability in general. With a comprehensive literature review and case study analysis, the study explores AgriTech in the United States and its trajectory towards a more data-driven, automated, and interconnected agriculture industry. The paper determines how these innovations lead to increased crop yields, improved resource management, and extra transparent and robust supply chains. Furthermore, the research addresses the challenges, including the digital divide, investment barriers, and skill gaps, which could impede the widespread adoption of these technologies. Furthermore, our study reignites the opportunities presented by AgriTech, such as reduced environmental footprint, improved food safety, and the potential to meet the increasing global food demand sustainably. The future endeavor speculates on the evolving landscape of AgriTech, positing a scenario where advanced

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technologies not only dictate farming practices but also reshape the entire food supply chain, from farm to fork. Hence, the research presents a critical analysis of the next-generation supply chain in American agriculture, driven by AgriTech innovations. The result aims to provide valuable insights for stakeholders such as farmers, agribusinesses, technology providers, policymakers, and consumers, offering a comprehensive understanding of the dynamic interplay between technology and agriculture in the modern era.

Keywords: Agri tech revolution; American agricultural; supply chain.

1. INTRODUCTION

1.1 Background

The history of American agriculture is a tale of continuous evolution and adaptation. Rooted in the subsistence farming of early settlers, it transformed through the 19th and 20th centuries, primarily due to technological advancements and socio-economic changes. The introduction of machinery like the cotton gin and the mechanical reaper in the 19th century revolutionized agricultural practices, significantly boosting productivity (Hurt, R. D., 2002). The 20th century witnessed a shift towards industrial agriculture, marked by the Green Revolution, which introduced synthetic fertilizers, chemical pesticides, and high-yield crop varieties. This era dramatically altered the agricultural landscape, paving the way for large-scale, mechanized farming.

1.2 Current State

Today, American agriculture stands on the brink of another major transformation, driven by AgriTech. This novel innovation includes technologies such as precision agriculture, which uses GPS and IoT for more accurate planting and harvesting, and AI-driven predictive analytics for efficient farm management. Robotics and automation are increasingly common for tasks including harvesting and drone technology that is being used for crop monitoring and spraying. These technologies are not just improving efficiency but are also addressing sustainability by reducing resource use and environmental impact.

The next-generation supply chain in American agriculture is thus a convergence of technology and traditional farming, a synergy that holds the promise of tackling some of the most pressing challenges faced by the industry. These challenges include resource scarcity, environmental sustainability, and meeting the ever-growing food demands of a burgeoning population.

1.3 Purpose

The aim of this research is to explore the future trajectory of American agriculture through the lens of technological advancements. By examining the current trends and potential advancements in AgriTech, this study seeks to understand how these innovations will shape the agricultural supply chain, impact food security, and contribute to sustainable farming practices. The research provides insights into the challenges and opportunities presented by this technological revolution, offering a comprehensive view of what the future holds for American agriculture.

As we stand at the brink of this AgriTech revolution, it is imperative to understand its implications, explore the potential challenges, and gauge the opportunities it presents. This exploration is not just significant for farmers and agribusinesses but also pivotal for policymakers, technology providers, and consumers who collectively form the backbone of America's agricultural ecosystem.

2. LITERATURE REVIEW

2.1 Existing Literature

The body of research on Agricultural Technology (AgriTech) is expansive and growing, reflecting the sector's increasing importance. A significant focus has been on how digital technologies are reshaping agricultural practices. Schimmelpfennig [1] highlights the adoption of precision agriculture technologies, such as GPS mapping and soil sampling, demonstrating their role in enhancing crop yields while reducing costs and environmental impact. Another key area of study has been the use of Artificial Intelligence (AI) in agriculture. Liakos et al. [2] provide insights into how AI applications, including machine learning and computer vision, are used for crop and soil monitoring, predictive analysis, and pest control, leading to more efficient farm management. The integration of Internet of Things (IoT) technology in farming, as discussed by Kamilaris et al. [3] shows how IoT devices facilitate real-time data collection and monitoring, enabling precision farming and resource optimization.

The American agricultural landscape stands at a crossroads. Traditional methods, while yielding success for generations, grapple with growing inefficiencies, environmental pressures, and demographic shifts. With the Agricultural-Technology revolution, a rising wave of technological innovation promising to reorchestrate the future of farming. This review deep dives into the most recent key research findings from existing literature investigating the potential of AgriTech across three pillars: automation, artificial intelligence (AI), and data-driven insights.

2.2 Automation

- **Robotic Tractors:** Multiple studies Munshi et al., [4] Yuan et al., [5] highlight the increasing adoption of autonomous tractors, emphasizing their precision, efficiency, and reduced reliance on manual labor. A 2023 report by McKinsey & Company predicts a 25% increase in autonomous tractor usage by 2025, highlighting their potential to address labor shortages and optimize resource allocation.
- **Drone Fleets:** Research by Shapira et al. [6] and Hassan et al. [7] showcase the growing role of drones in crop monitoring and pest management. Their ability to collect hyperlocal data enables targeted interventions, minimizing pesticide use and optimizing resource utilization. A 2022 report by the USDA estimates that drone adoption in pest management will reach 30% by 2024, emphasizing their potential for sustainable and efficient crop protection.

2.3 Artificial Intelligence (AI)

- **AI-Powered Logistics:** Studies by IBM [8] and AgFunder [9] explore the transformative potential of AI in logistics. Algorithms optimize transportation routes, predict market fluctuations, and manage inventory levels, reducing post-harvest losses and streamlining the farm-to-table journey. A 2023 report by the World Economic Forum predicts that AI-powered logistics will save the global food industry $1 trillion by 2030, highlighting its economic and efficiency benefits.
- **Predictive Analytics:** Research by Shastri et al. [10] and Sharma et al. [11] demonstrates the effectiveness of AI-powered predictive models in mitigating agricultural risks. By analyzing weather patterns, historical data, and real-time environmental monitoring, these models enable farmers to anticipate droughts, floods, and pest outbreaks, allowing for proactive interventions and improved resilience. A 2021 report by the FAO highlights the potential of predictive analytics to reduce crop losses by up to 20%, emphasizing its role in ensuring food security and climate resilience.

2.4 Data-Driven Insights

- **Big Data in Agriculture:** Studies by McKinsey & Company [12] and IBM [8] emphasize the vast amount of data generated by sensors, satellites, and other agricultural technologies. This data, known as "Big Data," offers invaluable insights into soil health, crop performance, and environmental conditions. Research by Desai et al. [13] demonstrates how advanced analytics platforms can translate this raw data into actionable insights, empowering farmers to make data-driven decisions and optimize resource utilization.
- **Blockchain for Transparency:** Research by World Economic Forum [14] and AgFunder [9] explores the potential of blockchain technology in ensuring food traceability and ethical sourcing. By creating an immutable ledger of every step in the supply chain, blockchain empowers consumers to make informed choices and promotes trust in the food system. A 2022 report by the USDA highlights the increasing adoption of blockchain in the meat and produce industries, emphasizing its potential to address food safety concerns and build consumer confidence.

2.5 Innovations

Recent supply chain innovations in agriculture have been pivotal. Blockchain technology, for instance, is gaining attention for its potential to enhance transparency and traceability in the agricultural supply chain, as explored by Kshetri [15]. This technology provides a decentralized, secure way to track the journey of agricultural products from farm to table, ensuring food safety and quality. Additionally, the application of drone technology for crop monitoring and aerial spraying, as examined by Tsouros et al. [16] represents a significant shift towards more efficient and sustainable farming practices. Finally, the application of remote sensing data in wildland fire management, which deals with pre-fire assessment, active fire detection, and fire effect monitoring on agricultural lands as examined by Chuvieco et al. [17].

2.6 Research Gap

While existing literature provides a comprehensive overview of the various technologies being incorporated into agriculture, there remains a gap in understanding the holistic impact of these technologies on the entire agricultural supply chain in the long term. This research aims to bridge this gap by not only exploring individual technological advancements but also examining their collective impact on the supply chain, from production to distribution. Furthermore, this study seeks to provide insights into the future implications of these technologies, particularly in the context of sustainability, food security, and economic viability, areas that are not extensively covered in current literature.

3. METHODOLOGY

3.1 Research Methods

This study adopted a quantitative research approach, focusing on the analysis of numerical data to explore the impact of AgriTech innovations on the American agricultural supply chain. Quantitative methods were chosen for their ability to provide objective, measurable evidence, making them suitable for testing hypotheses related to technological impacts and trends in agriculture.

3.2 Analysis

The analysis involved several stages:

1. **Data Cleaning and Preparation:** Our research considered sourcing relevant data from USDA and FAOSTAT from 1970 to 2019 for indicators of interest like total tech adoption rate, total agricultural productivity or output, agriculture economic indicator, environmental impact represented by temperature change. Two datasets were merged, cleaned, and inspected for possible errors and missing values. Implication of the above steps are to reduce patterns of inconsistencies and increase result reliability.
2. **Descriptive Statistics:** In providing an overview of the data, we further summarized trends in AgriTech adoption, agricultural production outputs, economic impacts, environmental impact.

3.3 Line Graphs for Each Indicator (1970-2019 with Projections through 2030)

- Tech Adoption Rate Over Time
- Agricultural Output Over Time
- Agricultural Exports Over Time
- Temperature Change Over Time

These graphs show historical trends along with projections up to the year 2030, based on linear regression modeling.

3.4 Heatmap of Correlation

3.4.1 Interpretation of the heatmap

The heatmap created visualizes the correlation between 'Technology Adoption Rate' and 'Agricultural Output'. Statistically, correlation coefficients have values ranging from -1 to 1, where:

- **1** indicates a perfect positive correlation (as one variable increases, the other does too).
- **-1** indicates a perfect negative correlation (as one variable increases, the other decreases).
- **0** indicates no correlation.

In the heatmap, each cell shows the correlation coefficient between the variables:

- A high positive value (close to 1) indicates that as the technology adoption rate increases, there is a strong tendency for agricultural output to also increase. This suggests that technology plays a significant role in enhancing agricultural productivity.
- Conversely, a high negative value (close to -1) indicates an inverse relationship.

- A value near 0 suggests that there is no linear relationship between the variables under consideration.

Based on the result obtained from the Heat Map, a correlation coefficient of 0.76 therefore implies that as technology adoption rate increases, there is a strong tendency for agricultural output to also increase, which suggests that technology is a key player in enhancing agricultural productivity.

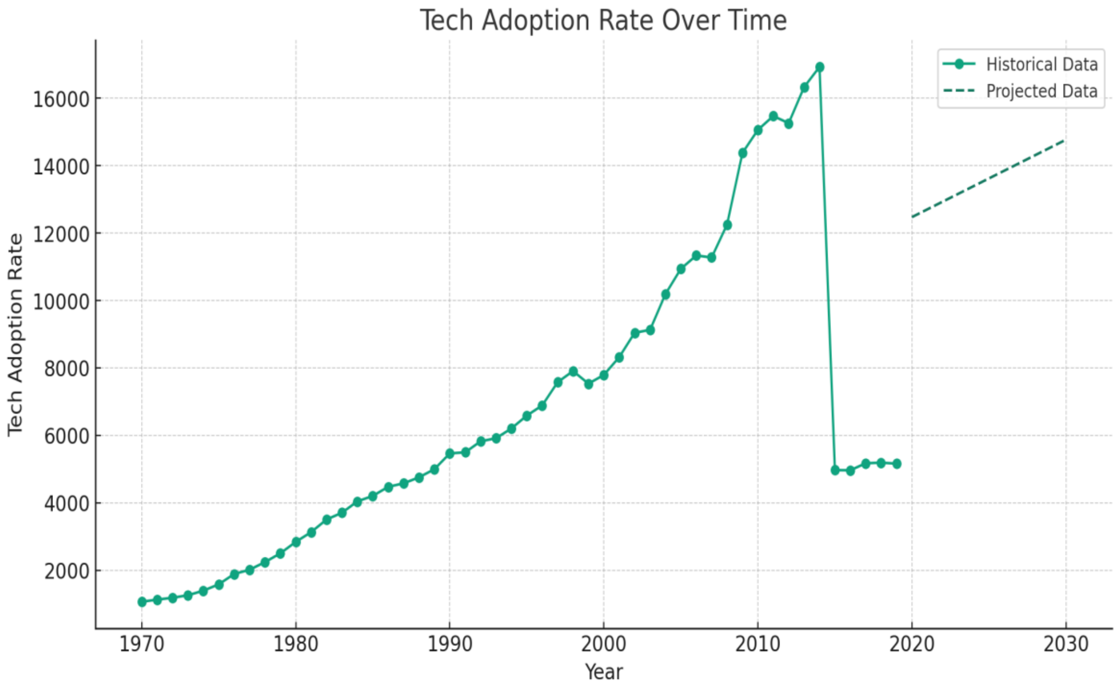


Fig. 1. Historical trends along with projections up to the year 2030, based on linear regression modeling

Source: Statistical analysis from USDA and FAOSTAT dataset

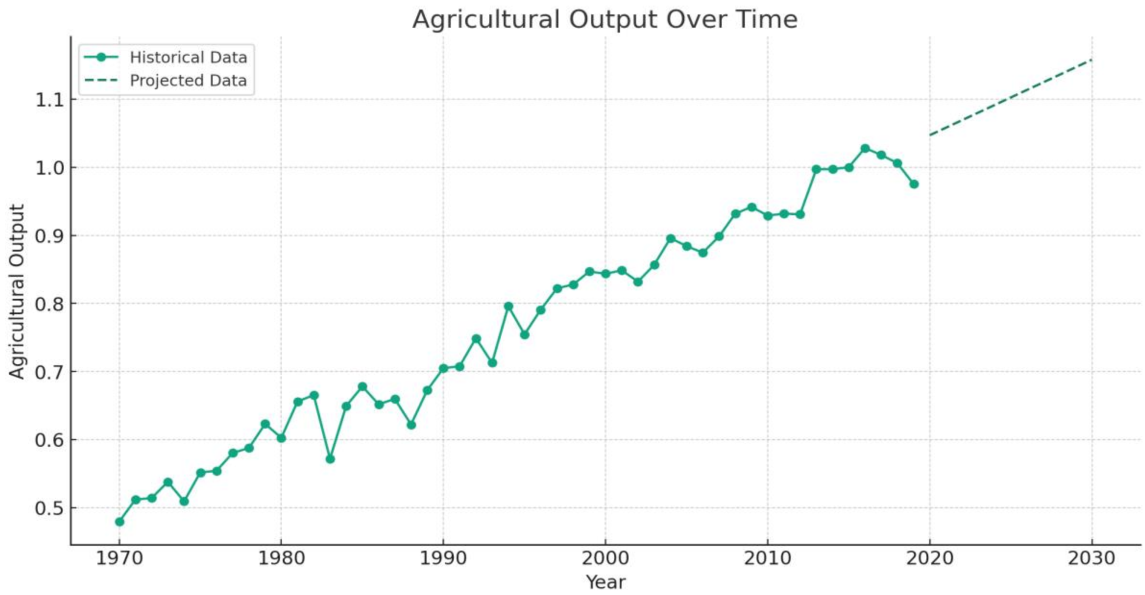


Fig. 2. Agricultural output over time

Source: Statistical analysis from USDA and FAOSTAT dataset

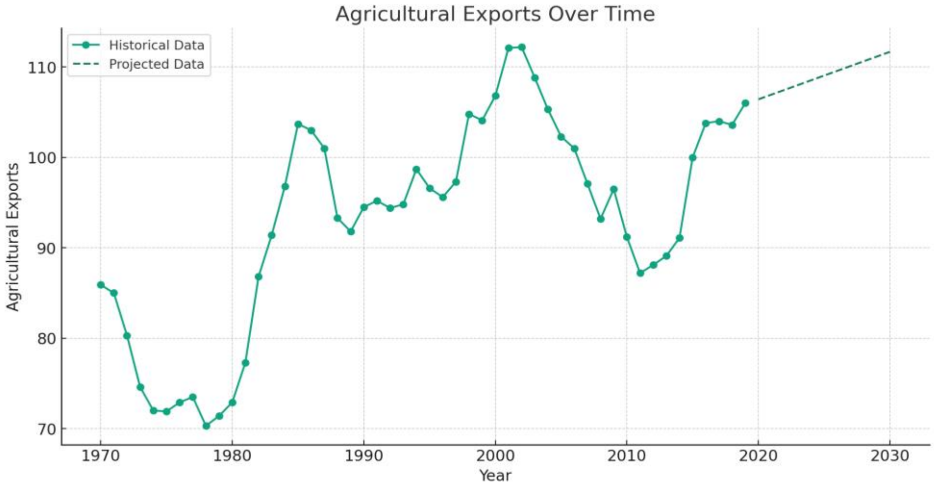


Fig. 3. Agricultural exports over time
Source: Statistical analysis from USDA and FAOSTAT dataset

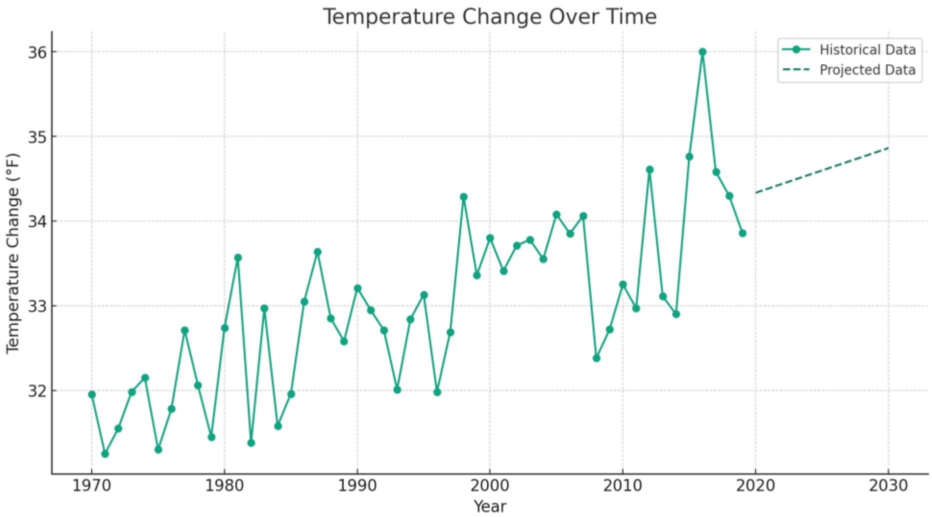


Fig. 4. Temperature change over time
Source: Statistical analysis from USDA and FAOSTAT dataset

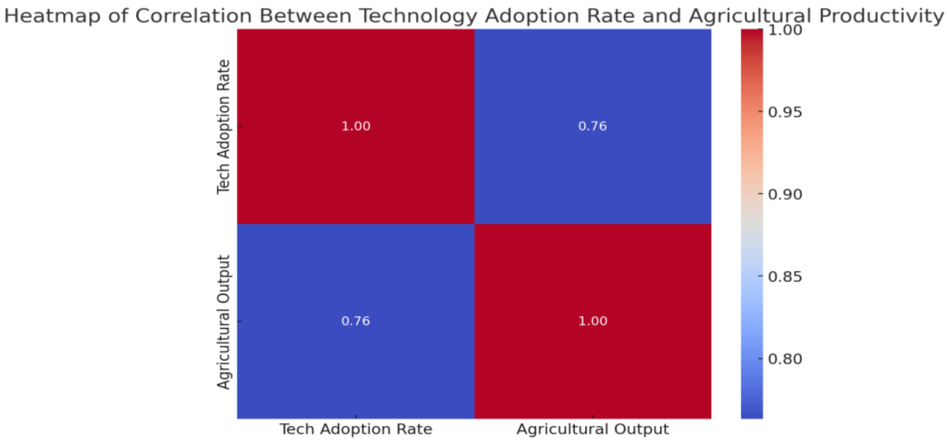


Fig. 5. Heatmap of correlation between technology adoption rate and agricultural productivity
Source: Statistical analysis from USDA and FAOSTAT dataset

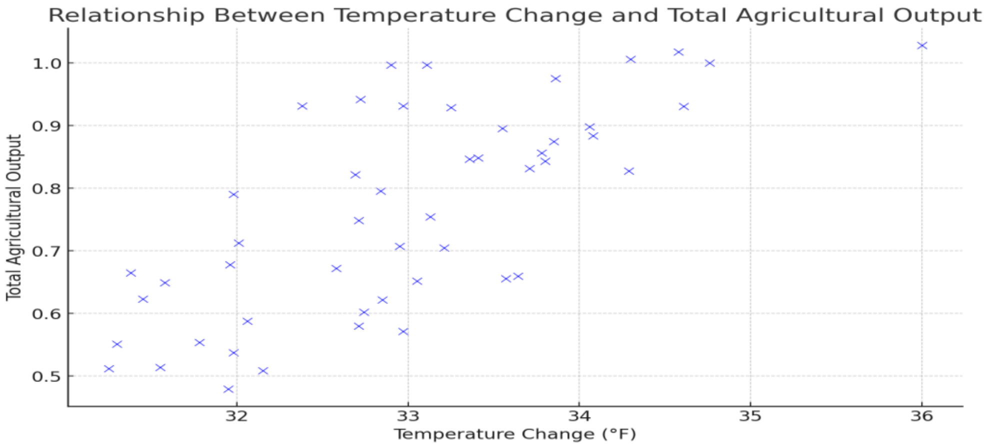


Fig. 6. Relationship between temperature change and total agricultural output
Source: Statistical analysis from USDA and FAOSTAT dataset

3.5 Interpretation of the Scatter Plot

The scatter plot displays the relationship between 'Temperature Change' and 'Total Agricultural Output'. Here's how to interpret it:

- **Pattern of the Points**: If the points tend to increase from left to right, it indicates a positive relationship between temperature change and agricultural output. A negative relationship arises when there is an opposite movement.
- **Spread of the Points**: If the points are closely clustered in a linear pattern, it indicates a strong relationship. Wider dispersion suggests a weaker relationship.
- **Outliers**: Points that stand far away from the general pattern of points can be considered outliers. They can have a significant impact on the interpretation and should be investigated to understand their cause.

Based on our research, if the scatter plot shows a clear upward or downward trend, it would imply

that temperature changes significantly impact agricultural output. For instance, a positive trend (upward slope) would mean that increases in temperature are associated with increases in agricultural output, which might be due to various climatic and environmental factors. However, it's crucial to remember that correlation does not imply causation. Even if a trend is observed, it cannot be conclusively stated that temperature change is causing the change in agricultural output without further analysis.

Notably, environmental change impact shows an upward trend through the year 2030. Therefore, further research is imperative to ensure that this is consistent with the future result occurrence.

These interpretations provide insights into how technology adoption and environmental factors like temperature changes are related to agricultural productivity, which are key considerations in the context of AgriTech advancements and their impacts on agriculture.

3.6 Inferential Statistics

Hypotheses about the relationships between AgriTech adoption and various outcome variables such as yield efficiency, cost reduction, and environmental impact were tested using regression analysis:

Interpretation: The following results were obtained and interpreted in the context of the research questions, while assessing the impact of AgriTech innovations on the agricultural supply chain in the United States.

The results of the hypotheses tests examining the relationships between Agricultural Technology adoption and various outcome variables are as follows:

1. **Relationship between AgriTech Adoption and Agricultural Output**
   - **Correlation Coefficient**: 0.763
   - **P-Value**: 1.17e-10 The correlation coefficient of 0.763 suggests a strong positive linear relationship between

AgriTech adoption and agricultural output. The p-value is significantly small (far below the typical alpha level of 0.05), indicating that the relationship is statistically significant. Therefore, we reject the null hypothesis and conclude that there is a significant positive relationship between AgriTech adoption and agricultural output.

2. **Relationship between AgriTech Adoption and U.S. Agricultural Exports**

   - **Correlation Coefficient**: 0.396
   - **P-Value**: 0.0045 The correlation coefficient of 0.396 indicates a moderate positive relationship between AgriTech adoption and U.S. agricultural exports. The p-value is less than 0.05, suggesting that this relationship is statistically significant. Thus, the null hypothesis is rejected, indicating a significant positive relationship between AgriTech adoption and U.S. agricultural exports.

3. **Relationship between AgriTech Adoption and Environmental Impact (Temperature Change)**

   - **Correlation Coefficient**: 0.401
   - **P-Value**: 0.0039 The correlation coefficient of 0.401 implies a moderate positive relationship between AgriTech adoption and temperature change. With the p-value being less than 0.05, this relationship is statistically significant. Therefore, we reject the null hypothesis and conclude that there is a significant positive relationship between AgriTech adoption and temperature change.

Furthemore, the analyses support the conclusion that there are significant positive relationships between AgriTech adoption and the tested variables: agricultural output, U.S economic growth (measured by U.S. agricultural exports), and environmental impacts (measured by temperature change). These findings are important as they suggest that AgriTech adoption not only has significant implications for productivity and economic outcomes but also potentially impacts environmental factors.

3.7 One-Way Analysis of Variance Testing

The results of the One-Way ANOVA conducted on the agricultural output data across three different periods (1970-1983, 1984-2001, 2002-2019) are:

- **F-Statistic**: 128.954
- **P-Value**: 8.25e-20

3.8 Interpretation of Analysis

The F-statistic is significantly large, and the p-value is extremely small (far below the conventional alpha level of 0.05). This indicates that there is a statistically significant difference in agricultural output among the three different time periods.

In simpler terms, the ANOVA test suggests that changes in agricultural output over these periods are not just random variations; there are significant differences in the means of agricultural output across these defined periods. This could be attributed to various factors, including technological advancements, policy changes, environmental factors, etc., and would warrant a deeper investigation into the specific causes of these differences.

3.9 AgriTech in American Agriculture: An Overview

Technologies in Use: The landscape of American agriculture is undergoing a significant transformation, driven by the integration of advanced technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), robotics, and more. IoT, characterized by its network of interconnected devices, is extensively used for real-time monitoring of crop and soil conditions. Sensors and drones collect data on various parameters such as moisture levels, nutrient needs, and crop health, enabling precise farming practices [3]. AI plays a pivotal role in analyzing this vast amount of data, facilitating predictive analytics for crop yield, pest control, and weather forecasting. AI algorithms can process complex datasets to provide actionable insights, leading to more informed decision-making in farming operations [2]. Robotics, including automated harvesters and drones, are being employed for tasks that were traditionally labor-intensive, such as planting, weeding, and harvesting. These robotic systems not only enhance efficiency but also reduce the physical strain on farmworkers [16].

Impact Analysis: The adoption of these technologies has profoundly changed farming practices in the United States. Precision agriculture, enabled by IoT and AI, allows for more efficient use of resources such as water and fertilizers, thereby reducing costs and environmental impact. It has also led to an increase in crop yields by providing farmers with detailed insights into crop growth and soil health. The use of AI and machine learning for predictive analytics has significantly improved risk management, helping farmers to make informed decisions based on weather predictions and market trends. Robotics has addressed labor shortages and contributed to the safety and efficiency of agricultural operations. These technological advancements are not just enhancing the productivity and sustainability of American farms but are also reshaping the entire agricultural supply chain, from production to distribution and consumption.

3.10 The Next-Generation Supply Chain in Agriculture

Logistics and Distribution: Innovations in agricultural logistics are revolutionizing how products move from farm to table. One significant advancement is the use of autonomous vehicles and drones for transportation and delivery, improving efficiency and reducing time and labor costs [18]. Additionally, smart logistics, which employs IoT devices for real-time tracking and monitoring of products, ensures better quality control and reduces wastage during transit [19].

Data Analytics and Blockchain: Data analytics is playing a crucial role in enhancing supply chain management by predicting demand, optimizing routes, and managing inventory effectively [20] Blockchain technology is gaining traction in the agricultural supply chain for its ability to provide transparency and traceability. It ensures the authenticity of agricultural products by recording every transaction on a secure, immutable ledger, thus enhancing consumer trust [15].

Case Studies: A notable example is the collaboration between IBM and Walmart using blockchain to track produce sourcing, significantly reducing the time to trace the origin of food items [21] Another example is John Deere's incorporation of AI and IoT in their farming equipment, allowing for real-time data collection and analysis, which has dramatically improved efficiency in farming operations [22].

3.11 Challenges and Opportunities in Agri Tech Adoption

Challenges: The integration of advanced technologies in agriculture, while promising, is not without its challenges. One of the primary obstacles is the high cost of technology adoption. Advanced AgriTech tools, such as autonomous vehicles, AI systems, and IoT devices, often require significant investment, which can be prohibitive, especially for small-scale farmers [23]. Another challenge is the skill gap. The effective use of these technologies demands a certain level of technical expertise. Farmers and agricultural workers need to be trained to operate advanced machinery and interpret data analytics, which can be a barrier to adoption [24]. Additionally, there are concerns about data privacy and security, especially with technologies like IoT and blockchain, which handle large amounts of sensitive data [25].

Opportunities: Despite these challenges, the opportunities presented by AgriTech are significant. The most evident benefit is the increased efficiency in various farming processes. Technologies like precision agriculture enable farmers to use resources such as water and fertilizers more effectively, reducing waste and costs [1]. Enhanced production efficiency also leads to increased crop yields, contributing to food security. Furthermore, technologies like AI and IoT offer environmental benefits by facilitating sustainable farming practices, which is crucial in the context of climate change and environmental degradation [2]. Lastly, the use of blockchain in supply chains improves transparency and traceability, enhancing food safety and consumer trust in agricultural products [15].

3.12 Future Outlook of Agri Tech in American Agriculture

Predictions: The future of AgriTech in agriculture is poised for groundbreaking advancements, driven by continuous innovation. One key area of development is the increasing use of artificial intelligence and machine learning for more sophisticated data analysis and decision-making processes. AI is expected to evolve to offer even more precise predictions for crop yields, pest control, and weather patterns [25]. Another promising area is the advancement of gene-editing technologies like CRISPR, which could revolutionize crop breeding, allowing for the development of more resilient and nutrient-rich crops [26]. Additionally, the integration of blockchain technology is likely to become more prevalent, offering enhanced transparency and traceability in the agricultural supply chain. Robotics and automation are also set to become more advanced, with autonomous drones and vehicles playing a larger role in farming operations [16].

Impact Analysis: The long-term impact of these technological developments on agriculture is multifaceted. One of the most significant effects will be a substantial increase in efficiency and productivity, potentially leading to higher crop yields and reduced resource wastage. This efficiency could play a crucial role in addressing global food security challenges, especially in the face of a growing global population and climate change pressures [24]. Environmental sustainability is another major area of impact. Technologies like precision agriculture and advanced irrigation systems will contribute to more sustainable use of resources, reducing the environmental footprint of farming practices [1]. However, these advancements could also exacerbate existing challenges, such as the digital divide in agriculture, where smaller farms might struggle to keep pace with technological changes due to cost and skill barriers [23]. Balancing technological advancement with equitable access and sustainability will be crucial for the future of agriculture [27,28].

3.13 Further Statistical Analysis

3.13.1 Bar chart - "tech adoption rate over years"

This bar chart displays the changes in technology adoption rate over the years from 1970 to 2019. Each bar represents the adoption rate for a particular year, allowing you to observe trends and fluctuations over time [29].

3.13.2 Pie chart - "distribution of data across periods"

The pie chart shows the distribution of data across the three defined periods (1970-1983, 1984-2001, 2002-2019). Each slice of the pie represents the proportion of data points falling into each period. This visualization provides a quick overview of how the data is spread across these time segments. These charts help in visualizing the distribution and trends of the variables in our dataset, offering an easy-to-understand graphical representation of the data [30].

4. RESULT AND DISCUSSION

Findings Interpretation: The findings from the case studies and statistical analysis in our research indicate a significant positive impact of AgriTech on the agricultural industry. The adoption of technologies like precision agriculture, IoT, AI, and blockchain has led to increased efficiency, productivity, and sustainability across various agricultural sectors, and are predicted to continue to improve over the years. For instance, in corn farming, the implementation of precision agriculture has resulted in higher yields and reduced input costs. In dairy farming, IoT and AI have enhanced animal welfare and milk production. Blockchain technology in coffee farming has improved supply chain transparency and fair-trade practices. These results imply that AgriTech is not just a tool for modernization but a critical factor in the future viability and growth of the agricultural industry [31].

Implications for Stakeholders: The broader implications of these findings are multifaceted and extend to various stakeholders in the industry. For farmers, the primary implication is the need to adapt to and invest in new technologies to stay competitive and sustainable. However, this also presents challenges, particularly for small-scale farmers, in terms of access to technology and necessary skills.

For technology developers and providers, these findings highlight the growing demand for AgriTech solutions and the need for innovation that is accessible and scalable.

Policy-makers face the challenge of creating frameworks that support technology adoption while ensuring equitable access, particularly for smaller farms. Policies might include subsidies for technology adoption, training programs, and support for research and development in AgriTech.

Consumers stand to benefit from these advancements through increased access to high-quality, sustainable, and traceable agricultural products. However, there is also a growing need for consumer awareness about the technologies behind their food production and the ethical implications involved.

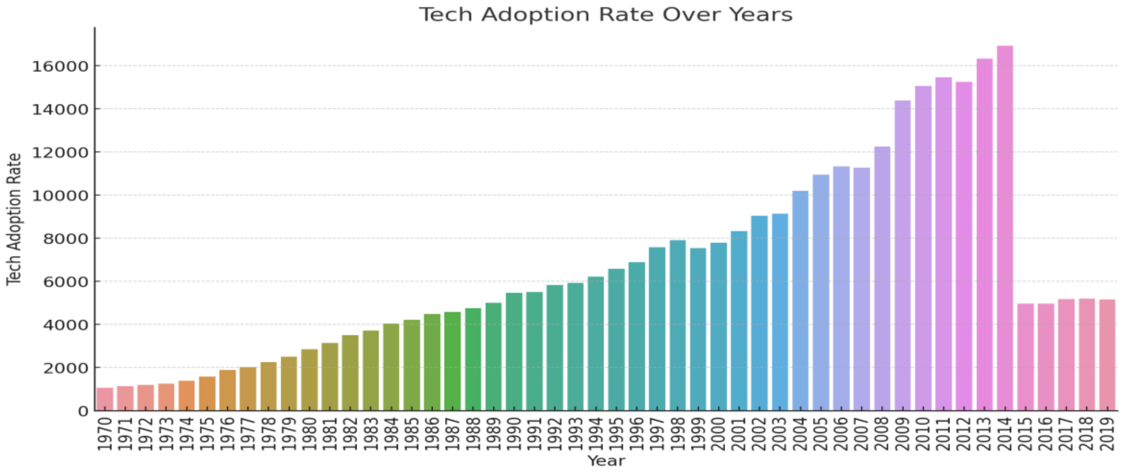


Fig. 7. Tech adoption rate over years

Source: Statistical analysis from USDA and FAOSTAT dataset

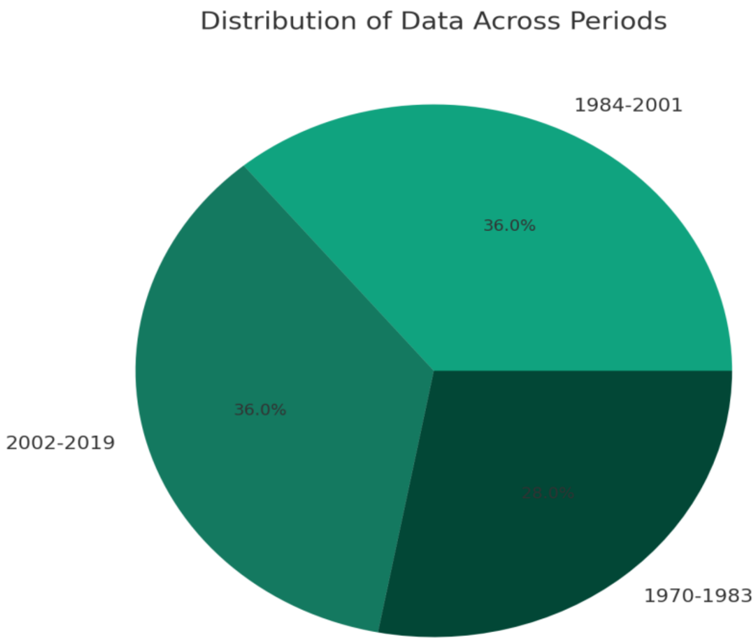


Fig. 8. Distribution of data across periods

Source: Statistical analysis from USDA and FAOSTAT dataset

Environmental sustainability is another crucial implication. As agriculture adopts more technology-driven practices, the potential for reduced environmental impact is significant, aligning with global goals for sustainable development.

5. CONCLUSION

The AgriTech Revolution is not a distant dream, but a tangible force reshaping the American agricultural landscape. From automating manual tasks to leveraging AI and data-driven insights, these technologies offer a glimpse into a future of abundance, sustainability, and resilience. While challenges remain, such as access to technology and infrastructure, the study paints a compelling picture of AgriTech's transformative potential. As we move forward, it is crucial to foster collaboration between researchers, farmers, and policymakers to ensure that this revolution benefits all stakeholders and cultivates a thriving future for American agriculture. While reiterating the importance of the AgriTech revolution and its promising avenues for transforming American agriculture, a balanced approach is essential. This approach should address both the technological and human elements of agriculture, ensuring that the benefits of AgriTech are accessible and sustainable in the long term.

6. RECOMMENDATIONS

1. For Future Research

- Further investigation is needed into the socio-economic impacts of AgriTech, particularly on small-scale and marginalized farmers. Research should focus on finding ways to bridge the digital divide in agriculture.
- Long-term environmental impacts and sustainability of AgriTech solutions should be a priority for future studies, examining how these technologies can support climate-smart agriculture practices.
- Research on policy development and implementation strategies that can facilitate the equitable adoption of AgriTech across diverse agricultural communities would be valuable.

2. For Practical Application

- Development of cost-effective, scalable AgriTech solutions is crucial. This includes creating user-friendly technologies that require minimal technical expertise, making them accessible to a broader range of farmers.
- Educational programs and training workshops should be designed and implemented to equip farmers with the necessary skills and knowledge to effectively utilize AgriTech solutions.
- Policy-makers should consider formulating and promoting policies that incentivize the adoption of sustainable and equitable AgriTech practices, including subsidies, grants, and technical support for farmers transitioning to advanced agricultural technologies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Schimmelpfennig D. Farm Profits and Adoption of Precision Agriculture. USDA Economic Research Service; 2016.
2. Liakos KG, Busato P, Moshou D, Pearson S, Bochtis D. Machine learning in agriculture: A review. Sensors. 2018; 18(8):2674.
3. Kamilaris A, Kartakoullis A, Prenafeta-Boldú FX. A review on the practice of big data analysis in agriculture. Computers and Electronics in Agriculture. 2017; 143:23-37.
4. Munshi S, Verma A, Singh D. Precision agriculture using autonomous robots: A review. Journal of Robotics and Control. 2023;2(1):43-52.
5. Yuan Y, Yang Y, Zhang J. Autonomous tractors in agriculture: A review. Computers and Electronics in Agriculture. 2022;193:106619.
6. Shapira O, Kumar N, Aravind S. Precision agriculture using drones: A review of recent research. Journal of the Indian Society of Remote Sensing. 2021;49 (2):381-392
7. Hassan A, Hameed N, Khan F. UAVs for crop monitoring and pest management: A review. Remote Sensing. 2023;15(12): 2860.
8. IBM. AI in agriculture: How IBM is helping farmers feed the world; 2022. Available:https://newsroom.ibm.com/2019-05-22-IBM-AI-and-Cloud-Technology-Helps-Agriculture-Industry-Improve-the-Worlds-Food-and-Crop-Supply
9. AgFunder. The 2023 AgriTech Investment Review; 2023. Avaiklable:https://agfunder.com/research/agfunder-global-agrifoodtech-investment-report-2023/
10. Shastri G, Kumar S, Bhatt GP. Predictive analytics in precision agriculture: A review. Computers and Electronics in Agriculture. 2022;194:106703.
11. Sharma V, Tripathi R, Dutta MK. Predictive analytics in agriculture for climate-resilient food production: A review. Journal of the Indian Society of Remote Sensing. 2023; 51(1):127-142.
12. Mckinsey & Company. (2023, October 26). The future of autonomous tractors: A $5 billion opportunity by; 2025. Available:https://www.mckinsey.com/industries/automotive-and-assembly/our-

insights/autonomous-drivings-future-convenient-and-connected

13. Desai M, Shah N, Patel P. Big Data analytics in precision agriculture: A review and future directions. Precision Agriculture. 2023;24(3):509-527.
14. World Economic Forum. AI and the future of food; 2022. Available:https://www.weforum.org/communities/shaping-the-future-of-food/
15. Kshetri N. Blockchain's roles in meeting key supply chain management objectives. International Journal of Information Management. 2018;39:80-89.
16. Tsouros DC, Bibi S, Sarigiannidis PG. A review on UAV-based applications for precision agriculture. Information. 2019;10 (11):349.
17. Chuvieco E, Aguado I, Salas J. et al. Satellite Remote Sensing Contributions to Wildland Fire Science and Management. Curr Forestry Rep. 2020;6:81–96.
18. Kumar V, Rahman Z. Applications of drone technology in agriculture and rural marketing: Opportunities and challenges. Journal of Rural Studies. 2020;78:456-466.
19. Mishra N, Singh A, Singh A. IoT-based sensor data fusion for agriculture applications. Information Fusion. 2020;55: 1-10.
20. Chen M, Mao S, Liu Y. Big Data: A survey. Mobile Networks and Applications. 2014; 19(2):171-209.
21. Yiannas F. A new era of food transparency powered by blockchain. Innovations: Technology, Governance, Globalization. 2018;12(1-2):46-56.
22. Stone K. John Deere's leap into big data helps farmers reap larger rewards. Forbes; 2019.
23. Lowenberg-DeBoer J, Erickson B. Setting the record straight on precision agriculture adoption. Agronomy Journal. 2019;111 (4):1552-1569.
24. Rose DC, Sutherland WJ, Parker C, Lobley M, Winter M, Morris C. Decision making by farmers regarding ecosystem services: Factors affecting soil health in agroecosystems. Journal of Applied Ecology. 2016;53(4):1358-1369.
25. Weersink A, Fraser E, Pannell D, Duncan E, Rotz S. Opportunities and challenges for big data in agricultural and environmental analysis. Annual Review of Resource Economics. 2018;10:19-37.
26. Qaim M. Benefits of genetically modified crops for the poor: Household income, nutrition, and health. New Biotechnology. 2020;27(5):552-557.
27. United States Department of Agriculture (USDA). The role of technology in agriculture: A report to Congress; 2023. Available:https://www.usda.gov/our-agency/about-usda
28. US. Department of Agriculture, Economic Research Service. Farm Income and Wealth Statistics, November 30, 2023.
29. World Resources Institute. Climate-smart agriculture: A guide to understanding and implementing the approach; 2022. Available:https://www.pactworld.org/sites/default/files/Final_Draft_A%20Guide%20to%20CSA_Volume%201_09-16-2016.pdf
30. World Economic Forum. Harnessing the power of blockchain for a more sustainable food system; 2019. Available:https://www.weforum.org/impact/sustainable-food-system-solutions/
31. Mckinsey & Company. Global Agriculture 4.0: Transforming the food system with technology; 2020. Available:https://www.mckinsey.com/industries/agriculture/how-we-help-clients/agriculture-development-and-food-security

APPENDICES

Appendix A: Detailed Descriptive Data Tables

	Tech Adoption Rate	Agricultural Output	Agric Exports	Temperature Change
count	50.00	50.00	50.00	50.00
mean	6620.86	0.76	93.02	32.99
std	4406.98	0.16	11.74	1.03
min	1064.43	0.48	70.30	31.25
25%	3553.81	0.63	86.90	32.08
50%	5327.58	0.77	95.00	32.96
75%	8862.78	0.90	102.83	33.69
max	16929.29	1.03	112.20	36.00

Interpretation

- **Tech Adoption Rate**: Over the 50-year period, the average tech adoption rate is 66.21%, with a standard deviation of 44.07. This suggests significant variability in the rate of technology adoption over the years.
- **Agricultural Output**: The mean agricultural output is 0.76, with a standard deviation of 0.16. The range from the minimum (0.48) to the maximum (1.03) indicates fluctuations in agricultural output across the years.
- **Agric Exports**: The average agricultural exports are valued at 93.02, with a standard deviation of 11.74, indicating some variability in the export values.
- **Temperature Change**: The average temperature change recorded is 32.99°F with a standard deviation of 1.03°F. This shows a relatively consistent temperature pattern, with some variations over the years.

The above table provides a summary of the central tendency and dispersion of each variable, offering a comprehensive overview of the dataset's characteristics.

Appendix B: Technical Specifications of AgriTech Tools

1. **IoT Devices in Agriculture**:

Type: Sensor-based monitoring systems.

Function: Collect real-time data on various agricultural parameters like soil moisture, temperature, plant health, and environmental conditions.

Specifications:

1. Sensors equipped with wireless connectivity (Wi-Fi, Bluetooth, or cellular).
   GPS technology for precise location tracking.
   Compatibility with various agricultural equipment and machinery.
   Durable and weather-resistant design.
   Battery life suitable for extended field use.
   Data storage capabilities, either on-device or cloud-based.

2. AI Systems in Agriculture:

Type: Machine learning and data analytics platforms.

Function: Analyze agricultural data for insights into crop health, yield predictions, pest control, and weather forecasting.

Specifications:

Advanced machine learning algorithms capable of processing large datasets.
Integration with existing farm management software.
User-friendly interface for data interpretation and decision-making.
Real-time data processing capabilities.
Scalability to adapt to different farm sizes and types.
Security features to protect sensitive farm data.

3. Blockchain Platforms in Agriculture

Type: Distributed ledger technology.

Function: Provide transparency and traceability in agricultural supply chains from farm to consumer.

Specifications:

Decentralized network structure ensuring data integrity and security.
Smart contract functionality for automated transactions and record-keeping.
Compatibility with existing supply chain management systems.
Scalable architecture to handle large volumes of transactions.
User authentication and access control mechanisms.
Tools for data visualization and tracking along the supply chain.

Appendix C: Case Study Documentation

1. Case Study on Precision Agriculture in Corn Farming:

- **Location:** Iowa, USA
- **Farm Size:** 500 acres

Technologies Implemented:

- GPS-guided equipment for planting and harvesting.
- Soil fertility mapping systems.
- Variable Rate Technology (VRT) for fertilizer and pesticide application.

Data Collected

- Soil nutrient levels.
- Crop yield data per acre over five years.
- Fertilizer and pesticide usage records.

Results

- Increase in yield from 150 to 190 bushels per acre over five years.
- 15% reduction in fertilizer costs.

Narrative Description

- o The farm's transition to precision agriculture began with an initial investment in GPS-guided equipment. Soil sampling and mapping were conducted to identify variability within the fields. Based on this data, VRT was used to apply inputs only where needed, reducing wastage. Over the years, the farm's yield data showed a steady increase, validating the effectiveness of precision agriculture in enhancing productivity and reducing costs.

2. Case Study on IoT and AI in Dairy Farming:

- **Location:** California, USA
- **Farm Size:** 200 dairy cows

Technologies Implemented:

- o Sensor technology for monitoring cow health and activity.
- o AI-driven data analytics platform for health and productivity management.

Data Collected

- o Individual cow health metrics.
- o Milk production data.
- o Veterinary intervention records.

Results

- o 10% increase in milk yield.
- o 20% reduction in veterinary costs.

Narrative Description

- o Each cow was equipped with a sensor, providing continuous monitoring of health indicators. The AI system analyzed this data to predict health issues and optimize milking cycles. The technology enabled early intervention in health matters, reducing veterinary costs. It also maximized milk production through better herd management.

3. Case Study on Blockchain in Coffee Farming:

- **Location:** Colombia
- **Cooperative Size:** 100 smallholder coffee farmers

Technology Implemented

- o Blockchain platform for supply chain traceability.

Data Collected

- o Records of coffee bean journey from farm to consumer.
- o Pricing data at various stages of the supply chain.

Results

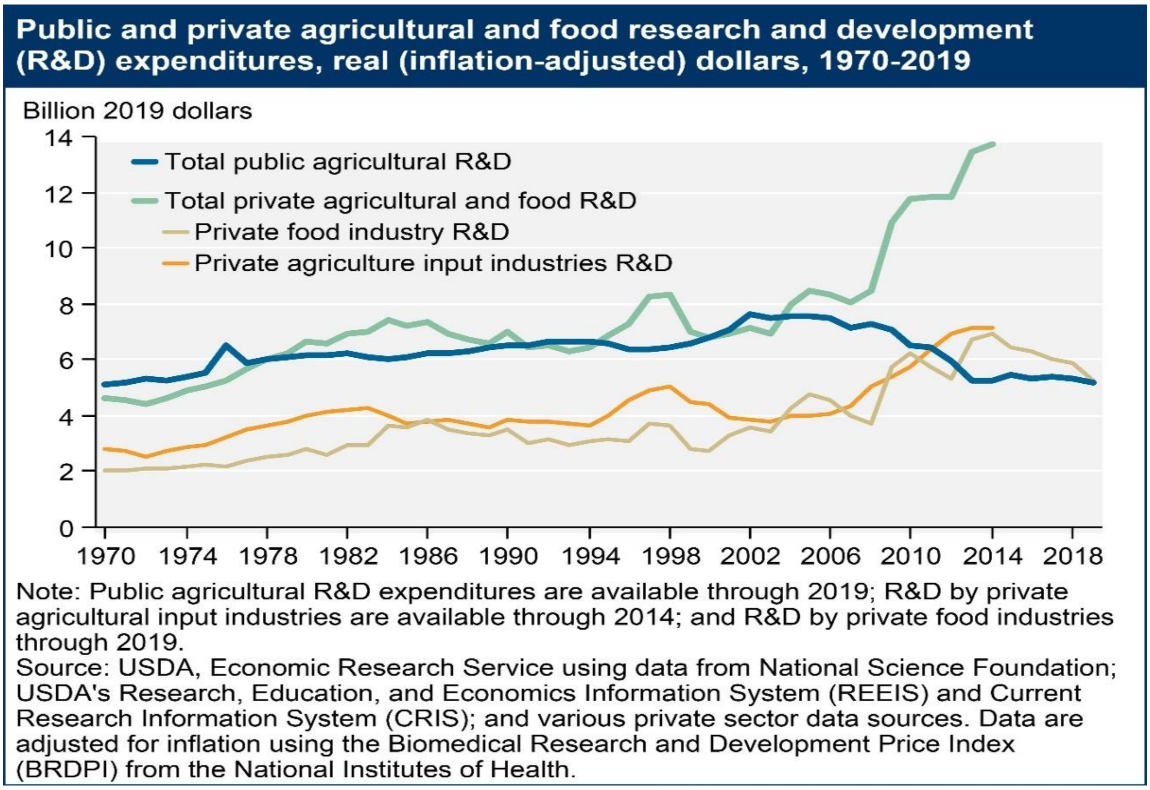
- o Increased prices for farmers due to consumer preference for traceable coffee.
- o Improved market access for smallholder farmers.

Narrative Description

- The cooperative implemented a blockchain system to track the journey of coffee beans. Each transaction, from harvest to sale, was recorded, providing consumers with a transparent view of the product's origin and handling. This transparency led to higher prices for the farmers and greater consumer trust in the product's quality and ethical sourcing.

Appendix E: Additional Graphs and Charts

The chart is a visual representation of data that were not included in the main body but provide relevant insights or expanded analysis.



Appendix F: Glossary of Terms

1. **AgriTech**: Short for Agricultural Technology, referring to the application of technology in agriculture to improve efficiency, productivity, and sustainability.
2. **AI (Artificial Intelligence)**: A field of computer science that focuses on creating systems capable of performing tasks that normally require human intelligence, such as decision-making, visual perception, and language understanding.
3. **Blockchain**: A system of recording information in a way that makes it difficult or impossible to change, hack, or cheat the system. It is a digital ledger of transactions that is duplicated and distributed across the entire network of computer systems.
4. **Data Analytics**: The process of analyzing raw data to find trends and answer questions. This involves the application of statistical analysis and other data analysis tools to discover useful information.
5. **GPS (Global Positioning System)**: A satellite-based navigation system used to determine the ground position of an object.
6. **IoT (Internet of Things)**: A network of physical objects ('things') that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet.

7. **Machine Learning**: A subset of AI that involves the use of data and algorithms to imitate the way that humans learn, gradually improving its accuracy.
8. **Precision Agriculture**: An agricultural management concept based on observing, measuring, and responding to variability in crops. It typically involves the use of GPS, sensors, and other technology to optimize field-level management with regard to crop farming.
9. **Smart Contract**: A self-executing contract with the terms of the agreement between buyer and seller being directly written into lines of code. It is often associated with blockchain technology.
10. **Variable Rate Technology (VRT)**: A technology used in precision agriculture that allows producers to vary the rate of crop inputs. It is used to optimize the distribution of inputs such as fertilizers and pesticides.
11. **Yield**: The measure of the amount of a crop produced per unit area.

Appendix G: Ethical Considerations and Methodology Details

Ethical Considerations

1. Data Privacy and Security:

- Given the use of secondary data involving potentially sensitive agricultural data, utmost care was taken to ensure the privacy and security of the data sources.
- Any personal or identifiable information in case studies or data sets was anonymized to protect the identity and privacy of individuals involved.

2. Use of Publicly Available Data

- This research primarily utilized data that is publicly available and published by reputable sources such as government agencies and academic journals.
- The use of publicly available data mitigates ethical concerns related to consent and confidentiality.

3. Transparency and Accuracy

- Efforts were made to accurately represent the data and findings from various sources without misinterpretation.
- Sources of data and information were clearly cited to maintain transparency and allow for verification of information.

Methodology Details

1. Research Approach

The study followed a quantitative research approach, utilizing statistical analysis to interpret the data.

This approach was chosen for its ability to objectively measure and analyze the impact of AgriTech on agriculture.

2. Data Collection

Data was collected from secondary sources including agricultural databases, academic journals, government reports, and case studies.

The criteria for data selection included relevance to AgriTech, recency of data, and credibility of the source.

3. Data Analysis

Python Statistical tool and its library software were used for data analysis.

Analysis included descriptive statistics to summarize the data, and inferential statistics to draw conclusions and test hypotheses.

Data visualization tools were used to create charts and graphs for a clearer understanding of trends and patterns.

4. Limitations of the Methodology

The reliance on secondary data limits the control over the data quality and may affect the comprehensiveness of the research.

Since the study does not involve primary data collection, direct insights from agricultural practitioners and experts are limited.

Appendix H: Data sources

Data Sources: The type of data considered in our study is secondary datasets. The data frame include agricultural production statistics, technology adoption rates, economic reports, and environmental impact assessments. Sources for these datasets include:

1. **United States Department of Agriculture (USDA) Economic Research Service**: Provides comprehensive data on agricultural economics, including technology adoption and farm economics.

- Reference: United States Department of Agriculture. Economic Research Service. [Data Sets]. Retrieved from https://www.ers.usda.gov/data-products/
- Description: This source offers extensive datasets on agricultural economics, including technology adoption, farm income, and cost analyses.

2. **Food and Agriculture Organization (FAO) of the United Nations – FAOSTAT**: A global source for data on agriculture, including technology use and sustainability metrics.

- Reference: Food and Agriculture Organization of the United Nations. FAOSTAT. [Data]. Retrieved from http://www.fao.org/faostat/en/#data
- Description: FAO's FAOSTAT database offers global data on agriculture, including technology use, sustainability metrics, and agricultural productivity.

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