

**The 5<sup>th</sup> Advances in Business Research Conference 2023**  
**Langkawi Island, Malaysia, 27 Sep 2023**

Organised by: Faculty of Business and Management, UiTM Puncak Alam, Selangor, Malaysia

**Adopting Innovations in Agri-Tech Sector for a Sustainable Future**

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**Abstract**

The global food chain has been affected by climate change and geopolitical conflicts. To guarantee access to food, food production must be increased as predicted in the next 30 years, the world's population is to surpass 10 billion. This study aims to examine current and future developments in the food industry with a particular emphasis on how agri-tech companies and startups will react. The main purpose is to examine how agri-tech innovations are adopted, to identify the capacity-building requirements for improved data utilization, and to look at the financial and intermediary variables impacting innovation uptake.

**Keywords:** Adopting Innovations; Agri-Tech; Sustainable;

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DOI: <https://doi.org/10.21834/e-bpj.v9iSI%2019.5773>

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**1.0 Introduction**

The COVID-19 epidemic, climate change, and Russia's - Ukraine crisis have all disrupted the current state of the world's food system (Allam et al., 2022). It is estimated that in the next 30 years, the global population will reach over 10 billion people which means that food production will have to expand by at least 70 per cent to ensure that everyone has access to food (Numa, Wolf & Pastore, 2023). Currently, there is a significant loss and waste of food in a world where almost 1 billion people are already undernourished. According to Lindgren et al. (2018) and the FAO (2018), almost one-third of all food produced on farms, in factories, markets, and our homes is wasted. In light of this, the idea of "Agri-Tech" emerges, which refers to businesses that change the agricultural industry through the use of new technologies to create a new market that is smarter, healthier, sustainable, dynamic, and flexible. Innovation is the core action for the development and productivity of any economic activity. Research institutions and the food industry are looking for ways to produce food that promotes health, increases food security, and achieves environmental sustainability (Zickafoose, Lu & Baker, 2022). The primary objective of this study is to understand the adoption of innovation in the AgriTech sector for a sustainable future.

**1.1 Background of the study**

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DOI: <https://doi.org/10.21834/e-bpj.v9iSI%2019.5773>

Future food sustainability depends on improvements in agricultural production, agribusiness market profitability, and food technology innovations (Zickafoose, Lu & Baker, 2022). This study will analyse the recent advancements in the food industry and identify upcoming developments that will continue. Additionally, it can aid in the analysis of how organisations and the business community will react to upcoming advances. The inclusion of sustainability in this study emphasises the experts' focus on adopting innovation and technology in the production of food in the agri-food sector while catering for a growing population (Liang, Jia & Ooi, 2019). Currently, very little research has been conducted to determine the perception of Malaysians towards this technology (Liang, Jia & Ooi, 2019).

### 1.2 Problem statement

The agri-tech sector in Malaysia is struggling with several obstacles that are delaying its development and ability to promote productive and sustainable agriculture practices. The challenges include traditional agricultural practices, limited access to new technology, a slow uptake of digital solutions, and insufficient assistance for small-scale farms. These factors contribute to lower yields, higher production costs, impact on the environment, and lessening global agricultural market competition (Ministry of Agriculture and Food Industries Malaysia, 2021). Therefore, the agri-tech sector needs creative solutions to reduce these difficulties. The agri-tech sector can play a key role in enhancing productivity, profitability, and environmental sustainability by providing affordable and user-friendly technologies, enhancing access to financing and technical support, promoting data-driven decision-making, and supporting sustainable farming practices (Ministry of Agriculture and Food Industries Malaysia, 2021).

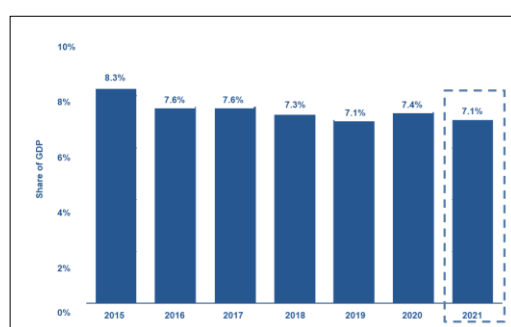


Fig. 1: Contribution of agriculture to the Gross Domestic Product (GDP) of Malaysia from 2015 to 2021  
(Source: Department of Statistics Malaysia - DOSM)

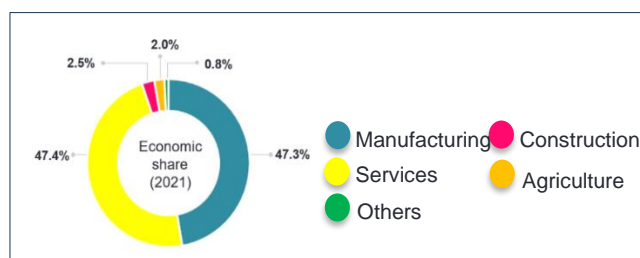


Fig. 2: Contribution of agriculture to the Gross Domestic Product (GDP) of Penang for year 2021  
(Source: Department of Statistics Malaysia - DOSM)

The agricultural sectors in Malaysia contributed 7.1 per cent to the country's GDP in the year 2021 as per in Figure 1 while the agricultural sectors in Penang contributed two per cent to the state's GDP in the same year after manufacturing, services and construction sectors as per shown in Figure 2. Penang's agricultural land accounts for around forty per cent of the total landmass in Penang. It is expected that the size of agricultural land will decrease from 43,278 hectares in 2015 to 36,405 hectares by 2030 (Penang State Government (Penang 2030 Vision). Smallholder farmers frequently struggle to obtain and implement agricultural technology, due to obstacles including limited resources, ignorance, and inadequate training. For sustainable agricultural development, smallholder farmers must close the gap and employ more technology (Lowder, Sánchez & Bertini, 2021). The lack of specified data formats among various agricultural technologies and platforms makes it difficult to integrate and share data effectively. To enable data-driven decision-making and increase the overall effectiveness of agricultural systems, it is vital to establish consistent guidelines and protocols (Klerkx, Aarts & Leeuwis, 2020). Research can also be done on resource management techniques, sustainable agricultural practices, and technology that reduces agriculture's negative environmental externalities (Heinemann, Beluco, Backes & Santin, 2020). According to Yu & Chi (2021), the Technological-Organizational-Environmental (TOE) framework is used in their study on Examining the determinants of eco-innovation adoption: An empirical analysis using the TOE framework. The study examines numerous technological, organizational, and environmental elements that may unintentionally include intermediaries' functions, even when intermediaries are not specifically specified. Chemmanur, He & Xuan (2021), suggested that financial support from venture capitalists can facilitate the development and commercialization of innovative ideas. Financial constraints negatively affected firms' innovation activities, underscoring the importance of adequate financial support for fostering innovation within organizations (Caggese, Cuñat & Metzger, 2022).

### 1.3 Research objectives and research questions

The main purpose of this research is to study the following research objectives:

To explore the adoption and acceptance of innovations in agri-tech to improve food safety, quality control, transparency and sustainability throughout the agricultural value chain.

To determine the essential capacity-building program and data literacy abilities needed to enable better usage of agri-tech data for farm management.

To explore the financial and intermediary factors that influence the adoption of innovation among farmers and agricultural startups to adopt innovation

The significant issues discussed in the paper will be explored to further investigate the following:

How do the adoption and acceptance of innovations in agri-tech improve food safety, quality control, transparency and sustainability throughout the agricultural value chain?

How can capacity-building programs be created and implemented to strengthen farmers' and agricultural stakeholders' data literacy and analytical abilities, enabling them to use agri-tech data for better farm management?

How can financial and intermediary factors influence the adoption of innovation among farmers and agricultural startup companies to adopt innovation?

### 1.4 Significance of the study

Body of knowledge: This research may contribute to the body of knowledge that is used in teaching, training and consulting the challenge of improving innovations in agri-tech industry

Theory and framework: This research aims to contribute to shaping the theoretical perspective and novelty of the framework that other academics will adopt or refer to in the future.

Policymaker: To present to the government a framework for developing appropriate strategies and improved laws that can be implemented to encourage more companies and start-ups to adopt and promote innovation in agri-tech

Environment: This research is hoped to improve environmental performance by ensuring sufficient global food security for a growing population with the help of smart agricultural technology and innovation.

Industry: This study tends to provide important implications to Agri-Tech companies specially to inspire more young start-up technologists to take on and venture into the Agri-culture sector

### 1.5 Research gap

Based on the problem stated above, this study is aimed at addressing the gaps and has been identified into four main areas of concentration. Adoption and acceptance of technology: Exploring adoption motivations and obstacles as well as socioeconomics and cultural influences on technology uptake can offer insights into practical methods for fostering innovation adoption in various situations (Van Der Fels-Klerx, H. J., et al.2020). Sustainability Impact: Sustainable agricultural methods, resource management strategies, and technology that lessen the harmful environmental externalities connected to agriculture can all be the subject of research (Heinemann, Beluco, Backes & Santin, 2020). Data Management: Sophisticated data management, integration, and analytics techniques are required to monitor the improvement of agriculture operations (Paul & Mishra, 2021). Capacity Building: Focus on providing training programs, capacity building initiatives, and knowledge transfer to enable the successful adoption and effective application of agri-tech advancements (Huang, J., et al. 2021).

## 2.0 Literature Review

To produce crops sustainably, new technology and innovations in smart agriculture such as IoT, data analytics, robots, and machine learning are used to support sustainable agricultural practices, real-time crop disease diagnosis, and precision agriculture (Goud, Rane, Verma, Prakash & Goyal, 2021). The innovation of institutional and technological changes that are currently taking place in particular situations in both developed and developing countries will determine the future of small farms (Herrero, Hugas, Lele, Wira & Torero, 2020, 2021). In Sustainable Agricultural Development through Innovations in Agri-Tech Sector: A Systematic Review study, the authors focus on the possibility of using a variety of technologies and innovations, including smart sensors, IoT, data analytics, and precision agriculture, to increase resource efficiency, lessen environmental impact, and increase agricultural production (Rasool & Niazi, 2021).

Smith, Brown, and Johnson (2022) find various beneficial environmental effects of AgriTech innovation for instance, using pesticides and fertilisers excessively is reduced by precision agricultural technology, which reduces environmental contamination. Smart irrigation systems optimise water use, helping to manage resources sustainably and conserve water. The literature however also indicates possible difficulties and unfavorable environmental effects connected to several AgriTech advancements. The increased usage of technology might result in higher energy demand and electronic trash production. The use of genetically modified crops might also spark worries about the loss of biodiversity and associated ecological problems.

In Pandey & Kumar's (2022) study on Agriculture Technologies for Sustainable Farming: A Data Analytics Perspective, they explore data to examine various agricultural technologies for sustainable farming. The study covers the optimization of agricultural operations, boosting crop output, and enhancing resource management using data-driven techniques including machine learning and big data analytics. According to Gonsalves, Anandaraja, Alagaraja & Kumara, (2022), this in-depth analysis looks at both the theory and the reality of agricultural technology adoption. It examines several aspects, such as socioeconomic, institutional, and policy-related aspects, that affect farmers' adoption of agricultural technologies. The evaluation offers information on tactics and measures that can speed up

the use of technology for increased agricultural productivity and sustainability. Improved yield prediction, water and fertilizer management, crop monitoring, and insect control are some of the applications of precision agricultural technology (agri-tech) and their effects on sustainable farming methods (Galanakis. 2021).

Having said that, food technology businesses work to find answers to a range of problems, including sustainability, scarcity, waste, logistics, and dietary restrictions. They operate in a way that maximizes cost-effectiveness, boosts productivity, and lowers pollution emissions from the process, which impacts people's lives by making food more widely available at lower prices and improving the performance of businesses (Hetler, 2023). According to Liu, Feng, and Yu (2022), they look at sustainability in the agri-tech industry, covering digitalization, smart farming, precision agriculture, and sustainable practices. They examine the effects of agri-tech advancements on resource efficiency, socioeconomic factors, and environmental sustainability.

To understand the adoption and application of technical breakthroughs, the agriculture sector can also make use of the Technological, Organizational, and Environmental (TOE) model. There are prior relevant references that discussed the innovation variable within the TOE model in the context of agriculture, even though there may not be many particular references relating to the agriculture sector and the TOE model. According to Gai, Yan, Zhang, Batchelor & Tian (2021), the TOE model investigates the organizational, technical, and environmental influences on farmers' adoption choices. It highlights the significance of organizational elements like farmers' expertise, resources, and support networks as well as innovative traits like compatibility with current methods and relative advantage in fostering adoption.

The dynamics of innovation in agricultural systems are examined in research titled "Innovation in Agricultural Systems: A Systematic Review of the Literature and an Integrative Framework," which was published in the Journal of Agricultural Science and Technology A in 2021. Within the framework of the National Innovation Systems (NIS) theory, the study investigates many aspects of innovation, such as technological, organizational, and institutional innovation. It offers a thorough framework that incorporates these various characteristics and explores their effects on agricultural innovation and system change (Zare, Ahmadi, Nazari & Mansoori, (2021).

### 3.0 Methodology

This research design uses a qualitative method with an inductive approach based on the exploratory traits to explore the motivational elements in adopting innovations in the agri-tech sector for a sustainable future. According to Aspers and Corte (2019), qualitative research is a continual procedure in which the scientific community improves its understanding as it gets closer to the topic being examined by identifying new meaningful distinctions. A qualitative approach is the best way to explore and comprehend this phenomenon, which is crucial to this exploratory study while taking into account the advances in the relatively new and understudied agri-tech industry in Malaysia, notably Penang. One of the limitations of this study will be the location of the study which is in Penang.

To explore and gain a thorough understanding of the innovation adoption in the agri-tech sector, this research project bases its methodology on an interpretive qualitative approach through interview sessions with identified agri-tech companies in Penang that have just recently begun using technology in this industry. The study's objectives, which include examining the adoption and acceptance of agri-tech innovations to improve food safety, quality control, transparency, and sustainability throughout the agricultural supply chain, as well as identifying the critical elements of capacity-building programs and data literacy skills required to enable better usage of agri-tech data for farm management, were adequately met by the qualitative approach, which was chosen for the study. In addition, this study also investigates the financial and intermediary factors that affect farmers' and agricultural startup's adoption of innovation.

Key stakeholders such as agri-tech entrepreneurs, farmers, or industry experts will be interviewed on an individual basis. Participants will be able to discuss their perspectives, difficulties, and creative solutions connected to innovation acceptance and adoption in the agri-tech sector as well as sustainability through semi-structured interviews used in the study. All interviews will be recorded with the participants' consensus. After that, a written version of the audio data will be produced while ensuring its reliability and accuracy. Relevant qualitative analysis techniques, such as thematic or content analysis, will be applied to the qualitative data. Finally, the findings will be re-checked to validate to assure accuracy, and reliability and strengthen the credibility of the research.

### 4.0 Findings

This study is underpinned by two theories which are the technological-organizational-environmental model by Tornatzky and Fleischer, 1990 and the National Innovation Systems Theory by Christopher Freeman, 1987 as per Fig. 3 below.

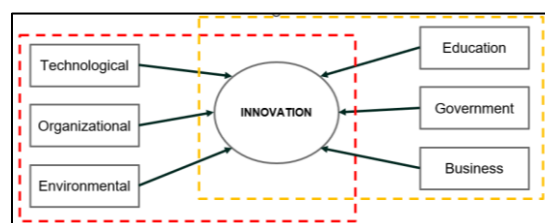


Fig. 3: Underpinning Theories

(Source: Tornatzky and Fleischer, 1990 and [Christopher Freeman, 1987])

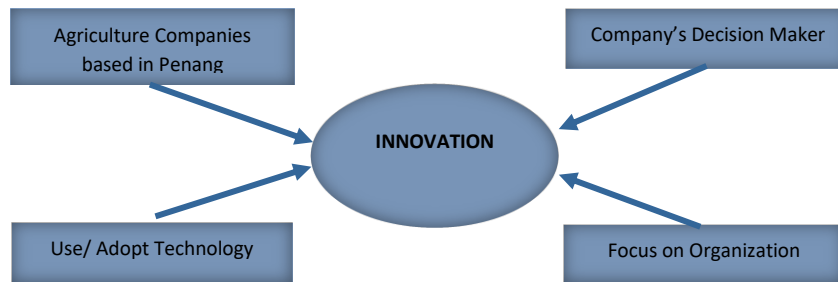


Fig. 4: Conceptual Framework  
(Source: Authors)

From the underpinning theories, the researchers have come out with a conceptual framework where to understand the adoption of innovation in the AgriTech sector, the researchers will focus the interview sessions with the decision makers at the agriculture companies in Penang who are willing to use and adopt technology in their organization.

It is hoped that the findings from the interview sessions will provide insights into how to improve food safety, quality control, transparency, and sustainability throughout the agricultural supply chain through the adoption and acceptance of innovations in the AgriTech sector. The findings too are hoped to identify the critical elements of capacity building and data literacy skills programs that are required to enable better usage of agri-tech data for farm managers and farm workers. Another important element is to identify if any financial or intermediary support would influence the farmers and AgriTech startups to adopt innovation in this sector.

The findings will depend solely on the interview sessions, where participants will be able to openly share their perspectives, challenges, and creative solutions to the acceptance and adoption of innovation in the agri-tech industry, as well as sustainability.

## 5.0 Discussion

Startup companies may need capital at several levels, including pre-seed, seed, and series funding. Increased agricultural productivity and farmer income are under intense strain (Kumar, 2023). Agri-tech start-ups, banks, insurance companies, suppliers of agricultural inputs, and the government all collaborate on the agricultural ecosystem initiative (Nugroho, 2022). It is crucial to include partners who can communicate, disseminate information, and provide the knowledge and support needed. at the project level as well as umbrella organizations like farmers' associations or standardization organizations that represent target groups (Wolfert, Verdouw, van-Wassenaer, Dolfma, & Klerkx, 2023). With that, this study would like to propose two variables which are financial institutions and intermediaries which play important roles in contributing to the acceptance and adoption of innovation in the agri-tech sector.

The study's expected objectives include insights into how to improve food safety, quality control, transparency, and sustainability in the agricultural supply chain. Furthermore, the identification of essential factors for capacity development and data literacy skills programmes, as well as the impact of financial or intermediary assistance on farmers and agri-tech businesses, deepens the research's potential impact.

Overall, the study aims to better understand the complex dynamics of innovation uptake in the agri-tech sector. The study's relevance and potential contributions to Malaysian sustainable farming practices are enhanced by its emphasis on practical solutions and the engagement of key stakeholders.

## 6.0 Conclusion & Recommendations

The study will emphasize the significance of adopting innovation and technology to satisfy a growing population while ensuring sustainability and focusing on recent changes in the food business. Traditional farming methods, restricted access to technology, the gradual adoption of digital solutions, and a lack of assistance for small-scale farms are some of the challenges the Malaysian agri-tech industry must overcome. These issues lead to poorer yields, higher production costs, and decreased competitiveness. Affordable and user-friendly technologies, increased access to funding and support, data-driven decision-making, and support for sustainable farming methods are just a few of the innovative solutions that are required to deal with these challenges. This study is hope to offer insightful information to stakeholders in academia, government, and business, ultimately fostering innovation and enhancing food security around the world.

This study intends to close gaps in technology adoption and acceptance, the impact of sustainability, data management, and capacity building to help the agri-tech industry evolve for a sustainable future. By examining these topics, the study hopes to offer insightful information to stakeholders in academia, government, and business, ultimately fostering innovation and enhancing food security around the world. The study's contribution to the body of knowledge, theory, policies, the environment, and the industry is significant since it has repercussions for future strategy development and teaching, training, and consulting. To gather information and knowledge, the study methodology uses a qualitative approach that includes interview sessions with important stakeholders.

## Acknowledgement

I would like to extend my sincere appreciation to "The 5th Advances in Business Research International Conference 2023" team who have accepted this paper to be presented at the conference in September 2023. I would also like to express my profound gratitude to Prof Dr. Norzanah Mat Nor and Assoc Prof Dr Amirul who have served as my research advisors and supervisors, for their consistent advice, knowledge, and support throughout this research journey. Their advice and guidance played a crucial role in determining the course of this study.

## Paper Contribution to Related Field of Study

This study hopes to help identify innovative solutions and raise awareness among farmers, industry professionals, policymakers and the general public about the importance of agri-tech innovation in achieving sustainable agriculture. The study also aims to be able to formulate policy recommendations for fostering an environment conducive to the adoption of agri-tech innovation for sustainability.

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