Economic and Technology Management Review, Vol. 23(2024): 13 – 27

Exploring farmers' decision-making: A systematic review of socio-economic, behavioral and technological influences

(Meneroka pembuatan keputusan petani: Kajian sistematik terhadap pengaruh sosio-ekonomi, tingkah laku dan teknologi)

Poonthalir Veeran[1, 2*], Muhammad Asraf Abdullah[2] and Nivakan Sritharan[3]

Keywords: farmer decision-making, sustainable agriculture, socio-economic factors, behavioral influences, technological adoption

Abstract

This systematic literature review examines the factors that influence farmer decision-making in agricultural practices, focusing on socio-economic, behavioral, and technological determinants. The review analyses 59 selected articles, identified through a rigorous process of identification, screening, eligibility and inclusion. It explores the key drivers of sustainable practice adoption, including economic incentives, social networks, cognitive traits and environmental challenges. The findings emphasise the critical roles of economic stability, resource availability, peer influence and adaptive strategies in technology adoption and climate resilience. The review also identifies gaps in current research, particularly the lack of longitudinal studies that assess the long-term impact of these factors. It encourages future research to use mixed methods approaches to gain a more comprehensive understanding of how these influences evolve. This review offers valuable insights for policymakers, researchers and practitioners seeking to support sustainable agricultural development.

Introduction

Agriculture has always played a vital role in human civilisation by providing the necessary resources for sustenance and economic progress (Zonneveld et al. 2020). However, in recent years, the sector has encountered unprecedented challenges stemming from climate change, environmental degradation, and rapid technological advancements (Lanza Castillo et al. 2021). As a result, agricultural practices have undergone significant changes, making it imperative to gain a comprehensive understanding of the decision-making processes of farmers (Yuan et al. 2020). This systematic literature review aims to examine the various factors that influence farmers' decisions, with a specific focus on adaptive strategies to address climate change and the adoption of emerging agricultural technologies.

The agricultural sector is indeed becoming more susceptible to the effects of climate change and environmental degradation (Singh 2020). Challenges like changes in precipitation patterns, more

[1]R&D Department, Rexil Asia JSC, Room 603, VCCI Building, No.1 LeNin Str, Vinh City, Nghe An, Vietnam
[2]Faculty of Economics and Business, University Malaysia Sarawak, Jalan Datuk Mohammad Musa, 94300 Kota Samarahan, Sarawak, Malaysia
[3]Faculty of Business, Design and Arts, Swinburne University of Technology, Jalan Simpang Tiga, 93350 Kuching, Sarawak, Malaysia
e-mail: vthalir@gmail.com

frequent extreme weather events, and soil degradation are posing significant risks to crop yields and food security. As a result, farmers are constantly adapting their practices to ensure productivity and sustainability (Gütschow et al. 2021; Lanza Castillo et al. 2021). At the same time, the emergence of advanced agricultural technologies, like precision farming and biotechnology, presents new possibilities for improving productivity and efficiency (Zeleke et al. 2024; Michels et al. 2020). Nevertheless, the implementation of these technologies is not without its obstacles, including high initial costs, the requirement for technical expertise, and differing levels of accessibility.

Farmers' decision-making is indeed influenced by a complex interplay of economic, social and environmental factors. Understanding these influences is crucial in developing effective policies and support systems that can facilitate sustainable agricultural practices and technology adoption. Previous studies have examined various aspects of farmers' decisions, but there is still a need for a comprehensive synthesis that highlights the key drivers and barriers in this context. Despite the increasing amount of research on agricultural adaptation and technology adoption, there is currently a lack of comprehensive understanding regarding the specific factors that influence farmers' decision-making processes. Researchers need to close the existing research gaps to allow the developing of targeted interventions and policies that promote sustainable practices and technological innovations in agriculture. Furthermore, the diverse contexts in which farmers operate, such as variations in geographic, economic, and social conditions, further complicate our understanding of decision-making dynamics. Therefore, it is crucial to address these issues to enhance the resilience and sustainability of agricultural systems considering ongoing environmental and technological changes.

Despite its long-standing role as the backbone of global economies, agriculture is increasingly vulnerable to a complex set of challenges. The ongoing impacts of climate change, including erratic weather patterns, rising temperatures, and soil degradation, are creating substantial uncertainty in crop yields and food production (Singh 2020). These environmental challenges are further compounded by the socioeconomic pressures farmers face, such as fluctuating market prices, limited access to financial resources, and inequities in land ownership (Gütschow et al. 2021). As agricultural practices evolve to cope with these pressures, it has become evident that farmers must make more intricate decisions that incorporate not only environmental considerations but also socioeconomic and technological factors. However, farmers often lack sufficient support systems to navigate these multifaceted issues effectively. This highlights the need to explore the factors influencing their decision-making processes to inform policies and intervention strategies that can mitigate these challenges.

In addition to environmental and socioeconomic pressures, technological advancements have transformed the agricultural landscape, offering potential solutions to improve productivity and sustainability (Michels et al. 2020). Technologies such as precision agriculture, biotechnology, and automation hold great promise for enhancing resource management and reducing environmental impact. However, the high cost of implementation, limited access to technological infrastructure, and the digital divide between rural and urban areas create barriers for farmers, particularly those in developing countries (Zeleke et al. 2024). Understanding how these technological developments interact with socioeconomic and environmental conditions is crucial for supporting farmers' ability to adopt them. Given the complex and dynamic nature of these challenges, a comprehensive review of the factors influencing farmers'

decision-making is essential. Understanding the socio-economic, behavioral, and technological influences on farmers' choices will help in developing effective policies that encourage sustainable agricultural practices. This systematic literature review aims to fill this gap by consolidating existing research on these topics and providing a framework for future interventions.

The main objective of this systematic literature review is to analyse and consolidate the existing research on the factors that influence farmers' decision-making processes. By reviewing a wide range of studies, the aim is to identify recurring themes and significant findings that can contribute to the development of effective strategies to support farmers. This review will concentrate on comprehending the effects of climate change and environmental degradation on agricultural productivity and sustainability, and how farmers can adopt adaptive strategies to minimise these impacts. Furthermore, the study will investigate the role of emerging agricultural technologies in revolutionising traditional farming practices, highlighting both the potential benefits and challenges associated with their implementation.
The objectives of this paper are to:

1. Identify the key factors that influence farmers' decision-making processes in the context of climate change and environmental degradation.
2. Explore the adaptive strategies that farmers employ to mitigate the impacts of climate change and environmental degradation on agricultural productivity and sustainability.
3. Examine the role of emerging agricultural technologies in transforming traditional farming practices
4. Assess the benefits and challenges associated with the adoption of advanced agricultural technologies.
5. Provide policy recommendations and practical insights for enhancing the resilience and sustainability of agricultural systems.

Methodology

Identification

In this study, several essential steps of the systematic review process were employed to select a significant amount of pertinent literature. Initially, keywords were chosen, followed by a search for related terms using dictionaries, thesauri, encyclopedias, and previous research. All relevant terms were identified after creating search strings for the Scopus databases (*Table 1*). In the initial phase of the systematic review, 589 publications relevant to the study topic were successfully retrieved from these three databases.

Screening

In the screening phase, we assess the collection of potentially relevant research items to determine if they align with the predefined research questions. During this stage, we use content-related criteria to select research items that are related to farmers' decision-making. Initially, we excluded 575 publications (*Table 2*). The main criterion we used was the inclusion of literature, such as research papers, which provide practical recommendations. This criterion also encompassed reviews, meta-syntheses, meta-analyses, books, book series, chapters and conference proceedings that were not part of the most recent study. Additionally, we limited our review to English language publications from the years 2020 – 2024.

Table 1. Relevant terms identified from Scopos databases

Scopus	TITLE-ABS-KEY (farmers AND “decision making” AND agriculture) AND (EXCLUDE (DOCTYPE , “cp”) OR EXCLUDE (DOCTYPE , “re”) OR EXCLUDE (DOCTYPE , “ch”) OR EXCLUDE (DOCTYPE , “bk”) OR EXCLUDE (DOCTYPE , “cr”) OR EXCLUDE (DOCTYPE , “no”) OR EXCLUDE (DOCTYPE , “sh”) OR EXCLUDE (DOCTYPE , “ed”) OR EXCLUDE (DOCTYPE , “tb”) OR EXCLUDE (DOCTYPE , “dp”) OR EXCLUDE (DOCTYPE , “le”) OR EXCLUDE (DOCTYPE , “er”)) AND (EXCLUDE (PUBSTAGE , “aip”)) AND (EXCLUDE (SRCTYPE , “k”) OR EXCLUDE (SRCTYPE , “b”) OR EXCLUDE (SRCTYPE , “d”) OR EXCLUDE (SRCTYPE , “Undefined”)) AND (LIMIT-TO (LANGUAGE , “English”)) Date of access: 8 July 2024

Table 2. The selection criterion in searching

Criterion	Inclusion	Exclusion
Language	English	Non-english
Time line	2020 – 2024	<2020
Literature type	Journal (article)	Conference, book, book chapter, review
Publication stage	Final	In Press
Subject	Business, management and accounting	None

Eligibility

In the third phase, called the eligibility assessment, a total of 635 articles were gathered. During this stage, a comprehensive examination of the titles and main content of all articles was conducted to ensure they met the inclusion criteria and were relevant to the research objectives of the study. As a result, 516 articles were excluded for various reasons: they were not related to the relevant field, their titles lacked significance, their abstracts were unrelated to the study’s objectives, or full-text access was not available. Consequently, 59 articles were selected for further review.

Data abstraction and analysis

An integrative analysis was used in this study to examine and synthesise different research designs, particularly quantitative methods. The main objective was to identify relevant topics and subtopics. The first step involved collecting data to help develop themes. The authors carefully analysed a collection of 128 publications for relevant information or material related to the study’s themes. They also reviewed important current studies on sustainability reporting and stakeholder engagement, looking at methodologies and research outcomes. The author, in collaboration with co-authors, developed themes based on the evidence within the study’s context. A log was kept throughout the data analysis to record any analyses, viewpoints, challenges, or insights related to data interpretation. Finally, the authors compared the results to identify any inconsistencies in the theme design process. Any disagreements between concepts were resolved through discussion among the authors. To ensure validity, two experts specializing in corporate reporting conducted a review. This expert review phase ensured the clarity, importance, and adequacy of each sub-theme by establishing domain validity, with adjustments made based on expert feedback and comments.

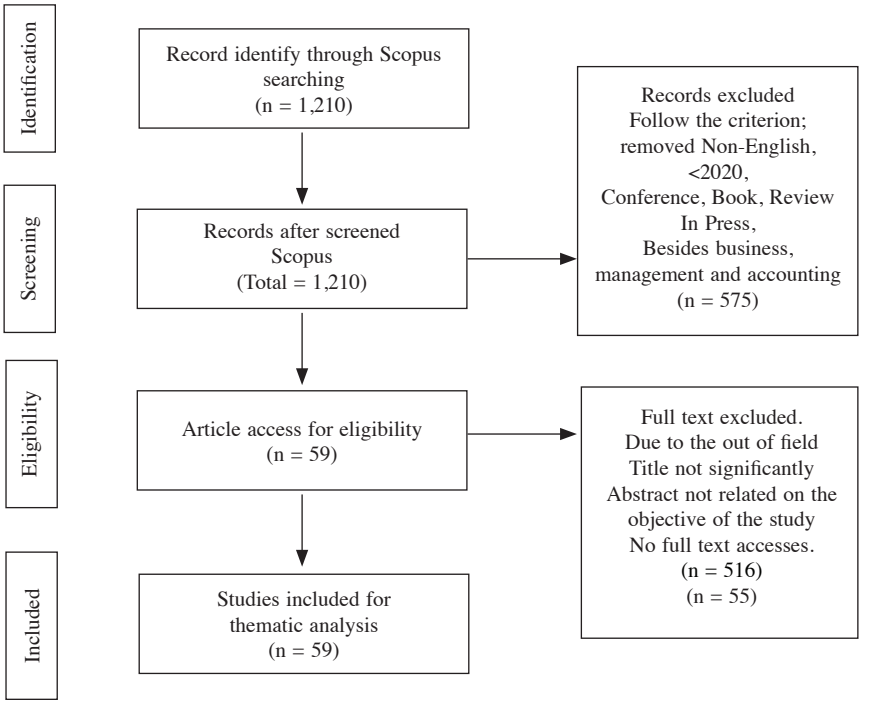

Figure 1. Flow diagram of the proposed searching study (Moher et al. 2009)

Analysis and discussion

Theme 1: Adoption of agricultural technologies

The adoption of agricultural technologies is influenced by a variety of socio-economic factors that interact in complex ways. Zeleke et al. (2024) highlight the importance of education, membership in local organizations, and access to resources such as irrigated land and media sources as positive determinants. Conversely, a lack of credit, large family size, and distance from extension services are notable barriers. Singh (2020) similarly identifies insurance and credit as key enablers of technology adoption, while low livelihood status, limited non-farm employment opportunities, and insufficient irrigation act as significant obstacles. Both studies highlight the role of economic stability and resource availability in facilitating the adoption of new agricultural practices.

Other studies further explore these findings by considering additional socio-economic dimensions. Llewellyn and Brown (2020) highlight the heterogeneity among smallholder farmers, including variations in constraints, capabilities, resources and attitudes. The adoption process is further complicated by cultural norms and the prioritization of subsistence over profits. Michels et al. (2020) and Vecchio et al. (2020) both emphasise the importance of factors such as farmers' age, education, and farm size, as well as technology literacy and labour intensity. Collectively, these studies suggest that a combination of personal attributes, educational background, and farm characteristics significantly influence technology adoption.

Furthermore, Mahmood et al. (2020) and Kangogo et al. (2021) emphasise the importance of cognitive traits and access to specific services.

According to Mahmood et al. (2020), education levels, participation in climate-resilient training, and access to advisory services are crucial for adaptation. Meanwhile, Kangogo et al. (2021) specifically focus on entrepreneurial orientation and highlight the critical roles of innovativeness, proactiveness, and risk-taking propensity in the adoption of climate-smart practices. These insights highlight the need for tailored interventions that consider both the socio-economic context and individual cognitive traits to promote the adoption of agricultural technologies.

Environmental and contextual factors play a crucial role in the adoption of agricultural technologies, especially among smallholder farmers in developing regions. Zeleke et al. (2024) emphasises the significance of steep slopes, the distance of farmland from home, and the importance of adopting an agroecological framework. These factors can greatly affect the practicality and suitability of climate-smart practices in rainfed farming systems. Similarly, Singh (2020) emphasises how temperature and rainfall variability, low cropped area under irrigation, and the availability of early maturing seed varieties and water-efficient crop varieties can impact farmers' ability to adapt to climate change. Additionally, Llewellyn and Brown (2020) highlight that constraints, capabilities, resources, attitudes and priorities vary among smallholder farmers, and cultural norms and reliance on non-agricultural income also influence the adoption of agricultural technologies. These factors highlight the complexity and variability involved in smallholder contexts.

Additionally, other studies highlight the impact of specific environmental and contextual factors on agricultural technologies adoption. Michels et al. (2020) discovered that factors such as farm size and proficiency in precision agriculture technology play a significant role in the adoption of drones. These factors reflect the preparedness and capability of farmers to incorporate new tools. Vecchio et al. (2020) observe that social norms, organisational pressure, farm size, and labour intensity shape farmers' decision-making and perceptions of the complexity of innovation. Mahmood et al. (2020) emphasise the influence of climate change fatalism, the availability of climate-specific extension services, and participation in climate-resilient farming training on farmers' willingness to adopt adaptation measures. Kangogo et al. (2021) further highlight that characteristics related to the farm, farmer, institution, and location impact the rate of adoption of climate-smart agriculture. They find that risk-taking and proactiveness have a positive effect on practices such as irrigation and crop rotation. These findings collectively suggest that a comprehensive understanding of environmental and contextual factors is crucial for promoting the adoption of agricultural technologies among smallholder farmers.

Theme 2: Farmer decision-making and behavioural factors

The psychological factors that influence farmers' decision-making processes are complex and multifaceted. They involve a combination of social, cognitive, attitudinal and emotional elements. Various studies, such as Brown et al. (2021), emphasise the important role played by social and attitudinal factors, in addition to economic and structural determinants, in influencing farmers' decisions. Similarly, Doran et al. (2020) identify perceived behavioural control, perceived social norms, and farmer attitudes toward Nutrient Best Management Practices (NBMPs) as crucial psychological drivers. These factors collectively shape how farmers perceive their ability to implement sustainable practices and the social pressures they face in making these decisions.

Moreover, the perceived action space significantly affects farmers' decision-making processes, as discussed by Gütschow et al. (2021). This concept pertains to the barriers that go beyond farmers' immediate

control, including market limitations, regulatory unpredictability, and resource constraints. These factors impact their ability to adopt sustainable agricultural practices. The psychological burden of these perceived constraints can hinder farmers' willingness to implement diversified crop rotations, highlighting the importance of policy interventions that foster a more enabling environment.

The role of social pressure and social capital is further elaborated by Lanza Castillo et al. (2021) and Skaalsveen (2020). According to Lanza Castillo et al. (2021), social norms and perceived control strongly influence farmers' intentions to adopt pressurised irrigation technologies, with social pressure often outweighing individual attitudes. Social capital enhances this process by increasing self-confidence and the perceived feasibility of adoption. Skaalsveen (2020) emphasises the importance of interpersonal networks in facilitating knowledge exchange and decision-making, especially for innovative practices such as no-till farming. These findings imply that utilising social networks and peer learning can play a crucial role in promoting the adoption of sustainable agricultural practices.

In addition to social factors, emotional and cognitive factors play a crucial role in farmers' decision-making. A study by Yazdanpanah et al. (2024) highlights the influence of anticipated pride, cognitive awareness, and behavioral habits on farmers' adaptive decisions in response to climate change. This integrated approach is consistent with the findings of Bakker (2021), who emphasises the impact of environmental considerations, peer behavior, and perceived autonomy on farmers' intentions to reduce pesticide use. Ghanian (2020) further expands on this by incorporating the Protection Motivation Theory (PMT), which identifies how economic disincentives and risk perceptions shape adaptation intentions. Taken together, these insights emphasise the importance of addressing both psychological and contextual factors to support effective decision-making in agriculture.

Theme 3: Adaptation and coping strategies

Farmers in various regions have implemented a variety of effective adaptation strategies to mitigate climate change's impact on agricultural productivity. In Ethiopia, farmers have employed mixed farming, mixed cropping, altered planting periods, utilised drought-resistant crop varieties, employed soil and water conservation techniques, shifted to non-farm income activities, and made use of irrigation. These strategies have been influenced by socio-economic and institutional factors, such as age, gender, family size, farm income, farm size, access to climate information and market access. These factors significantly shape the adoption and success of these strategies (Marie et al. 2020). Similarly, farmers in rural India have adapted by perceiving climate changes and adopting strategies influenced by socio-economic determinants, such as age, gender, household size, education level, off-farm income and farm size. This highlights the need for policies that consider these critical household characteristics (Jha and Gupta, 2021).

In South Africa's Vhembe District, small-scale farmers have implemented various strategies to cope with drought conditions. These strategies include using drought-tolerant seeds, opting for shorter cycle crops, diversifying their crops, adjusting planting dates, engaging in small-scale irrigation, migrating to urban areas and participating in petty businesses. The adoption of these strategies is significantly influenced by socio-economic and institutional factors. These factors include access to climate information, gender, farm size, education level, farmer experience and climate conditions such as decreasing rainfall and increasing temperatures. They play a crucial role in shaping farmers' decision-making processes and determining

the success of their adaptation efforts (Kom et al. 2020). Furthermore, the adaptive responses of farmers to drought in different regions have been influenced by factors such as response efficacy, perceived vulnerability, and response cost. This further emphasises the importance of socio-economic and institutional influences on farmers' adaptation strategies (Delfiyana et al. 2020).

Moreover, farmers around the world have embraced various strategies to adapt to climate change, including the adoption of technological advancements, improvements in infrastructure, increased access to credit, and better market access. In certain cases, farmers have even chosen to exit agriculture altogether as a viable option. The effectiveness of these strategies, however, is greatly influenced by socio-economic and institutional factors. These factors include farm size, land consolidation, access to technology, credit, market infrastructure, collective action, and good governance. It is crucial to consider these factors to develop comprehensive and inclusive approaches that meet the diverse needs of farmers and ensure sustainable adaptation to climate change (Stringer et al. 2020).

Theme 4: Economic and social factors in agricultural practices

Economic and social factors significantly impact agricultural practices, as evidenced by various studies examining how farmers adapt and cope with climate change and market dynamics. Economic incentives, such as the cost savings associated with adopting precision farming technologies, higher payments for reducing the use of chemical fertilisers, and improved market access, play a crucial role in farmers' decisions to adopt sustainable practices. For example, farmers' preferences for high-profit, high-water-use crops versus steady-profit, low-water-use crops are influenced by their tolerance for variations in profitability, highlighting the importance of tailored water management policies (Yuan et al. 2020). Moreover, providing higher entry payments can incentivize farmers to reduce their use of chemical fertilisers, while eco-labels can enhance the marketability of products for farmers who already use fewer chemicals (Chang et al. 2023).

Social networks and community dynamics play a crucial role in the dissemination and adoption of innovative agricultural techniques. Farmers are highly influenced by their peers' behaviors and the knowledge shared within their communities. An excellent example of this is the positive impact that knowing fellow farmers who have already implemented precision farming technologies has on the adoption of these techniques. This highlights the significant role that social networks play in promoting the adoption of new practices (Blasch et al. 2020). Furthermore, collective marketing and group membership have been found to have a substantial positive impact on farm performance and economic benefits. This is primarily due to the improved coordination and support among farmers that arise from social interactions and shared experiences within agricultural communities (Abdul-Rahaman and Abdulai 2020).

Moreover, social factors such as educational opportunities, extension visits, and farm experience contribute to the successful dissemination of agricultural innovations. Extension visits and interactions with educational institutions facilitate knowledge sharing and the adoption of best practices among farmers (Ayenew et al. 2020; Jitmun et al. 2020). The influence of social dynamics is also evident in farmers' participation in agri-environment schemes (AES), where targeted outreach and community engagement are crucial for increasing participation rates (McGurk et al. 2020). Overall, the interplay of economic incentives and social networks is vital for promoting sustainable agricultural practices, as these factors collectively shape farmers' decisions and behaviors in response to changing environmental and market conditions.

Theme 5: Environmental and technological impacts on agriculture

Climate change and environmental degradation have a significant impact on agricultural productivity and sustainability. They disrupt ecological balances and make traditional farming practices less viable. Major concerns include unsustainable soil use and reliance on synthetic pesticides. To address these issues, a shift towards more sustainable practices is necessary. Adaptive strategies, such as agroforestry, on-farm diversification, and participation in agri-environment schemes (AESs), offer promising solutions. However, they often require substantial initial investments and face challenges related to farmer perceptions and economic constraints. To promote the adoption of these sustainable practices, financial incentives, targeted conservation schemes, and improved communication between scientists and farmers are essential (Cullen et al. 2020; Do et al. 2020; Zonneveld et al. 2020 and Maas et al. 2021).

Emerging agricultural technologies, such as precision farming and biotechnology, are revolutionising traditional farming practices by improving resource management and productivity. Precision agriculture machinery, digital tools, and biotechnology offer advanced methods to enhance efficiency, reduce waste, and mitigate risks. For example, precision farming integrates data from sensors and equipment to optimize input use and increase yields. However, challenges such as high acquisition costs, connectivity issues, and the need for farmer education and training still exist. Custom hiring centers and supportive policies can facilitate access to these technologies, reducing financial burdens and enabling broader adoption (Bolfe et al. 2020; Thinda et al. 2020 and Rakhra 2022).

Despite the numerous benefits, the adoption of advanced agricultural technologies faces several barriers. Factors such as farmers' risk aversion, limited access to information, and socio-economic circumstances, including income level, education, and social trust, greatly influence their willingness to embrace new practices. To effectively overcome these challenges, it is crucial to address them through enhanced advisory services, educational programs, and supportive networks that connect farmers with stakeholders. This comprehensive approach can encourage the integration of innovative technologies and sustainable practices, ultimately enhancing resilience to climate impacts and market fluctuations (Balezentis et al. 2020; Mohammadi and Ahmadi, 2020; Nguyen and Drakou, 2020 and Ara et al. 2021).

Overall, climate change and environmental degradation require a comprehensive approach to achieve agricultural sustainability. This approach entails adopting adaptive strategies, promoting emerging technologies, and addressing socio-economic and informational barriers. Policymakers can support farmers in transitioning to more sustainable and productive agricultural systems by improving communication, providing financial assistance, and fostering education and training. These measures will not only ensure long-term resilience but also promote environmental health (Chèze et al. 2020; Constantine et al. 2020 and Yang et al. 2021).

Conclusion and recommendations

This systematic literature review has emphasised the intricate relationship between environmental challenges and technological advancements in influencing farmers' decision-making processes. Climate change and environmental degradation have a significant impact on agricultural productivity and sustainability, prompting farmers to adopt adaptive strategies like agroforestry, biodiversity-friendly practices, and diversified cropping systems. While these strategies offer benefits, they often necessitate substantial initial investments and face obstacles related to information access and socioeconomic factors.

Emerging agricultural technologies, such as precision farming and biotechnology, hold great promise in terms of enhancing productivity and sustainability. These technologies can improve resource management, minimise environmental impacts, and increase efficiency. However, their widespread adoption is hindered by various factors, including high costs, the need for specialised technical knowledge and the lack of effective communication and support systems. It is essential to bridge the gap between scientific advancements and their practical implementation to fully harness the benefits these technologies offer.

To promote sustainable agricultural practices, it is crucial to establish focused policies and support mechanisms that directly tackle the specific needs and challenges encountered by farmers. This entails offering financial incentives, improving access to information and training, and fostering collaborative networks that connect farmers with stakeholders and experts. Through comprehending and addressing the factors that influence farmers' decision-making, policymakers and practitioners can effectively assist the agricultural sector in aligning the simultaneous pressures of environmental change and technological innovation. Ultimately, this contribution will result in a more resilient and sustainable future for agriculture.

An obvious research gap in the adoption of agricultural technologies is the understanding of the interaction between socioeconomic factors and individual cognitive traits. While current studies emphasize the importance of education, access to resources, and economic stability, the role of cognitive traits such as innovativeness, proactiveness, and risk-taking propensity has been insufficiently explored. Future research should take a mixed-methods approach, combining quantitative surveys and qualitative interviews, to examine how these cognitive traits influence technology adoption decisions. Firstly, a quantitative survey should be conducted to collect data on the socio-economic characteristics of farmers, including education levels, access to credit, and farm size. This survey should also include validated scales to measure cognitive traits such as innovativeness, proactiveness, and risk-taking propensity. For example, a Likert scale could be used to evaluate farmers' willingness to try new technologies and their inclination to take calculated risks in their farming practices. After the survey, qualitative interviews should be conducted with a subset of the survey respondents to gain deeper insights into the context and rationale behind their decisions to adopt technology. These interviews should explore farmers' personal experiences, motivations, and perceived barriers to adopting new agricultural technologies. This approach will facilitate a comprehensive analysis that can inform the development of targeted interventions to support farmers in adopting sustainable agricultural technologies.

Another notable research gap exists in understanding the interaction between emotional factors and social norms in farmers' decision-making processes. While existing studies highlight the importance of cognitive, attitudinal, and social elements, the emotional dimensions, such as fear, pride, and stress, and their interplay with social norms remain underexplored. Future research should employ a longitudinal mixed methods approach to investigate how these emotional factors influence farmers' long-term adoption of sustainable practices. For instance, a study could start by conducting a large-scale quantitative survey among farmers from various regions to evaluate their initial emotions (e.g., fear, pride, stress) and their current engagement in sustainable practices. In the following three to five years, researchers could conduct annual follow-up surveys to monitor any changes in these emotional states and behaviors. At the same time, a subset of survey participants could be interviewed in-depth to delve into the underlying reasons behind emotional

and behavioral changes. This approach would offer a detailed understanding of how emotional factors evolve and influence decision-making over time.

One significant research gap in the theme of adaptation and coping strategies is the lack of longitudinal studies that examine the long-term effectiveness and sustainability of various adaptation strategies employed by farmers in different socio-economic and environmental contexts. Most existing research focuses on short-term outcomes and does not account for the dynamic nature of climate change and its evolving impact on agriculture. To improve clarity and flow, future research should adopt a longitudinal mixed methods approach to assess the long-term effectiveness of adaptation strategies. For instance, future research could involve a study that tracks a cohort of farmers over a decade. This study would utilise quantitative surveys to measure annual changes in crop yields, soil quality, and water usage. Additionally, biannual qualitative interviews would be conducted to explore farmers' evolving experiences with adaptation strategies such as mixed cropping and soil conservation techniques. It would combine quantitative surveys to measure changes in adaptation practices and productivity with qualitative interviews to gain deeper insights into farmers' experiences and decision-making processes over time. This approach would provide comprehensive insights into the long-term sustainability and effectiveness of these strategies in mitigating the impacts of climate change.

While the impact of economic incentives and social networks on agricultural practices is well-documented, there is still a need to understand the specific ways in which these factors interact over time to influence farmers' decision-making processes. To improve the understanding, future research should use a longitudinal mixed method approach again. This approach would involve studying the long-term adoption and success of sustainable agricultural practices by examining how sustained economic incentives and evolving social networks contribute to these outcomes. For example, this could entail examining a cohort of farmers over ten years and integrating yearly surveys on economic incentives like subsidies and market accessibility with semi-annual interviews to investigate shifts in social networks and peer influences. To accomplish this, researchers could conduct repeated surveys and in-depth interviews with farmers over several years. Monitoring these variables over time would help the researchers obtain valuable insights into the role of continuous economic support and evolving social relationships in fostering the long-term adoption and efficacy of sustainable agricultural practices. These methods would help capture changes in the farmers' economic conditions, social interactions, and farming practices.

One research gap in the theme of environmental and technological impacts on agriculture is the limited understanding of how different types of financial incentives influence the long-term adoption of sustainable practices and advanced technologies among diverse groups of farmers. Future research should employ a mixed methods approach to investigate the effectiveness of various financial incentives. This approach could involve tracking a cohort of farmers over several years, combining quantitative data on adoption rates with qualitative insights from interviews to understand the motivations and barriers faced by farmers from different demographics. As a result, researchers will gain a better understanding of how tailored financial incentives can promote sustainable agricultural practices and technological adoption.

Acknowledgment

The authors of this study wish to thank Rexil Asia JCE for funding this research study.

References

Abdul-Rahaman, A. & Abdulai, A. (2020). Farmer groups, collective marketing and smallholder farm performance in rural Ghana. *Journal of Agribusiness in Developing and Emerging Economies*, *10*(5), 511–527. https://doi.org/10.1108/JADEE-07-2019-0095

Afriyie-Kraft, L., Zabel, A. & Damnyag, L. (2020). Adaptation strategies of Ghanaian cocoa farmers under a changing climate. *Forest Policy and Economics*, *113*, 102115. https://doi.org/10.1016/j.forpol.2020.102115

Appau, A., Drope, J., Goma, F., Magati, P., Labonte, R., Makoka, D., Zulu, R., Li, Q. & Lencucha, R. (2020). Explaining Why Farmers Grow Tobacco: Evidence From Malawi, Kenya, and Zambia. *Nicotine & Tobacco Research*, *22*(12), 2238–2245. https://doi.org/10.1093/ntr/ntz173

Ara, I., Turner, L., Harrison, M. T., Monjardino, M., deVoil, P. & Rodriguez, D. (2021). Application, adoption and opportunities for improving decision support systems in irrigated agriculture: A review. *Agricultural Water Management*, *257*, 107161. https://doi.org/10.1016/j.agwat.2021.107161

Bakker, L., Sok, J., van der Werf, W. & Bianchi, F. J. J. A. (2021). Kicking the Habit: What Makes and Breaks Farmers' Intentions to Reduce Pesticide Use? *Ecological Economics*, *180*, 106868. https://doi.org/10.1016/j.ecolecon.2020.106868

Balezentis, T., Ribasauskiene, E., Morkunas, M., Volkov, A., Streimikiene, D. & Toma, P. (2020). Young farmers' support under the Common Agricultural Policy and sustainability of rural regions: Evidence from Lithuania. *Land Use Policy*, *94*, 104542. https://doi.org/10.1016/j.landusepol.2020.104542

Blasch, J., van der Kroon, B., van Beukering, P., Munster, R., Fabiani, S., Nino, P. & Vanino, S. (2022). Farmer preferences for adopting precision farming technologies: a case study from Italy. *European Review of Agricultural Economics*, *49*(1), 33–81. https://doi.org/10.1093/erae/jbaa031

Bolfe, É. L., Jorge, L. A. de C., Sanches, I. D., Luchiari Júnior, A., da Costa, C. C., Victoria, D. de C., Inamasu, R. Y., Grego, C. R., Ferreira, V. R. & Ramirez, A. R. (2020). Precision and Digital Agriculture: Adoption of Technologies and Perception of Brazilian Farmers. *Agriculture*, *10*(12), 653. https://doi.org/10.3390/agriculture10120653

Brown, C., Kovács, E., Herzon, I., Villamayor-Tomas, S., Albizua, A., Galanaki, A., Grammatikopoulou, I., McCracken, D., Olsson, J. A. & Zinngrebe, Y. (2021). Simplistic understandings of farmer motivations could undermine the environmental potential of the common agricultural policy. *Land Use Policy*, *101*, 105136. https://doi.org/10.1016/j.landusepol.2020.105136

Castillo, G. M. L., Engler, A. & Wollni, M. (2021). Planned behavior and social capital: Understanding farmers' behavior toward pressurized irrigation technologies. *Agricultural Water Management*, *243*, 106524. https://doi.org/10.1016/j.agwat.2020.106524

Chang, S.-H.-E., Benjamin, E. O. & Sauer, J. (2024). The role of rice farmers' attitude and trust in government in decision-making for participating in a climate-related agri-environmental scheme. *Journal of Environmental Planning and Management*, *67*(8), 1724–1745. https://doi.org/10.1080/09640568.2023.2180348

Chèze, B., David, M. & Martinet, V. (2020). Understanding farmers' reluctance to reduce pesticide use: A choice experiment. *Ecological Economics*, *167*, 106349. https://doi.org/10.1016/j.ecolecon.2019.06.004

Constantine, K. L., Kansiime, M. K., Mugambi, I., Nunda, W., Chacha, D., Rware, H., Makale, F., Mulema, J., Lamontagne Godwin, J., Williams, F., Edgington, S. & Day, R. (2020). Why don't smallholder farmers in Kenya use more biopesticides? *Pest Management Science*, *76*(11), 3615–3625. https://doi.org/10.1002/ps.5896

Cullen, P., Ryan, M., O'Donoghue, C., Hynes, S., hUallacháin, D. Ó. & Sheridan, H. (2020). Impact of farmer self-identity and attitudes on participation in agri-environment schemes. *Land Use Policy*, *95*, 104660. https://doi.org/10.1016/j.landusepol.2020.104660

Delfiyan, F., Yazdanpanah, M., Forouzani, M. & Yaghoubi, J. (2021). Farmers' adaptation to drought risk through farm–level decisions: the case of farmers in Dehloran county, Southwest of Iran. *Climate and Development*, *13*(2), 152–163. https://doi.org/10.1080/17565529.2020.1737797

Do, H., Luedeling, E. & Whitney, C. (2020). Decision analysis of agroforestry options reveals adoption risks for resource-poor farmers. *Agronomy for Sustainable Development*, *40*(3), 20. https://doi.org/10.1007/s13593-020-00624-5

Doran, E. M. B., Zia, A., Hurley, S. E., Tsai, Y., Koliba, C., Adair, C., Schattman, R. E., Rizzo, D. M. & Méndez, V. E. (2020). Social-psychological determinants of farmer intention to adopt nutrient best management practices: Implications for resilient adaptation to climate change. *Journal of Environmental Management*, *276*, 111304. https://doi.org/10.1016/j.jenvman.2020.111304

Gardezi, M. & Arbuckle, J. G. (2020). Techno-Optimism and Farmers' Attitudes Toward Climate Change Adaptation. *Environment and Behavior*, *52*(1), 82–105. https://doi.org/10.1177/0013916518793482

Ghanian, M., M. Ghoochani, O., Dehghanpour, M., Taqipour, M., Taheri, F. & Cotton, M. (2020). Understanding farmers' climate adaptation intention in Iran: A protection-motivation extended model. *Land Use Policy*, *94*, 104553. https://doi.org/10.1016/j.landusepol.2020.104553

Gütschow, M., Bartkowski, B. & Felipe-Lucia, M. R. (2021). Farmers' action space to adopt sustainable practices: a study of arable farming in Saxony. *Regional Environmental Change*, *21*(4), 103. https://doi.org/10.1007/s10113-021-01848-1

Issahaku, G. & Abdulai, A. (2020). Adoption of climate smart practices and its impact on farm performance and risk exposure among smallholder farmers in Ghana. *Australian Journal of Agricultural and Resource Economics*, *64*(2), 396–420. https://doi.org/10.1111/1467-8489.12357

Jha, C. K. & Gupta, V. (2021). Farmer's perception and factors determining the adaptation decisions to cope with climate change: An evidence from rural India. *Environmental and Sustainability Indicators*, *10*, 100112. https://doi.org/10.1016/j.indic.2021.100112

Jitmun, T., Kuwornu, J. K. M., Datta, A. & Kumar Anal, A. (2020). Factors influencing membership of dairy cooperatives: Evidence from dairy farmers in Thailand. *Journal of Co-Operative Organization and Management*, *8*(1), 100109. https://doi.org/10.1016/j.jcom.2020.100109

Kangogo, D., Dentoni, D. & Bijman, J. (2021). Adoption of climate smart agriculture among smallholder farmers: Does farmer entrepreneurship matter? *Land Use Policy*, *109*, 105666. https://doi.org/10.1016/j.landusepol.2021.105666

Kom, Z., Nethengwe, N. S., Mpandeli, N. S. & Chikoore, H. (2022). Determinants of small-scale farmers' choice and adaptive strategies in response to climatic shocks in Vhembe District, South Africa. *GeoJournal*, *87*(2), 677–700. https://doi.org/10.1007/s10708-020-10272-7

Llewellyn, R. S. & Brown, B. (2020). Predicting Adoption of Innovations by Farmers: What is Different in Smallholder Agriculture? *Applied Economic Perspectives and Policy*, *42*(1), 100–112. https://doi.org/10.1002/aepp.13012

Maas, B., Fabian, Y., Kross, S. M. & Richter, A. (2021). Divergent farmer and scientist perceptions of agricultural biodiversity, ecosystem services and decision-making. *Biological Conservation*, *256*, 109065. https://doi.org/10.1016/j.biocon.2021.109065

Mahmood, N., Arshad, M., Kaechele, H., Shahzad, M. F., Ullah, A. & Mueller, K. (2020). Fatalism, Climate Resiliency Training and Farmers' Adaptation Responses: Implications for Sustainable Rainfed-Wheat Production in Pakistan. *Sustainability*, *12*(4), 1650. https://doi.org/10.3390/su12041650

Mao, H., Zhou, L., Ying, R. & Pan, D. (2021). Time Preferences and green agricultural technology adoption: Field evidence from rice farmers in China. *Land Use Policy*, *109*, 105627. https://doi.org/10.1016/j.landusepol.2021.105627

Marie, M., Yirga, F., Haile, M. & Tquabo, F. (2020). Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. *Heliyon*, *6*(4), e03867. https://doi.org/10.1016/j.heliyon.2020.e03867

McGurk, E., Hynes, S. & Thorne, F. (2020). Participation in agri-environmental schemes: A contingent valuation study of farmers in Ireland. *Journal of Environmental Management*, *262*, 110243. https://doi.org/10.1016/j.jenvman.2020.110243

Michels, M., von Hobe, C.-F., & Musshoff, O. (2020). A trans-theoretical model for the adoption of drones by large-scale German farmers. *Journal of Rural Studies*, *75*, 80–88. https://doi.org/10.1016/j.jrurstud.2020.01.005

Mohammadi, Y., & Ahmadi, Z. (2021). Determinants of Wheat Farmers' Decision to Adoption a Crop Risk Management Tools in Ilam Province. *Iranian Journal of Agricultural Economics and Development Research*, *52*(1), 127–142. https://doi.org/10.22059/ijaedr.2020.302342.668904

Nguyen, N. & Drakou, E. G. (2021). Farmers intention to adopt sustainable agriculture hinges on climate awareness: The case of Vietnamese coffee. *Journal of Cleaner Production*, *303*, 126828. https://doi.org/10.1016/j.jclepro.2021.126828

Oyetunde-Usman, Z., Olagunju, K. O. & Ogunpaimo, O. R. (2021). Determinants of adoption of multiple sustainable agricultural practices among smallholder farmers in Nigeria. *International Soil and Water Conservation Research*, *9*(2), 241–248. https://doi.org/10.1016/j.iswcr.2020.10.007

Quandt, A. (2021). Coping with drought: Narratives from smallholder farmers in semi-arid Kenya. *International Journal of Disaster Risk Reduction*, *57*, 102168. https://doi.org/10.1016/j.ijdrr.2021.102168

Rakhra, M., Sanober, S., Quadri, N. N., Verma, N., Ray, S. & Asenso, E. (2022). Implementing Machine Learning for Smart Farming to Forecast Farmers' Interest in Hiring Equipment. *Journal of Food Quality*, *2022*, 1–17. https://doi.org/10.1155/2022/4721547

Savari, M., Eskandari Damaneh, H. & Damaneh, H. E. (2021). Factors influencing farmers' management behaviors toward coping with drought: evidence from Iran. *Journal of Environmental Planning and Management*, *64*(11), 2021–2046. https://doi.org/10.1080/09640568.2020.1855128

Singh, S. (2020). Farmers' perception of climate change and adaptation decisions: A micro-level evidence from Bundelkhand Region, India. *Ecological Indicators*, *116*, 106475. https://doi.org/10.1016/j.ecolind.2020.106475

Skaalsveen, K., Ingram, J. & Urquhart, J. (2020). The role of farmers' social networks in the implementation of no-till farming practices. *Agricultural Systems*, *181*, 102824. https://doi.org/10.1016/j.agsy.2020.102824

Stringer, L. C., Fraser, E. D. G., Harris, D., Lyon, C., Pereira, L., Ward, C. F. M. & Simelton, E. (2020). Adaptation and development pathways for different types of farmers. *Environmental Science & Policy*, *104*, 174–189. https://doi.org/10.1016/j.envsci.2019.10.007

Thinda, K. T., Ogundeji, A. A., Belle, J. A & Ojo, T. O. (2020). Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. *Land Use Policy*, *99*, 104858. https://doi.org/10.1016/j.landusepol.2020.104858

van Zonneveld, M., Turmel, M.-S. & Hellin, J. (2020). Decision-Making to Diversify Farm Systems for Climate Change Adaptation. *Frontiers in Sustainable Food Systems*, *4*. https://doi.org/10.3389/fsufs.2020.00032

Vecchio, Y., Agnusdei, G. P., Miglietta, P. P. & Capitanio, F. (2020). Adoption of Precision Farming Tools: The Case of Italian Farmers. *International Journal of Environmental Research and Public Health*, *17*(3), 869. https://doi.org/10.3390/ijerph17030869

Workineh, A., Tayech, L. & Ehite, H. K. (2020). Agricultural technology adoption and its impact on smallholder farmers welfare in Ethiopia. *African Journal of Agricultural Research*, *15*(3), 431–445. https://doi.org/10.5897/AJAR2019.14302

Yang, W., Qi, J., Arif, M., Liu, M., & Lu, Y. (2021). Impact of information acquisition on farmers' willingness to recycle plastic mulch film residues in China. *Journal of Cleaner Production*, *297*, 126656. https://doi.org/10.1016/j.jclepro.2021.126656

Yazdanpanah, M., Homayoon, S. B., Zobeidi, T., Woosnam, K. M., Löhr, K. & Sieber, S. (2024). Bridging farmers' non-cognitive and self-conscious emotional factors to cognitive determinants of climate change adaptation in southwest Iran. *Climate and Development*, 1–15. https://doi.org/10.1080/17565529.2024.2332380

Yuan, S., Li, X. & Du, E. (2021). Effects of farmers' behavioral characteristics on crop choices and responses to water management policies. *Agricultural Water Management*, *247*, 106693. https://doi.org/10.1016/j.agwat.2020.106693

Zeleke, G., Teshome, M. & Ayele, L. (2024). Determinants of Smallholder Farmers' Decisions to Use Multiple Climate-Smart Agricultural Technologies in North Wello Zone, Northern Ethiopia. *Sustainability*, *16*(11), 4560. https://doi.org/10.3390/su16114560

Zheng, W., Luo, B. & Hu, X. (2020). The determinants of farmers' fertilizers and pesticides use behavior in China: An explanation based on label effect. *Journal of Cleaner Production*, *272*, 123054. https://doi.org/10.1016/j.jclepro.2020.123054

Abstrak

Kajian literatur sistematik ini meneliti faktor-faktor yang mempengaruhi keputusan petani dalam amalan pertanian, dengan tumpuan kepada faktor sosio ekonomi, tingkah laku dan teknologi. Kajian ini menganalisis 59 artikel terpilih yang dipilih melalui proses pengenalpastian, saringan, kelayakan dan penyertaan yang teliti. Ia mengkaji faktor-faktor utama penerimaan amalan lestari, termasuk insentif ekonomi, rangkaian sosial, ciri-ciri kognitif dan cabaran persekitaran. Dapatan kajian menekankan peranan penting kestabilan ekonomi, ketersediaan sumber, pengaruh rakan sebaya dan strategi penyesuaian dalam penerimaan teknologi dan daya tahan terhadap perubahan iklim. Kajian ini juga mengenal pasti jurang dalam penyelidikan semasa, terutamanya kekurangan kajian longitudinal yang menilai kesan jangka panjang faktor-faktor ini. Ia menggalakkan penyelidikan masa depan menggunakan pendekatan kaedah campuran untuk mendapatkan pemahaman yang lebih komprehensif tentang bagaimana pengaruh-pengaruh ini berkembang. Kajian ini menawarkan pandangan yang bernilai untuk penggubal dasar, penyelidik dan pengamal yang ingin menyokong pembangunan pertanian yang lestari.