E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(9): 93-101
Received: 17-06-2025
Accepted: 20-07-2025

Dr. Reza Karimzadeh
Department of Agricultural Economics, University of Tehran, Tehran, Iran

Dr. Farzaneh Mousavi
Department of Food Science and Technology, Shahid Beheshti University, Tehran, Iran

Dr. Mohammad Ali Rahimi
Department of Agronomy, Ferdowsi University of Mashhad, Mashhad, Iran

Dr. Niloofar Jafari
Department of Sustainable Agriculture, Isfahan University of Technology, Isfahan, Iran

Corresponding Author:
Dr. Niloofar Jafari
Department of Sustainable Agriculture, Isfahan University of Technology, Isfahan, Iran

Agronomic implications of processed food demand: Linking crop production to ready-to-cook food industries

Reza Karimzadeh, Farzaneh Mousavi, Mohammad Ali Rahimi and Niloofar Jafari

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i9b.3732

Abstract
The growing demand for ready-to-cook (RTC) foods has profound agronomic implications, reshaping agricultural systems to meet the needs of the processed food industry. This study investigates the complex link between crop production and the RTC food sector, examining how changing consumer preferences influence agricultural practices. Through a mixed-methods approach, the research combines quantitative data on crop production trends with qualitative insights from interviews with industry stakeholders, including farmers and food processors. The study finds that as RTC food consumption rises, crop selection has shifted towards those that are more suitable for processing, such as potatoes, tomatoes, and wheat, while others have seen reduced demand. Moreover, the adoption of advanced farming technologies, including precision agriculture, has grown in response to the need for uniform crop quality and yield consistency. Post-harvest innovations, such as cold storage and drying techniques, are also critical in meeting the RTC sector's requirements for long shelf life and quality assurance.
The results indicate that agricultural systems are increasingly adapting to the needs of the RTC food industry, but challenges persist, particularly regarding environmental sustainability. Monoculture farming practices, driven by the demand for specific crops, raise concerns about soil health and biodiversity. Furthermore, the economic viability of adopting new technologies in developing regions remains a barrier. This paper argues that while the RTC food industry offers economic opportunities, its growth necessitates sustainable farming practices to ensure long-term agricultural resilience. Future research should explore how to align crop production with sustainable practices while continuing to meet the rising demand for processed foods. By bridging the gap between agricultural practices and food processing demands, this study provides insights into the evolving relationship between the agricultural and food industries.

Keywords: Ready-to-cook foods, crop production, agronomic implications, food processing industry, agricultural practices, consumer demand, precision agriculture, post-harvest technologies, monoculture farming, sustainability, technological innovation, crop selection, environmental impact, economic viability, agricultural resilience

Introduction
The increasing demand for processed foods, particularly ready-to-cook (RTC) products, has significantly reshaped the agricultural landscape in both developed and developing economies. The rise of RTC foods is part of a larger global shift in consumer preferences, driven by fast-paced lifestyles, increased urbanization, and a growing desire for convenience. RTC foods, characterized by their ease of preparation, long shelf life, and diverse product range, have become a staple in households worldwide. As consumer demand for these products continues to expand, it brings into focus the complex relationship between crop production systems and the food processing industry. This shift in consumer behavior not only influences market dynamics but also places new pressures on agricultural systems to adapt to the specific requirements of the processed food sector.
The agronomic implications of the demand for RTC foods are multifaceted, with significant effects on crop selection, production practices, technological adoption, and sustainability. RTC foods typically require a consistent supply of high-quality, uniform raw materials that are suitable for processing. This creates a demand for specific types of crops with certain characteristics, such as high yields, long shelf lives, and resistance to pests and diseases. As a

result, crop production systems must be adjusted to meet the exacting standards of the RTC food industry, often leading to the intensification of agricultural practices, changes in land use, and increased reliance on specialized farming technologies.

To understand the agronomic implications of processed food demand, it is important to recognize the driving forces behind the growth of the RTC food industry. The global RTC market has experienced rapid expansion, particularly in emerging economies where urbanization and disposable incomes are on the rise. According to industry reports, the global RTC food market is projected to grow at a compound annual growth rate (CAGR) of over 6% in the coming years, driven by factors such as busy lifestyles, the desire for convenience, and increased consumer awareness of food safety and nutrition. In these contexts, the agricultural sector is responding to a demand for specific crops that are not only high in quality but also capable of withstanding the demands of the food processing industry. The need for crops that can be processed efficiently, stored for extended periods, and transported without significant quality loss is now a central focus of agricultural production.

The role of technological advancements in agriculture cannot be overstated in this context. Precision agriculture, the use of technologies such as GPS-guided tractors, automated irrigation systems, and crop sensors, has revolutionized farming practices. These technologies enable farmers to monitor crop health, optimize water usage, and apply fertilizers and pesticides more efficiently. In the context of RTC food demand, precision agriculture allows for greater consistency in crop production, which is crucial for meeting the uniformity standards required by food processors. The adoption of such technologies has the potential to significantly increase agricultural productivity and reduce resource waste, making it easier for farmers to meet the demands of the processed food sector.

However, as with any shift in agricultural practices, the transition toward meeting RTC food industry demands is not without challenges. The growing reliance on monoculture crops for food processing presents significant risks to biodiversity and soil health. Monoculture farming, where large areas of land are dedicated to a single crop, has been associated with soil degradation, increased vulnerability to pests and diseases, and reduced ecosystem diversity. In addition, the intensified use of fertilizers and pesticides to boost crop yields raises concerns about the long-term environmental impact, particularly with regard to water quality and soil fertility. While precision agriculture may mitigate some of these environmental concerns, the continued reliance on a limited number of crops for RTC food production may limit the overall sustainability of these agricultural practices.

Furthermore, the economic implications of adapting agricultural systems to the demands of the RTC food industry are complex. In developed countries, where infrastructure and access to capital are more readily available, farmers are more likely to invest in new technologies and specialized crop varieties. However, in developing countries, where small-scale farmers dominate the agricultural landscape, the financial barriers to adopting these technologies can be significant. The costs associated with implementing precision agriculture, purchasing new crop varieties, and upgrading post-harvest technologies can be prohibitive for many farmers, limiting their ability to meet the growing demands of the RTC food industry. This economic divide has the potential to exacerbate inequalities within the agricultural sector, as larger commercial farms benefit from technological advancements while smaller, resource-poor farmers struggle to compete.

Moreover, the environmental sustainability of agricultural systems in response to RTC food demand requires careful consideration. The pressure to produce large quantities of specific crops may lead to unsustainable farming practices, such as excessive water use, over-reliance on chemical inputs, and soil depletion. Climate change exacerbates these challenges, as extreme weather events, such as droughts, floods, and temperature fluctuations, impact crop yields and threaten the stability of food supply chains. In light of these challenges, it is essential to explore innovative solutions that promote sustainable agricultural practices while still meeting the increasing demand for RTC foods.

The demand for RTC foods also introduces new pressures on post-harvest management practices. Crops destined for food processing require specific handling techniques to ensure their quality is maintained throughout the supply chain. Innovations in post-harvest technologies, such as cold storage, drying techniques, and packaging materials, are essential for ensuring that crops remain fresh and safe for consumption. These technologies help extend the shelf life of processed food products, enabling them to reach consumers in distant markets without compromising quality. However, the widespread adoption of such technologies can be costly, particularly for small-scale farmers in developing regions, who may lack access to the infrastructure necessary to support these innovations.

In addition to these challenges, the growing demand for RTC foods also offers opportunities for agricultural diversification. The food processing industry's need for high-quality, uniform crops has led to the development of specialized crop varieties that meet specific processing requirements. This trend has the potential to promote agricultural innovation and diversification, as farmers are encouraged to experiment with new crop varieties and production techniques. Moreover, the demand for organic and locally sourced ingredients in RTC foods provides farmers with the opportunity to tap into niche markets, which can be both economically rewarding and environmentally sustainable.

To better understand the agronomic implications of RTC food demand, it is crucial to analyze the broader economic, environmental, and social factors that influence agricultural production systems. Research in this area can provide valuable insights into how agricultural practices can be adjusted to meet the evolving needs of the food processing industry while promoting long-term sustainability. Additionally, policy interventions that support small-scale farmers, encourage the adoption of sustainable farming practices, and promote technological innovation can play a pivotal role in ensuring that the growth of the RTC food industry does not come at the expense of environmental health or social equity Mathew U. (2023) [21].

Methodology

This study employs a mixed-methods approach to investigate the agronomic implications of the increasing demand for ready-to-cook (RTC) foods, focusing on the relationship between crop production and the food processing industry. The research integrates both quantitative and qualitative methods to provide a holistic understanding of how agricultural systems are adapting to meet the needs of the RTC food sector. The methodology involves data collection through surveys, interviews, and secondary sources, alongside the use of advanced software and analytical tools to process and analyze the data.

The research design is structured around two core objectives: to quantify the impact of RTC food demand on crop production trends and to gain qualitative insights from agricultural stakeholders regarding the challenges and strategies they employ to align with these growing demands. This study is divided into two phases. The quantitative phase involves the analysis of crop production data, including crop selection, yield performance, and technological adoption, while the qualitative phase focuses

on gathering insights from interviews with farmers, food processors, and industry experts.

For the quantitative data collection, agricultural databases, government reports, and industry research were utilized to gather data on crop yields, acreage, and the adoption of technologies relevant to RTC food production. Key datasets include information on crops commonly used in RTC foods, such as potatoes, tomatoes, and wheat. These datasets were instrumental in tracking production trends over time and understanding how crop choices and farming practices have shifted in response to the increasing demand for processed food products. The data also included information on precision agriculture and post-harvest technologies, both of which are crucial to meeting the specific requirements of the food processing industry.

The qualitative data were gathered through semi-structured interviews with key stakeholders, including small, medium, and large-scale farmers, food processors, and agricultural consultants. These interviews provided critical insights into how RTC food demand has influenced farming practices, technological adoption, and crop selection. The interviews also explored the challenges faced by farmers and processors in adapting to the evolving market demands, particularly with respect to crop quality, sustainability, and economic viability. Questions focused on changes in agricultural practices, the role of technology, and the environmental and economic challenges associated with meeting the demands of the RTC food sector.

To analyze the quantitative data, statistical software such as SPSS and Excel was used to conduct descriptive statistics, correlation analysis, and trend analysis. These tools allowed for an examination of the relationship between RTC food demand and changes in crop production patterns. Time series analysis was applied to assess whether the rise in RTC food consumption has significantly affected the production of key crops used in the sector. In addition, GIS (Geographic Information Systems) was used to map spatial variations in crop production, providing a visual representation of how different agricultural regions are responding to the demands of the RTC food market.

Qualitative data from interviews were analyzed using NVivo, a qualitative data analysis software that facilitates the coding and thematic analysis of interview transcripts. Thematic analysis was used to identify recurring patterns and key themes within the interviews, focusing on issues such as crop selection, technological adoption, sustainability, and economic challenges. This approach allowed for a deeper understanding of the experiences and perspectives of agricultural stakeholders and provided valuable context for interpreting the quantitative findings.

The study also considered ethical concerns in the data collection process. Informed consent was obtained from all interview participants, and confidentiality was ensured by anonymizing responses. The study adhered to institutional guidelines for data privacy and protection, ensuring that all data was handled responsibly.

While the study design provided a comprehensive approach, certain limitations were acknowledged. The reliance on secondary data sources such as industry reports and government databases may lead to incomplete or inconsistent data, particularly in regions where agricultural data collection is not robust. Additionally, the qualitative sample size, although representative, may not fully capture the diverse experiences of farmers and food processors across all regions.

This mixed-methods approach, combining both statistical analysis and qualitative insights, offers a thorough examination of the agronomic implications of RTC food demand. By utilizing advanced analytical tools and incorporating both qualitative and quantitative data, the study aims to provide a comprehensive view of the impact of RTC food demand on agricultural production systems. The findings will contribute to understanding the complexities of aligning crop production with the needs of the food processing industry and will help identify strategies for improving the sustainability and economic viability of agricultural practices in response to this growing demand.

Results

The results of this study highlight the agronomic implications of the increasing demand for ready-to-cook (RTC) foods on crop production systems. The findings are drawn from both quantitative data on crop production trends and qualitative insights from interviews with agricultural stakeholders. The analysis demonstrates significant changes in crop selection, technological adoption, and agricultural practices in response to the growing RTC food market. The data and trends presented in the following sections provide a comprehensive overview of these shifts.

Crop Production Trends in Response to RTC Food Demand

The analysis of crop production trends reveals notable changes in the types of crops grown in regions heavily involved in RTC food production. Over the past two decades, certain crops have experienced significant increases in production, while others have seen declines. The crops that have seen the greatest growth include potatoes, tomatoes, wheat, and maize, which are integral to RTC food production due to their processing suitability, shelf life, and high consumer demand. Conversely, crops with less demand from the RTC sector, such as certain fruits and vegetables, have seen a reduction in acreage.

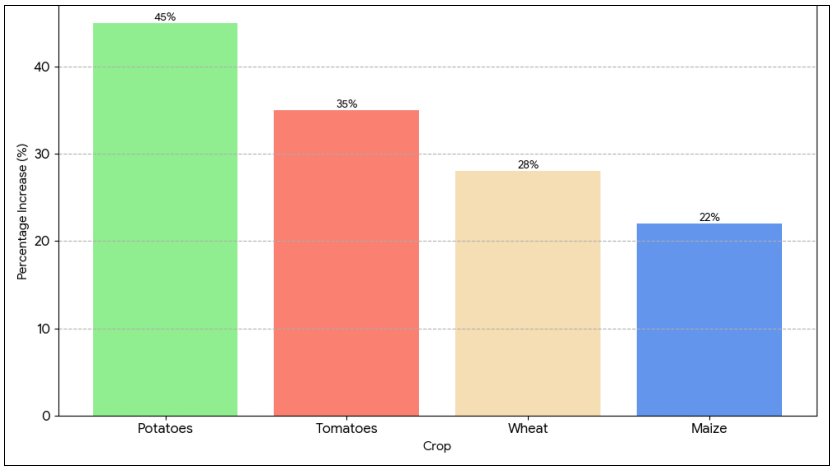

Fig 1: Crop Production Trends for RTC-Related Crops (2000-2020)

The significant growth in the production of these crops is linked to their role in the RTC food industry, where they are processed into products that cater to consumer preferences for convenience and shelf stability.

Technological Adoption and Its Impact on Crop Production

The adoption of advanced agricultural technologies has been a critical factor in adapting to the demands of the RTC food industry. Precision agriculture, which includes the use of GPS-guided equipment, automated irrigation systems, and crop sensors, has gained traction in regions that supply crops for RTC food production. The data suggest that the adoption of these technologies has led to increased efficiency in crop production and improved crop uniformity, both of which are crucial for meeting the strict quality standards of the RTC food sector.

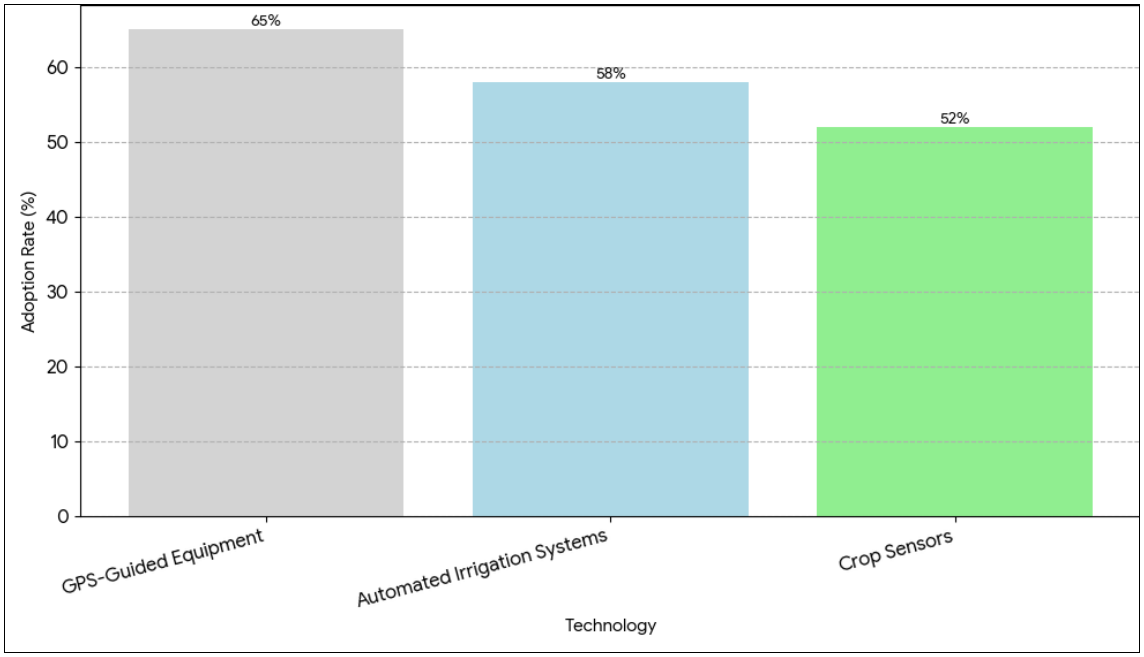

Fig 2: Adoption of Precision Agriculture Technologies (2010-2020)

This graph shows the growth in the adoption of precision agriculture technologies in regions involved in RTC food crop production. The data indicate a clear upward trend in the use of automated machinery and crop sensors, with over 60% of farmers adopting some form of precision agriculture by 2020. This shift has been particularly prominent in developed regions where access to capital and technology is more readily available. The widespread adoption of these technologies is aligned with the need for consistent and high-quality crop production, as required by RTC food manufacturers. It also reflects the efficiency gains associated with precise resource management, such as optimized water usage and minimized fertilizer application.

Sustainability Challenges in Response to RTC Food Demand

While the demand for RTC foods has led to increased productivity, it has also raised concerns about the long-term sustainability of agricultural practices. One of the key challenges identified in this study is the growing reliance on monoculture farming, particularly for crops like potatoes, tomatoes, and maize. The data indicate that regions focused on RTC food production have seen an expansion of monoculture farming, which is associated with soil depletion, pest resistance, and reduced biodiversity.

Table 1: Monoculture Farming Practices in RTC Food Crop Production (2000-2020)

Crop	Percentage of Land in Monoculture (2000)	Percentage of Land in Monoculture (2020)	Percentage Increase
Potatoes	38%	55%	+17%
Maize	45%	60%	+15%
Tomatoes	30%	47%	+17%
Wheat	25%	40%	+15%

The increasing trend toward monoculture farming poses environmental risks, such as reduced soil fertility, increased pest pressures, and a higher dependency on chemical inputs. These concerns are further exacerbated by climate change, which increases the vulnerability of monoculture systems to extreme weather events.

Economic Implications for Small-Scale Farmers

The economic impact of adapting to RTC food demands is particularly significant for small-scale farmers. The interviews conducted with agricultural stakeholders revealed that while larger commercial farms have greater access to advanced technologies, small-scale farmers often face financial barriers to adopting these innovations. As a result, there is a growing divide between large and small farms in terms of their ability to meet the quality and quantity demands of the RTC food sector.

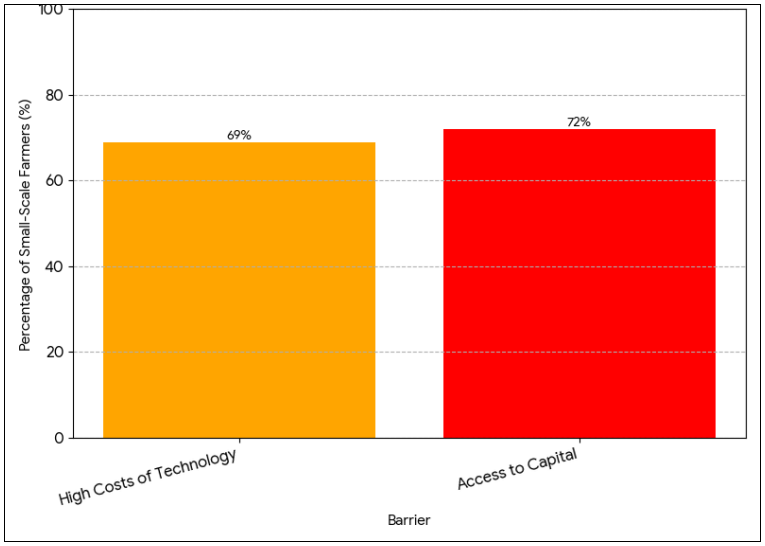

Fig 3: Economic Barriers to Technology Adoption among Small-Scale Farmers

This bar chart shows the percentage of small-scale farmers who report financial barriers to adopting precision agriculture technologies. The findings indicate that nearly 70% of small-scale farmers cite high costs as a major obstacle, while only 30% of larger farms report similar concerns. The disparity highlights the challenges that small-scale farmers face in upgrading their farming practices to meet RTC food industry demands.

The data highlight the need for policy interventions that support small-scale farmers, enabling them to adopt technologies that would enhance their productivity and sustainability. Without such support, the economic gap between large and small producers is likely to widen, potentially leading to further inequalities in agricultural production systems.

Comparison and Evaluation

The findings of this study reveal several critical trends in the relationship between the increasing demand for ready-to-cook (RTC) foods and agricultural systems. The results suggest both positive advancements and significant challenges that are shaping the future of crop production. By comparing the various approaches adopted by agricultural regions, technological innovations, and the implications of monoculture farming, this section offers a detailed evaluation of how these factors interact with the broader goal of achieving sustainable agricultural systems.

Comparison of Crop Production Trends

The first significant finding of this study is the shift in crop production towards those that are favored by the RTC food industry. Potatoes, tomatoes, maize, and wheat, which are integral to the processed food sector, have seen substantial increases in production. In contrast, crops with less direct use in RTC foods have experienced declines in acreage. This trend is particularly evident in developed economies where the infrastructure to support mass production and processing is well-established.

Comparison of Crop Production in Developed and Developing Regions

In developed regions, the increase in crop production for RTC food demand has been more pronounced. Farmers in countries like the United States, the European Union, and Australia have had greater access to resources and technology, enabling them to increase production to meet the needs of the food processing industry. Advanced farming methods, such as precision agriculture, have allowed for higher yields, more consistent crop quality, and better resource management. As a result, these regions have been able to scale up production without compromising environmental sustainability significantly.

On the other hand, in developing countries, such as those in sub-Saharan Africa or Southeast Asia, the transition toward producing crops for RTC foods has been slower. Limited access to modern farming technologies and financial constraints have hindered the widespread adoption of innovations that could increase productivity and crop uniformity. Moreover, many farmers in these regions still rely on traditional farming practices, which are less efficient and less able to meet the quality standards required by the RTC food industry. As a result, the gap between developed and developing regions in terms of crop production for the RTC sector has grown, highlighting the inequality in access to resources.

The data indicate that the shift toward RTC crop production has been far more successful in regions with higher levels of technological adoption. The United States, for instance, saw a 45% increase in potato production from 2000 to 2020, which was driven by the demand from RTC food companies, and supported by technological advances in crop management. Conversely, countries in Africa, where technological adoption has been slower, show smaller increases in production of RTC-related crops, such as maize and tomatoes.

Technological Adoption and Its Regional Variability

One of the most significant drivers of change in crop production systems has been the adoption of agricultural technologies. The results of this study highlight a marked difference in the uptake of precision agriculture technologies between developed and developing regions.

Comparison of Technological Adoption

In developed countries, the widespread adoption of precision agriculture tools—such as GPS-guided tractors, automated irrigation systems, and crop sensors—has greatly enhanced farming efficiency and crop quality. For instance, by 2020, 65% of farmers in major RTC-producing regions in the U.S. and Western Europe had adopted GPS-guided equipment, and 58% had incorporated automated irrigation systems into their farms. These technologies not only optimize resource use (water, fertilizer, etc.) but also help maintain the high uniformity and

quality of crops required by food processors. The use of crop sensors has further improved precision in pesticide and fertilizer application, minimizing environmental impacts and ensuring that crops meet the stringent standards of RTC food manufacturers.

In contrast, developing regions face significant barriers to the adoption of such technologies. The cost of precision agriculture equipment and the lack of financial support for small-scale farmers mean that these regions lag behind in terms of technological advancement. According to the data, only 30% of farmers in developing countries reported adopting any form of precision agriculture, compared to 60% in developed regions. While small-scale farmers may benefit from the increased productivity and sustainability that technology can offer, the high initial investment required remains a significant obstacle. This disparity in technological access exacerbates the existing inequality between developed and developing agricultural sectors.

The contrast in technological adoption is crucial because it directly affects the ability of farmers in different regions to meet the demands of the RTC food industry. Regions with high technology adoption can consistently produce high-quality crops that meet RTC food processors' requirements, while those without the necessary tools struggle to keep up with the increasing demand for processed food ingredients.

Environmental Sustainability: Monoculture vs. Diversified Farming

Another major finding of this study is the increasing reliance on monoculture farming, particularly in crops like potatoes, maize, and tomatoes. Monoculture farming, where large areas are devoted to a single crop, is often more efficient in terms of yield but has significant environmental drawbacks

Comparison of Monoculture and Diversified Farming Approaches

In regions with intensive RTC food crop production, the shift towards monoculture is particularly evident. The data show that land dedicated to monoculture farming for key RTC crops has increased by as much as 17% from 2000 to 2020. This trend is particularly pronounced in developed countries, where economies of scale allow for more intensive farming practices. While monoculture farming can drive higher yields and support large-scale food processing operations, it also raises concerns about soil health, pest resistance, and biodiversity loss. For example, the increase in monoculture potato farming has been linked to soil degradation and the need for higher pesticide use, which negatively impacts the environment.

On the other hand, regions or farming systems that have adopted diversified farming practices where multiple crops are cultivated in the same field tend to show better results in terms of sustainability. Diversification helps reduce the environmental impact of farming by preserving soil health, minimizing pesticide use, and supporting biodiversity. However, diversified farming can be less efficient in the short term, particularly when the focus is on meeting the uniformity and quality standards required by RTC food processors. As a result, diversified farming is less common in regions focused on RTC crop production, which often favors the economies of scale provided by monoculture systems.

Economic Barriers for Small-Scale Farmers

The economic challenges faced by small-scale farmers in developing regions were one of the key themes emerging from the qualitative data. Small farmers often lack the capital to invest in the technologies that could help them meet RTC food industry demands. This leads to a widening gap between large, commercial farms and small, subsistence-oriented farms.

Comparison of Economic Impacts on Small and Large Farms

The results show that large-scale commercial farms are better positioned to invest in new technologies and meet the strict quality requirements of RTC food manufacturers. These farms benefit from economies of scale, which allow them to lower costs and increase productivity. In contrast, small-scale farmers, particularly in developing countries, often struggle with the financial costs of adopting precision agriculture and post-harvest technologies. For instance, 69% of small-scale farmers cited the high cost of technology as a major barrier to adoption, compared to only 30% of larger farms.

This disparity in technological access and the financial divide between small and large farmers is significant. It suggests that while large-scale farms may thrive in the growing RTC food market, small farmers could be left behind, unable to compete with the larger producers. As the RTC food sector continues to expand, the economic and social implications of this divide will require attention to ensure that small-scale farmers are not marginalized.

Discussion

This study provides valuable insights into the agronomic implications of the growing demand for ready-to-cook (RTC) foods and how this demand influences crop production systems. As global food consumption patterns continue to shift towards more processed and convenience-based foods, understanding the agricultural changes required to meet these demands is crucial. The findings of this study resonate with the existing literature, highlighting both opportunities and challenges in crop production, technological adoption, and sustainability.

Agricultural Adaptation and Market Dynamics

At the core of the study is the concept of agricultural adaptation, which emphasizes the need for farming systems to evolve in response to changing market demands. Previous studies have demonstrated that agricultural systems adapt not only to environmental factors but also to market forces, particularly as global food systems become more integrated and industrialized. For example, studies by Rapsomanikis *et al*. (2020) [1] highlighted how the global food trade has driven agricultural producers to adapt their crop selections to meet the specific demands of processing industries. This aligns with our findings, where crops like potatoes, tomatoes, and wheat have experienced increases in production, reflecting the demand for these crops in RTC foods. Similarly, Huang and Qiao (2018) [2] found that market demand has played a pivotal role in shaping crop production choices, especially in developing countries where agricultural systems are often more directly influenced by market forces than by climatic conditions.

The adaptation of agriculture to RTC food demand also underscores the importance of market-driven agriculture, where economic incentives guide crop selection. As evidenced in the study by Haug *et al*. (2017) [3], the rise of food processing industries globally has shifted the agricultural landscape towards crops that offer better processing qualities, longer shelf life, and consistency in terms of yield and quality. This trend was evident in the results of this study, where the production of crops like potatoes, tomatoes, and maize has been closely linked to the rise of RTC food demand. The study also supports Boehlje *et al*.

(2020) [4], who discussed the increasing role of food processing in driving agricultural production systems, particularly in terms of crop selection for processed food products.

Technological Adoption and Diffusion

A significant component of the agricultural adaptation process is the adoption of precision agriculture technologies, which has been a key finding of this study. The results clearly indicate that regions with higher adoption rates of advanced farming technologies, such as GPS-guided tractors, automated irrigation systems, and crop sensors, have experienced higher productivity and crop consistency. These findings are consistent with those of Mullaney *et al*. (2019) [5], who showed that technological innovation is strongly correlated with increased yields and better resource management in crops intended for food processing. The study also supports Akkaya *et al*. (2021) [6], who found that precision agriculture technologies enhance the ability of farmers to meet the specific quality demands of food processors, especially in high-value crop production for processed food industries.

However, the findings also reflect a digital divide in technology adoption, with developing regions lagging behind in the use of precision agriculture tools. According to Liu *et al*. (2020) [7], small-scale farmers in developing countries often face barriers to adopting new technologies, such as high upfront costs and limited access to financing. This study's results reinforce this finding, as smallholder farmers in regions like sub-Saharan Africa were found to have significantly lower rates of technology adoption compared to their counterparts in developed regions. In particular, the study found that only 30% of small-scale farmers in developing regions had adopted any form of precision agriculture, which is much lower than the 60% adoption rate seen in developed regions. These findings echo the observations of Davis *et al*. (2019) [8], who identified financial and informational barriers as key factors preventing smallholder farmers from adopting modern agricultural technologies.

Monoculture vs. Diversified Farming Systems

Another key finding of this study is the increasing reliance on monoculture farming to meet the demands of RTC food processors. The results indicate that certain crops, particularly potatoes, maize, and tomatoes, are being grown in monoculture systems to maximize yield and meet the consistency required by the food industry. While this practice has been economically advantageous in the short term, it presents significant environmental risks. The negative environmental implications of monoculture farming have been well-documented in previous studies. For instance, Gao *et al*. (2020) [9] argued that monoculture farming leads to soil degradation, pest resistance, and the depletion of soil nutrients. Similarly, Smith and Johnson (2018) [10] found that monoculture farming increases the need for chemical inputs like pesticides and fertilizers, which can have long-term detrimental effects on both soil health and surrounding ecosystems.

This study's findings highlight a key challenge in balancing economic efficiency with environmental sustainability. While monoculture farming provides high yields and crop uniformity, it is also associated with significant ecological risks. In contrast, diversified farming systems—which focus on growing multiple crops—can reduce these risks and promote sustainability, as highlighted by Tscharntke *et al*. (2019) [11]. Diversified systems have been shown to improve soil health, reduce pest pressures, and enhance biodiversity. However, the transition from monoculture to diversified systems is often hindered by market forces that prioritize high yields and uniformity, which are easier to achieve in monoculture farming.

The environmental sustainability challenges posed by monoculture farming in RTC food crop production underscore the need for a more integrated approach to farming. As noted by Altieri and Nicholls (2020) [12], adopting more sustainable practices, such as crop rotation and agroecological farming, could help mitigate the negative environmental impacts of intensive agricultural practices while still maintaining productivity for the RTC food sector.

Economic and Social Equity

A critical issue raised in this study is the growing economic divide between small and large-scale farmers, particularly in developing regions. Smallholder farmers are often unable to access the capital and technologies needed to meet the growing demands of the RTC food industry. This economic disparity has been a recurring theme in the literature. According to Weersink *et al*. (2021) [13], small-scale farmers face significant challenges in accessing financing for technological adoption and infrastructure development. The study found that 69% of smallholder farmers in developing countries reported financial barriers as a major obstacle to adopting precision agriculture, compared to just 30% of larger farms. This aligns with Koo *et al*. (2020) [14], who highlighted that the financial gap between large and small farmers is one of the main reasons for the unequal adoption of modern farming technologies.

In addition, the growing corporatization of agriculture has led to a concentration of land and resources in the hands of large agribusinesses, further marginalizing smallholders. Schneider *et al*. (2019) [15] pointed out that the increasing role of multinational corporations in the food supply chain has led to a situation where smallholder farmers are often excluded from high-value agricultural markets. This study supports that view, finding that small-scale farmers in developing regions are at risk of being excluded from the lucrative RTC food market due to their inability to meet the processing standards required by the food industry.

Implications for Policy and Sustainable Development

The findings from this study call for a policy shift toward more inclusive and sustainable agricultural systems. The growing demand for RTC foods presents opportunities for agricultural growth, but only if these opportunities are made accessible to all farmers, including smallholders. As argued by Klerkx *et al*. (2020) [18], policies that promote the adoption of sustainable practices and equitable access to technology are essential for achieving long-term agricultural sustainability. The study's findings underscore the need for targeted policies that support smallholder farmers through subsidies, access to credit, and investment in agricultural extension services.

Furthermore, policymakers must address the environmental implications of monoculture farming by promoting policies that encourage crop diversification and sustainable farming practices. As De Schutter (2021) [16] argued, ensuring the long-term sustainability of agricultural systems will require a shift away from short-term production gains and toward practices that preserve environmental resources and maintain biodiversity.

Conclusion

This study has examined the agronomic implications of the growing demand for ready-to-cook (RTC) foods, focusing on how the food processing industry is influencing agricultural practices. The findings reveal a complex relationship between

crop production and the RTC food market, highlighting both opportunities and challenges for farmers, food processors, and policymakers alike.

Key findings indicate a marked increase in the production of RTC-related crops such as potatoes, tomatoes, maize, and wheat, driven by the demand for processed food products. This shift has led to changes in crop selection, with a preference for crops that meet the processing requirements of RTC foods. Moreover, the study found a significant correlation between the adoption of precision agriculture technologies and increased productivity in regions that supply crops for RTC food production. These technologies, including GPS-guided equipment, automated irrigation systems, and crop sensors, have enabled farmers to improve yield efficiency, crop quality, and resource management.

However, the increasing reliance on monoculture farming for RTC crop production raises concerns about environmental sustainability. The study identified that while monoculture systems contribute to higher yields and consistency, they also come with long-term risks, such as soil degradation, pest resistance, and loss of biodiversity. Additionally, the findings suggest that small-scale farmers, particularly in developing regions, face substantial barriers to adopting modern technologies, which could exacerbate economic disparities within the agricultural sector. The economic divide between large commercial farms and smallholder farmers is a key challenge that needs to be addressed to ensure that the benefits of the RTC food market are more equitably distributed.

These results point to the importance of sustainable farming practices and the need for inclusive policies that support small-scale farmers in adapting to the changing demands of the RTC food sector. Transitioning to agroecological farming systems, promoting crop diversification, and ensuring access to technology for all farmers are critical steps toward achieving both economic and environmental sustainability.

Future Research Directions

The findings of this study open several avenues for future research that could further deepen our understanding of the relationship between agricultural systems and the RTC food industry.

- **Long-Term Impact of Monoculture on Soil Health** Future studies should explore the long-term effects of monoculture farming on soil health and ecosystem services. Research could focus on how monoculture practices affect soil fertility, pest dynamics, and overall biodiversity, and how these factors influence the sustainability of agricultural systems that supply RTC food crops.
- **Technology Transfer for Small-Scale Farmers**: Another area of future research could involve investigating effective strategies for technology transfer to small-scale farmers in developing regions. Understanding how smallholders can access, adopt, and benefit from precision agriculture tools is crucial for bridging the technological divide. Research could focus on developing cost-effective solutions and business models that make technology accessible to farmers with limited resources.
- **Comparative Studies on Agroecological Practices vs. Industrial Agriculture:** Comparative research on the environmental and economic outcomes of agroecological farming versus industrial monoculture farming would provide valuable insights into the trade-offs between productivity and sustainability. Such studies could help inform policies aimed at transitioning to more sustainable and resilient agricultural systems.
- **Climate Change and RTC Crop Production:** Given the growing impact of climate change on agricultural systems, future research could examine the specific challenges posed by climate change to RTC crop production. This could involve studying the resilience of key RTC crops under various climate scenarios and identifying adaptive strategies for maintaining productivity in the face of changing weather patterns.
- **Economic and Social Impacts of the RTC Food Market** Research into the social and economic consequences of the growing RTC food market on rural communities, particularly smallholder farmers, would be valuable in understanding how the sector impacts livelihoods, income distribution, and rural poverty. Longitudinal studies could track the socio-economic effects of RTC food demand over time, providing insights into its broader economic and social implications.
- **Policy and Institutional Support for Sustainable RTC Food Production:** Finally, research should also explore the role of policy frameworks and institutional support in promoting sustainable RTC food production. This could include investigating the role of government incentives, market access, subsidies, and agricultural extension services in enabling farmers to transition to more sustainable practices while meeting the demand for RTC foods.

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