

Review Article

Adoption of Smart Farming Technologies (SFTs) among Young Farmers: A Systematic Literature Review

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ABSTRACT

The concept of smart farming is increasingly being applied in the agricultural industry to enhance efficiency, boost productivity and strengthen food security. It also contributes to achieving sustainable farming practices. Young farmers who are more digitally literate and adaptable to new technologies are often more inclined to explore and adopt smart farming solutions. This systematic literature review article on the adoption of smart farming technologies, particularly among young farmers, examines the factors influencing their adoption. A comprehensive search was conducted in databases such as Scopus, IEEE Xplore, ScienceDirect, ProQuest, and Google Scholar, focussing on peer-reviewed studies published between 2019 and 2024. The review adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A total of 213 articles were retrieved during the identification process, and after the screening, eligibility assessment, and quality appraisal, only 15 articles were selected for inclusion in this SLR. The review identified six key themes, including individual factors, social influences, knowledge and experience, technology factors, institutional support, and economic factors. Further analysis of these themes resulted in the identification of 13 sub-themes. Findings suggest that perceived usefulness, followed by

psychological factors, are the primary factors of smart farming technology adoption among young farmers. However, economic factors, particularly cost, remain a significant barrier. Finally, the study presents several recommendations at the end of this research for the reference of future scholars.

ARTICLE INFO

Article history:

Received: 19 July 2025

Accepted: 30 December 2025

Published: 19 March 2026

DOI: <https://doi.org/10.47836/pjtas.49.S1.10>

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Keywords: Adoption, smart farming technologies, systematic literature review (SLR), young farmers

INTRODUCTION

According to the United Nations, the global population is projected to increase to between 9.4 and 10.1 billion by 2050, creating significant challenges for food production. In response, the concept of smart farming is increasingly recognised as a solution to address these challenges. Smart farming technologies (SFTs) are transforming agriculture by integrating advanced technologies into farming practices (Dias et al., 2022). The adoption of SFTs has become essential to address critical challenges in the agriculture sector, including climate change, extreme weather, pest and disease outbreaks, and the issue of an ageing farming population (Alotaibi, 2023; Talaviya et al., 2020; Yoe, 2017). These technologies have the potential to enhance productivity and efficiency by automating farm activities, improving agricultural output and strengthening food security. In addition, SFTs play an important role in promoting sustainable farming practices. These practices include precision agriculture, efficient irrigation systems and reduced chemical usage, all of which contribute to long-term environmental sustainability and soil health (Hadi Suzer et al., 2024; Sharma et al., 2024). Therefore, the integration of SFTs not only modernises agriculture but also aligns with global sustainability goals.

SFTs represent an innovative solution for overcoming challenges in the agricultural sector. By integrating technology into farming practices, smart farming modernises agriculture and enables farmers to remotely monitor crops (Zaman et al., 2023). SFTs refers to the use of technologies such as Internet of Things (IoT), cloud storage, robotics, big data analysis, and Artificial Intelligence (AI) to manage agricultural activities (Dhanaraju et al., 2022; Wee & Ting, 2023). Through precise resource utilisation, SFTs help farmers optimise agricultural inputs and improve data authenticity by providing accurate weather forecasts, yield predictions and disease mapping based on reliable meteorological and climate data networks (Amiri-Zarandi et al., 2022). Beyond their direct impact on farming practices, SFTs can also attract young individuals to the agricultural industry, addressing the ageing workforce issue (Kwakye et al., 2021).

To sustain the agricultural industry and achieve sustainable development, youth involvement in the sector must be encouraged. One approach to achieving this is by utilising SFTs in farm management, as these innovations can attract youth to pursue careers in agriculture, particularly in agribusiness (Harisudin et al., 2023; Kwakye et al., 2021). Osabohien (2023) highlighted that improved access to technology and ICT serves as a potential catalyst for increasing youth involvement in agriculture. Furthermore, an analysis by Jaafar et al. (2021) revealed that Malaysia's internet usage reached 88.7% in 2020, with a significant youth presence, as 85.9% of users fell within this demographic. This underscores the potential for technology-driven approaches in engaging young people in agriculture.

Despite the growing body of research on SFTs, most existing studies focus on examining adoption among the general farming population without considering age differences. What remains unclear is how these factors influence young farmers, given that their technological readiness and motivations might differ from older generation farmers. As youth play an important role in sustaining the future agriculture sector, a clearer understanding of their adoption patterns is needed. This SLR therefore addresses the gap by systematically identifying existing evidence on the determinants of SFT adoption among young farmers.

The Need for a Systematic Review

Systematic Literature Review (SLR) has been widely used in the social sciences for many decades, primarily to support practice and policy decisions and to guide future research efforts (Petticrew & Roberts, 2006). SLR is a literature review process that applies principles of empirical research to enhance transparency at every stage of the review and minimise the risk of bias (Lame, 2019). It is a methodical approach for identifying, reviewing, and synthesising all relevant studies available to address a specific research question. An SLR is particularly crucial compared to traditional literature reviews. It addresses issues such as transparency, author bias, retrieval bias, and publication bias.

The adoption of SFTs among young farmers is increasingly recognised as an important area of research due to its potential impact on sustainable agriculture. While many studies have explored the adoption of SFTs, the majority focus on the general farming population, with youth often included as a subset of respondents rather than the primary focus. Examples include the studies from Chuang et al. (2020a), Kwapong et al. (2023), Erokhin et al. (2024), Isma Addi et al. (2024) and Wee and Lim (2022). On the other hand, several studies have examined the adoption of SFTs specifically among young farmers, such as Chuang et al. (2020a) and Kwakye et al. (2021). These studies highlight the need for an SLR to better understand factors influencing SFT adoption among young farmers.

Existing SLRs on IoT and smart farming adoption largely emphasize the general farming population (Bashiru et al., 2024; Omar, 2021), leaving the perspectives of young farmers underexplored. To address this gap, an SLR focussed on the adoption of SFTs among young farmers is essential. Using a systematic approach, an SLR ensures a more objective and comprehensive review of the literature. The current literature review is structured around the research question: What are the key factors influencing young farmers' adoption of smart farming technologies? This review primarily focussed on factors affecting human adoption.

METHODOLOGY

This section discusses the four main sections, which are PRISMA, resources, process for selecting articles, and data abstraction and analysis.

Prisma

This paper adopts the PRISMA approach, also known as the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, to guide the SLRs process. PRISMA serves as a publication standard, providing a structured framework for authors to conduct SLRs by including the necessary information to evaluate and assess the quality of the review (Mohamed Shaffril et al., 2019). It is widely used to facilitate the development of SLRs and meta-analyses (Abbasi et al., 2022). Page et al. (2021) emphasised that PRISMA is particularly suitable for systematic reviews in various fields, including social sciences. They highlighted its ability to help academic authors produce comprehensive and well-structured systematic analyses that are highly relevant to the research community. PRISMA provides a detailed checklist of guidance for reporting literature searches within systematic reviews, with its core component being a flow diagram that outlines the process from initial search through selection and screening (Haddaway et al., 2022).

Information Sources and Search Strategy

The first step in developing the SLR is formulating suitable research questions. Given the focus of this SLR on the adoption of SFTs among young farmers, the following research questions were identified:

What are the key factors influencing young farmers' adoption of smart farming technologies?

Building on these research questions, the review methods for this study were implemented using several databases accessible through the Universiti Putra Malaysia library's website. The databases utilised include Scopus, IEEE Xplore and ProQuest. These databases were selected because they cover topics related to agriculture, technology and multidisciplinary studies. Additionally, to maximise the likelihood of retrieving relevant articles, manual searches were performed on established resources such as ScienceDirect and Google Scholar.

The Systematic Review Process for Selecting Articles

Identification

Identification is the process of determining and selecting various relevant keywords to facilitate the SLR search process. This stage is essential, as appropriate keywords ensure the selection of studies directly related to the research questions and address the specific issues of interest outlined in the review. Based on the research questions, the primary

keywords identified were adoption, smart farming technology, and youth. To expand the range of relevant studies, additional and related keywords were identified, resulting in a more comprehensive set of search terms. Furthermore, various agricultural technologies, such as Internet of Things (IoT), Machine Learning (ML), Artificial Intelligence (AI), robotics, and Big Data, were also included as keywords when searching for articles (Refer to Table 1). Then, the keywords were combined into a search sentence using Boolean operators (OR and AND) to optimise the search strategy.

Table 1
Primary and expanded keywords

Primary Keywords	Expanded Keywords
Adoption	Acceptance Intention
Smart farming technology	Smart farming Smart agriculture Digital farming Intelligent farming Internet of Things (IoT) Machine Learning (ML) Artificial Intelligence (AI) Robotics Big data
Youth	Young farmers

The article search was conducted across five databases: Scopus, IEEE Xplore, ScienceDirect, ProQuest, and Google Scholar, chosen for their relevance and coverage. Scopus, the largest abstract and indexing database, offers extensive coverage of subjects such as agriculture, technology, and life sciences (Burnham, 2006). IEEE Xplore focuses on computer science and technology, making it relevant for SFTs. ScienceDirect and ProQuest provide multidisciplinary coverage, including agriculture and social sciences. Google Scholar was used for manual searches due to its accessibility and widespread use.

Advanced search techniques were applied, including Boolean operators (AND, OR), phrase searching, field codes, filtering and selected keywords. Since each database has its own syntax and functionality, the search strings were specifically tailored to align with the capabilities of each database (Refer to Table 2). Based on the searching techniques employed, a total of 213 articles were retrieved.

Table 2
The search strings

Database	Search String
Scopus	ALL ("smart farming" OR "Internet of Things" OR "IoT" OR "AI" OR "ML" OR "Robotics") AND ("adoption" OR "acceptance") AND ("youth" OR "young farmer?") AND (LIMIT-TO (SUBJAREA, "SOC") OR LIMIT-TO (SUBJAREA, "AGRI")) AND (LIMIT-TO (DOCTYPE, "ar")) OR LIMIT-TO (EXACTKEYWORD, "Technology Adoption") OR LIMIT-TO (EXACTKEYWORD, "Technology") OR LIMIT-TO (EXACTKEYWORD, "Internet Of Things") OR LIMIT-TO (EXACTKEYWORD, "Agriculture") OR LIMIT-TO (EXACTKEYWORD, "Agricultural Technology") OR LIMIT-TO (EXACTKEYWORD, "Adoption"))
IEEE Xplore	("All Metadata":adoption) OR ("All Metadata":acceptance) AND ("All Metadata":smart farming) OR ("All Metadata":technology) OR ("All Metadata":IoT) OR ("All Metadata":Internet of Things) OR ("All Metadata":Artificial intelligence) AND ("All Metadata":youth) OR ("All Metadata":young farmers)
ScienceDirect	adoption of smart farming technologies among young farmers
Proquest	("Internet of Things" OR IoT) AND ("farm management" OR "agriculture management" OR "smart farming") AND ("adoption" OR "acceptance" OR "implementation" OR "utilisation") AND ("young farmers" OR "youth farmers" OR "youth in agriculture")
Google Scholar	adoption of smart farming technologies among young farmers

Screening

The 213 articles retrieved during the identification process underwent a screening process to select those suitable for the systematic review, guided by predefined inclusion and exclusion criteria (Mohamed Shaffril et al., 2021). Only articles published between 2019 and 2024, written in English, and peer-reviewed were considered. Additionally, only empirical research articles were included, while review articles were excluded, as the SLR aims to synthesize original research findings. Relevance was another key criterion: selected studies had to provide findings specifically related to the adoption of smart farming technologies (SFTs), ensuring alignment with the review’s objectives. Following the screening process, 153 articles were excluded as they did not meet the inclusion criteria. The inclusion and exclusion criteria are detailed in Table 3. Consequently, 60 articles remain and will proceed to the next stage of the systematic review process.

Eligibility

All 60 remaining articles underwent a second screening process, referred to as eligibility. This eligibility process involved manual screening by the researchers to minimize errors made by the database (Mohamed Shaffril et al., 2021). During this phase, the titles,

Table 3
Inclusion criteria

Criterion	Inclusion	Exclusion
Publication year	Published within the last 5 years (2019-2024)	Published before 2019
Publication type	Peer-reviewed journal articles (Research articles)	Review articles, books, or non-peer-reviewed sources
Language	English	Non-English
Findings type	Empirical data	Review data
Findings focus	Adoption of SFTs in farming practices; young farmers included as a respondents	Topics unrelated to adoption

abstracts, and the main contents, such as methodology, results and discussion, were thoroughly examined. As a result, 40 articles were excluded because their focus was not on SFTs adoption, they were review articles, or they did not include young farmers as a respondent. Thus, only 20 articles were deemed eligible to proceed to the next stage: data abstraction and analysis. Figure 1 illustrates the flow of the systematic review process for selecting articles.

Quality Appraisal

These 20 articles were then subjected to quality appraisal. Two researchers independently examined each article considered suitable for inclusion in the SLR. The quality of the articles was assessed by adapting the Mixed Method Appraisal Tool (MMAT) developed by Pace et al. (2012), which is designed to appraise qualitative, quantitative, and mixed methods studies. In this process, each selected article from the eligibility phase was further examined based on three criteria: 1) whether the study presented a clear research objective; 2) whether the collected data adequately addressed the stated research objective; 3) whether data, analysis and interpretations were coherent. Each criterion was rated as “Yes,” “No,” or “Cannot tell.” A minimum cut-off of two out of three criteria rated as “Yes” was applied for inclusion. After independently reviewing the quality of the articles, the researchers discussed their findings and decided which articles should remain in this SLR and which should be excluded. As a result, 15 articles were selected for further analysis in this SLR.

Data Abstraction and Analysis

The next step was data abstraction from the articles that had been assessed for quality. This process was carried out by two researchers. As the focus of this SLR was to examine previous findings on the adoption of SFTs among young farmers, data abstraction focussed on three main sections of each article: the abstract, results and discussion.

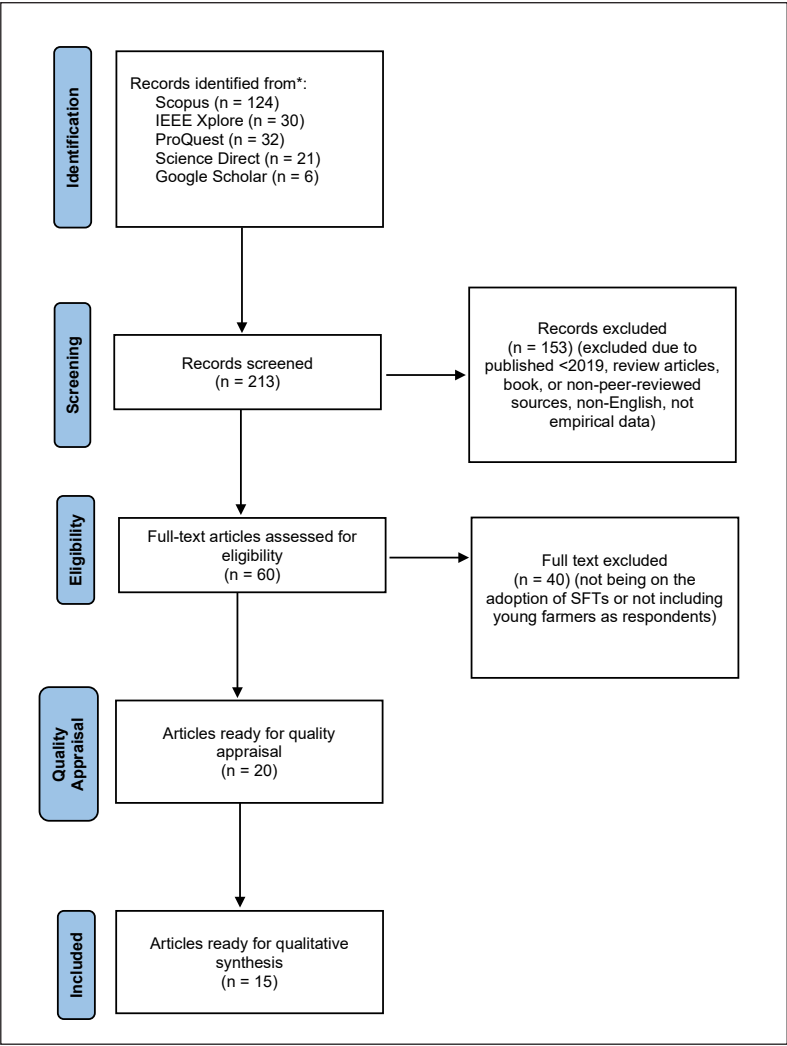


Figure 1. Flow diagramme of the systematic review process (adapted from Mohamed Shaffril et al. (2020))

After extracting the necessary data from the selected articles, the next step involved analysing the data. Since this SLR follows an integrative review approach that incorporates diverse methodologies (quantitative, qualitative, and mixed methods), qualitative synthesis was employed, as it is suitable for both quantitative and qualitative studies (Mohamed Shaffril et al., 2021). Qualitative synthesis is a method of systematically reviewing and integrating findings from various studies, making it particularly useful for understanding experiences, perceptions and social phenomena. For this synthesis, thematic analysis was utilised as the analytical method, as it was the most appropriate for synthesising mixed research design (Flemming et al., 2019). Thematic analysis is a systematic process for

identifying and organising key themes from qualitative data (Bearman & Dawson, 2013). This approach allows the synthesis of findings into coherent themes, offering deeper insights into the research topic.

To identify the appropriate themes, the extracted data were analysed one by one. Data with similarities were grouped, and each group was assigned a theme that represented its core idea. This process resulted in the identification of six main themes: (1) Individual factors, (2) Social Influences, (3) Knowledge and Experience, (4) Technology Factors, (5) Institutional Support, and (6) Economic Factors. Subsequently, the findings within each theme were analysed again to develop sub-themes, resulting in the identification of 14 sub-themes. The process of selecting the themes was discussed and agreed upon by two researchers to ensure accuracy and validity.

RESULTS

Background of the Studies included in the Review

Before discussing the main findings, this section provides background information on the selected articles for the SLR. Among the 15 selected articles, one was published in 2019 (Jithin Das et al., 2019), three were published in 2020 (Ali et al., 2020; Chuang et al., 2020a; Chuang et al., 2020b), two in 2022 (Giua et al., 2022; Wee & Lim, 2022), six in 2023 (Acharya et al., 2023; Dixit et al., 2023; Harisudin et al., 2023; Hassan et al., 2023; Irawan et al., 2023; Kwapong et al., 2023), and the remaining three in 2024 (Erokhin et al., 2024; Isma Addi et al., 2024; Mishra et al., 2024). Figure 2 presents the year of publication of the articles.

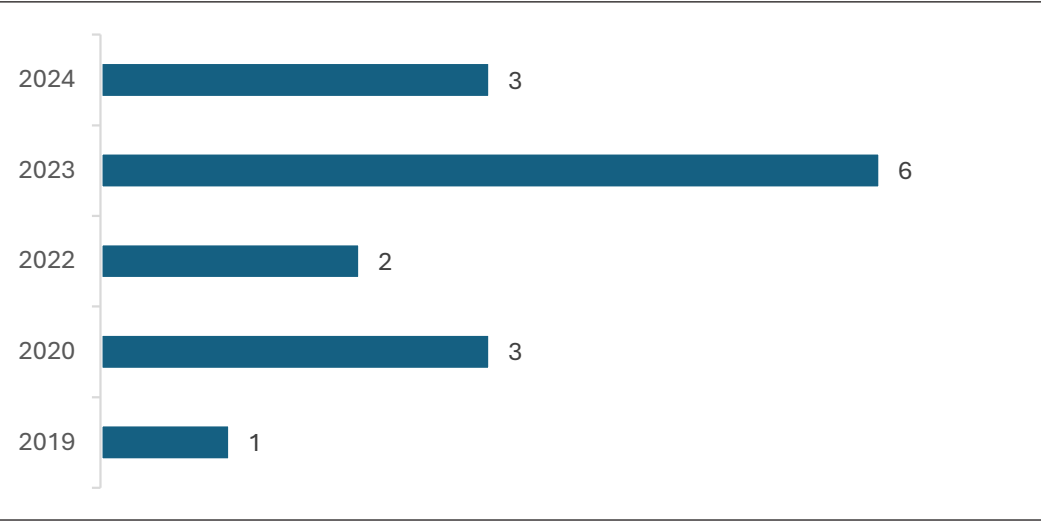


Figure 2. Year of publication

Additionally, the articles are published in various journals, including two in Technology in Society, one in Pakistan Journal of Agricultural Research (M. Ali et al., 2020), one in Agraris (Irawan et al., 2023), one in International Food and Agribusiness Management Review (Chuang et al., 2020a), one in Frontiers in Sustainable Food Systems (Kwapong et al., 2023), one in the International Journal of Environmental Research and Public Health (Chuang et al., 2020b), one in Sustainability (Switzerland) (Erokhin et al., 2024), one in PLoS One (Mishra et al., 2024), one in the International Journal of Academic Research in Business and Social Sciences (Isma Addi et al., 2024), one in AIMS Agriculture and Food (Harisudin et al., 2023), one in AgriEngineering (Jithin Das et al., 2019), one in ASEAN Journal on Science and Technology for Development (Hassan et al., 2023), and one in Journal of Agribusiness Marketing (Wee & Lim, 2022).

Out of the 15 articles, four specifically focussed on on young farmers as their respondents (Chuang et al., 2020a; Harisudin et al., 2023; Hassan et al., 2023; Irawan et al., 2023). For the remaining 11 articles, the percentage of young farmers among respondents was above 30%. Regarding the technology coverage across the 15 articles (Figure. 3), six examined the general adoption of SFTs (Chuang et al., 2020b; Dixit et al., 2023; Giua et al., 2022; Irawan et al., 2023; Mishra et al., 2024; Wee & Lim, 2022). Four articles focussed specifically on IoT adoption (Acharya et al., 2023; Chuang, Wang, & Liang, 2020; Harisudin et al., 2023; Isma Addi et al., 2024). Additionally, two articles explored Climate Smart Agriculture Technology (CSAT) adoption (Hassan et al., 2023; Kwapong et al., 2023), while one article investigated ICTs adoption (M. Ali et al., 2020). Furthermore, one article studied cloud computing adoption (Jithin Das et al., 2019), and another examined adoption of water-smart farming technologies (Erokhin et al., 2024).

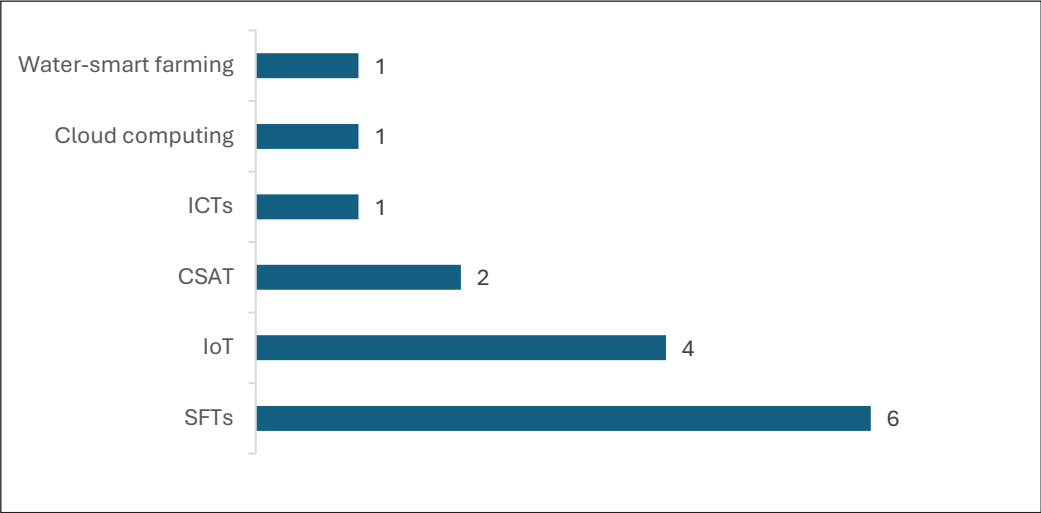


Figure 3. Technology coverage across the articles

Main Findings

In this section, the discussion synthesises the findings of the systematic literature review, highlighting six main themes influencing the adoption of SFTs among young farmers. The prominence of these themes varies significantly across the reviewed literature: Technology Factors emerged as the most frequently cited theme, supported by 12 out of 15 studies. This is followed by Individual Factors and Social Influences, each supported by 8 studies. Knowledge and Experience were supported by 7 studies, while Institutional Support and Economic Factors each received support from 4 studies. Additionally, the 14 sub-themes will also be discussed (Table 4).

Individual Factors

One of the main themes identified in this SLR is individual factors, comprise elements such as attitude, behaviour, motivation and perception. These elements play a crucial role in shaping their intention and willingness to adopt SFTs. Based on the analysis, individual factors are categorised into two sub-themes: psychological (P) and perception and belief (PB).

Psychological (P)

The adoption of SFTs among young farmers appears to be influenced by their psychological factors, supported by seven studies (Dixit et al., 2023; Erokhin et al., 2024; Isma Addi et al., 2024; Jithin Das et al., 2019; Kwapong et al., 2023; M. Ali et al., 2020). Specifically, positive attitude plays a positive role in encouraging young farmers to adopt SFTs in their farming practices. One key reason for their positive attitude is young farmers' concerns for food security and the environmental impact of farming, as emphasised by Kwapong et al. (2023). Furthermore, Isma Addi et al. (2024) found that young farmers perceive the use of IoT in agriculture as highly convenient, which positively influences their attitude. This, in turn, encourages a high level of behavioural intention to adopt IoT technologies in their agricultural practices.

Perception and Belief (PB)

PB sub-theme, derived from three studies (Irawan et al., 2023; Isma Addi et al., 2024; Mishra et al., 2024), underscores how individual worldviews shape adoption. These factors significantly affect young farmers' decisions to adopt such technologies. A study conducted by Irawan et al. (2023) revealed that young farmers believe digital farming contributes to making agriculture more sustainable, which further motivates their adoption of CSAT. Moreover, Isma Addi et al. (2024) found that young farmers believe using IoT can enhance

Table 4
Themes and sub-themes identified in the reviewed articles

Authors	Research Design	Individual Factors		Social Influences		Knowledge and Experience			Technology Factors			Institutional Support			Economic Factors	
		P	PB	IF	TSS	KA	PE	TB	PU	IA	FC	GS	OS	COE	EG	
(Acharya et al., 2023)	Quantitative								/			/		/		
(M. Ali et al., 2020)	Quantitative	/		/											/	
(Chuang et al., 2020a)	Quantitative				/				/				/		/	
(Chuang et al., 2020b)	Quantitative					/										
(Dixit et al., 2023)	Quantitative	/							/	/		/	/		/	
(Erokhin et al., 2024)	Quantitative	/				/			/						/	
(Giua et al., 2022)	Quantitative			/					/							
(Harisudin et al., 2023)	Mixed method			/					/							
(Hassan et al., 2023)	Mixed method	/		/						/	/	/			/	
(Irawan et al., 2023)	Mixed method		/			/		/								
(Isma Addi et al., 2024)	Quantitative	/	/			/		/	/						/	
(Jithin Das et al., 2019)	Mixed method	/		/	/	/			/	/				/	/	
(Kwapong et al., 2023)	Qualitative	/		/	/		/	/	/	/			/		/	
(Mishra et al., 2024)	Quantitative		/	/					/							
(Wee & Lim, 2022)	Quantitative			/			/		/	/						
Note. “/” indicates that the corresponding theme or sub-theme was identified or reported in the article.																
Individual Factors	Social Influences	Knowledge and Experience		Technology Factors		Institutional Support		Economic Factors								
P = Psychological	IF = Interpersonal Factors	KA = Knowledge & Awareness		PU = Perceived Usefulness		GS = Government Support		COE = Cost and Operational Efficiency								
PB = Perception & Belief	TSS = Trust & Support	PE = Practical Exposure		IA = Innovation Attribute		OS = Organisational Support		EG = Economic Gains								
		TB = Technology Benefits		FC = Facilitating Conditions												

their productivity. Furthermore, Mishra et al. (2024) emphasised that young farmers with high self-efficacy are more likely to adopt agricultural technologies, demonstrating the importance of confidence in their abilities to successfully use these tools.

Social Influence

Another theme identified is social influences. The analysis categorises social influences into two sub-themes: Interpersonal Factors (IF) and Trust and Support (TSS).

Interpersonal Factors (IF)

The adoption of SFTs among young farmers is significantly influenced by IF, supported by seven studies (Giua et al., 2022; Harisudin et al., 2023; Jithin Das et al., 2019; Kwapong et al., 2023; Mishra et al., 2024; Wee & Lim, 2022). IF refer to the consideration young farmers give to others' perceptions of their actions in adopting SFTs. This also includes cases where young farmers adopt SFTs because their peers or relatives have already done so, indicating that their decisions are influenced by others' actions. Adoption is heavily influenced by social influence from peers and relatives (Giua et al. 2022; Mishra et al. 2024; Wee & Lim 2022). Technology adoption among farmers is positively influenced by active peer communication, trusted social groups, and young farmers' social interactions (Harisudin et al., 2023; Jithin Das et al., 2019; Kwapong et al., 2023).

Trust and Support (TSS)

TSS sub-theme, derived from three studies (Chuang et al., 2020a; Jithin Das et al., 2019; Kwapong et al., 2023), emphasises the importance of reliable external guidance. A study by Jithin Das et al. (2019) highlighted that Irish farmers benefit from knowledge transfer through agricultural extension services and participate in discussion groups to share information about these technologies. Similarly, research by Kwapong et al. (2023) found that young farmers place confidence in the information provided by the agricultural extension agents. Furthermore, Chuang et al. (2020a) emphasised that a sense of trust is a crucial factor that encourages young farmers to adopt IoT-based technologies.

Knowledge and Experience

Individuals with knowledge and experience are more confident in adopting SFTs. Therefore, knowledge and experience are one of the themes identified in this SLR. This theme is divided into three sub-themes: Knowledge and Awareness (KA), Practical Exposure (PE) and Technology Benefits (TB:).

Knowledge and Awareness (KA)

KA sub-theme, supported by four studies (Chuang et al., 2020b; Erokhin et al., 2024; Irawan et al., 2023; Isma Addi et al., 2024; Jithin Das et al., 2019), reveals that a high level of knowledge about SFTs and their applications significantly increases the likelihood of adoption. Farmers who actively seek information through digital platforms (Jithin Das et al., 2019) and have a strong knowledge of smart agriculture, show higher adoption rates (Chuang et al., 2020b; Isma Addi et al., 2024). Specific knowledge, such as acknowledging the need to reduce water waste, can also directly motivate the adoption of targeted technologies like water-smart systems (Erokhin et al., 2024).

Practical Exposure (PE)

PE sub-theme highlights that hands-on experience with technologies plays a crucial role in building young farmers' confidence to adopt SFTs. According to Kwapong et al. (2023), young farmers often start by experimenting with the technologies on a small scale first, then once they confirm the innovation was beneficial, they gradually scale up its implementation across their entire farm. Similarly, Wee & Lim (2022) found that practical exposure serves as the initial step toward developing the behavioural intention to adopt SFTs.

Technology Benefit (TB)

The sub-theme of TB explores young farmers' knowledge and understanding of the benefits SFTs. Young farmers who have a high level of understanding of these technology benefits are more likely to adopt SFTs in their farming practices. A study by Kwapong et al. (2023) found that young farmers' willingness to adopt CSAT was driven by their desire to increase yields, soil fertility and conserve water for plant use. Additionally, Irawan et al. (2023) highlighted that young farmers' understanding of the benefits and outcomes of digital farming practices strongly influences their adoption decision.

Technology Factors

Technological factors become another key theme in this SLR. These technological factors include the ease of use, the benefits to users, and the innovation in technology itself. There are three sub-themes under this theme: Perceived Usefulness (PU), Innovation Attribution (IA) and Facilitating Conditions (FC).

Perceived Usefulness (PU)

PU sub-theme is a dominant predictor in SFTs adoption, supported by nine studies (Acharya et al., 2023; Chuang et al., 2020a; Dixit et al., 2023; Erokhin et al., 2024; Harisudin et

al., 2023; Isma Addi et al., 2024; Jithin Das et al., 2019; Kwapong et al., 2023; Mishra et al., 2024). Nine out of fifteen articles identified perceived usefulness as one of the factors influencing young farmers to adopt SFTs. This sub-theme aggregates perceived usefulness, ease of use, and relative advantage. This indicates that young farmers are more likely to adopt SFTs when the technologies contribute to simplifying and easing their farming activities (Jithin Das et al., 2019; Kwapong et al., 2023), contribute to agricultural production and field management (Chuang et al., 2020a) and easy to handle (Acharya et al., 2023; Dixit et al., 2023; Isma Addi et al., 2024; Mishra et al., 2024). The relative advantage, such as increased productivity at a lower cost, is a significant motivator, driving an openness to change (Dixit et al., 2023; Harisudin et al., 2023).

Innovation Attribution (IA)

IA sub-theme, including characteristics such as compatibility, technological complexity and performance expectancy, as identified across three studies (Dixit et al., 2023; Giua et al., 2022; Wee & Lim, 2022). SFTs that are compatible with existing farming techniques encourage adoption among young farmers (Dixit et al., 2023). Furthermore, performance expectancy, what the technology is expected to achieve, has been identified as a key driver of adoption intention (Giua et al., 2022; Wee & Lim, 2022).

Facilitating Conditions (FC)

FC sub-theme, supported by two studies (Hassan et al., 2023; Wee & Lim, 2022), refers to the necessary infrastructure and resources, such as internet access and necessary skills. These technological aspects are crucial in encouraging young farmers to adopt advanced technologies. According to Hassan et al. (2023), the technology dimension of FC, which includes the perceived benefits that address farmers' needs and the ease of implementation, significantly encourages young farmers' intention to adopt CSAT. Furthermore, Wee & Lim (2022) found that FC are the factor driving young farmers' behavioural intention to adopt SFTs.

Institutional Support

Adopting a technology requires consideration of multiple factors, therefore, support from related institutions is necessary. As a result, institutional support becomes another main theme. The sub-themes under institutional support are government support (GS) and organisational support (OS).

Government Support (GS)

GS sub-theme, supported by three articles (Acharya et al., 2023; Dixit et al., 2023; Hassan et al., 2023), is crucial for enhancing young farmers' confidence. This aligns with the findings of Hassan et al. (2023), who stated that youth are motivated to adopt CSAT with government support such as technology rental, access to land and infrastructure. Such support reassures them when facing any challenges in adopting the technology. Similarly, Dixit et al. (2023) emphasised that government support significantly influences the adoption of SFTs. In addition, Acharya et al. (2023) highlighted that the government should equip young farmers with sufficient knowledge and training on the technical aspects of SFTs, as well as provide standardised guidelines and frameworks for the adoption of SFTs.

Organisational Support (OS)

OS sub-theme, also derived from three articles (Chuang et al., 2020a; Dixit et al., 2023; Kwapong et al., 2023), centres primarily on the role of the Department of Agriculture and Agricultural Extension. Effective communication between extension officers and farmers positively influences adoption (Dixit et al., 2023). The active involvement of extension officers in meetings and field demonstrations is essential for transferring knowledge and information about SFTs (Kwapong et al., 2023), and this support is a significant factor in adoption decisions (Chuang et al., 2020a).

Economic Factors

Technology adoption involves financial considerations, including initial costs, ongoing expenses and maintenance fees. The financial aspects, such as the cost of technology implementation and the expected economic returns, impact their willingness to invest in these technologies. This theme is categorised into two sub-themes: Cost and Operational Efficiency (COE) and Economic Gains (EG).

Cost and Operational Efficiency (COE)

COE sub-theme, supported by three articles (Acharya et al., 2023; Jithin Das et al., 2019; Kwapong et al., 2023), presents a contradicting finding based on adoption status. For non-adopters, high costs are a major barrier to embracing new technologies (Jithin Das et al., 2019), and young farmers are more likely to adopt with a lower initial cost (Kwapong et al., 2023). However, adopters acknowledge that while the initial investment is high, the long-term operational efficiency and financial returns make it a worthwhile and profitable decision (Jithin Das et al., 2019; Kwapong et al., 2023).

Economic Gains (EG)

EG sub-theme, supported by three articles (Chuang et al., 2020a; Hassan et al., 2023; Jithin Das et al., 2019), highlights that anticipated returns are a primary concern given the high financial investment required. Jithin Das et al. (2019) highlighted that young farmers are willing to adopt a cloud computing system if they perceive the technology as profitable. Additionally, Chuang et al. (2020a) found that high average annual turnover increases young farmers' willingness to invest in SFTs. Furthermore, Hassan et al. (2023) emphasised that the economic dimension is a strong motivation for adoption. Young farmers, specifically those concerned about employment opportunities, view SFTs as capable of creating new jobs and enhancing financial stability.

DISCUSSION

This SLR has identified six main themes (individual factors, social influences, knowledge and experience, technology factors, institutional support, and economic factors) influencing the adoption of SFTs among young farmers. Each theme consists of various sub-themes, indicating that adoption decisions are shaped by a combination of psychological, technological, and structural conditions. The strongest factor is PU, followed by psychological, interpersonal factors, and knowledge. Additionally, economic factors, particularly the cost of adoption, are discussed as a barrier that hinders young farmers from integrating these technologies.

Among all the identified factors, PU is the strongest determinant influencing the adoption of SFTs among young farmers. Almost all the reviewed articles in this SLR emphasise the significance of PU, indicating that young farmers are more inclined to adopt SFTs when they perceive them as beneficial and capable of enhancing their farming practices (Acharya et al., 2023; Chuang et al., 2020a; Dixit et al., 2023; Erokhin et al., 2024; Harisudin et al., 2023; Isma Addi et al., 2024; Jithin Das et al., 2019; Kwapong et al., 2023; Mishra et al., 2024). These findings align with the Technology Acceptance Model (TAM), which highlights the crucial role of perceived usefulness in technology adoption.

Furthermore, TAM also posits that perceived ease of use influences the intention to use technology. However, in this SLR, only Dixit et al. (2023) highlighted perceived ease of use as a significant factor affecting young farmers' decisions. This suggests that young farmers prioritise the actual benefits of SFTs over their ease of use. However, studies outside this SLR, such as Kamrath et al. (2018) and El Bilali et al. (2021), also support the principles of TAM. Their findings indicate that both perceived usefulness and perceived ease of use influence technology adoption, suggesting that individuals are more likely to adopt technology that is both effective and easy to use.

Psychological factors are the second most frequently discussed in the articles selected for this SLR. Among these, young farmers' attitude towards SFTs stands out as a key

motivator. However, these attitudes stem from various motivations: environmental concerns (Erokhin et al., 2024; Kwapong et al., 2023), anticipated long-term profitability (Dixit et al., 2023; Jithin Das et al., 2019), and the alignment of SFTs with sustainable farming practices. While TPB suggests that positive attitudes should translate into intention and behaviour (Ajzen, 1991), many studies examine attitude or intention only, without assessing actual adoption behaviour (Ali et al., 2023; Erokhin et al., 2024). Similar emphasis on psychological factors by Cui and Wang (2023) is found in reviews of general farmers in China, but the evidence remains limited for the young farmers population.

To encourage SFTs adoption, government and industry stakeholders must highlight the benefits of these technologies through targeted training programs, demonstrations and guidance on their operation. These initiatives not only shape a positive attitude but also enhance young farmers' knowledge, increasing their confidence to adopt SFTs. This is relevant as knowledge and experience have been identified as factors influencing their willingness to adopt. Additional studies support that higher knowledge and understanding of technology will increase an individual's willingness to adopt innovations (Kwakye et al., 2021; Osei et al., 2022; Zhang & Zhu, 2023).

Social influence also plays a crucial role in influencing the willingness of young farmers to adopt SFTs. These factors include interpersonal interactions, external perception, and trust. Moreover, trust and relationship with the external expert further enhance young farmers' confidence in adopting SFTs (Jithin Das et al., 2019; Kwapong et al., 2023). These findings suggest that, beyond individuals' motivation, social factors also play a role in reinforcing young farmers' confidence in adopting SFTs. Therefore, the government or companies providing SFTs should highlight success stories of adopters who have effectively implemented these technologies to inspire and encourage wider adoption among non-adopters.

Economic factors play a decisive role in young farmers' adoption of SFTs because these technologies require high upfront investment, which many young farmers cannot afford due to limited capital. Although cost is widely reported as a major barrier (Jithin Das et al., 2019), this reluctance also reflects uncertainty about financial returns. Notably, several studies show that adopters do experience long-term economic benefits once they begin using SFTs (Chuang et al., 2020a; Kwapong et al., 2023), suggesting a gap between perceived and actual value. This indicates that the challenge is not only affordability but also limited financial knowledge and confidence in managing investment risk. Therefore, financial support mechanisms such as subsidies or rental schemes should be complemented with financial education to help young farmers evaluate long-term returns and view SFTs as viable investments rather than financial burdens.

The findings of this review generally align with earlier SLRs (Cui & Wang, 2023; Thomas et al., 2023), emphasising the central role of PU and the influence of economic, social, and knowledge-related factors. Yet, several patterns are uniquely pronounced among young farmers: ease of use is less influential and financial barriers are more restrictive. These observations highlight the value of considering youth-specific contexts when applying technology adoption frameworks, suggesting that existing models may benefit from adjustments to better capture the motivations and constraints of younger farmers.

CONCLUSION

In conclusion, this SLR on the adoption of SFTs among young farmers provides an understanding of the factors influencing their adoption. A key contribution of this review is the identification and synthesis of six major themes and 14 sub-themes, offering a more structured and comprehensive categorization of adoption determinants. This SLR contributes to young farmers' focussed perspectives, who play a crucial role in sustaining future crop production systems. The review also contributes to the field by highlighting technological factors, particularly PU, as the most influential factors across the studies reviewed (12 studies). In contrast, economic factors and institutional support were found to be the least explored (4 studies each), despite being well-recognised barriers for young farmers. This imbalance indicates a gap in existing research and underscores the need for future empirical studies to examine economic constraints more rigorously, given their potential to directly hinder SFTs' adoption.

Therefore, policies or interventions should be designed to specifically encourage the adoption of SFTs among young farmers. Initiatives that enhance young farmers' exposure to the tangible benefits of SFTs, such as demonstrations and training programs, may significantly improve adoption rates. Furthermore, targeted financial supports, such as subsidies, rental schemes and low-interest loans, with stronger institutional support, are essential to reduce the upfront financial burden that affects young farmers. Additionally, highlighting how these technologies contribute to sustainable and efficient farming practices can strengthen the alignment with young farmers' values and encourage their sustained commitment to sustainable agriculture.

This study recommends that future research focus specifically on young farmers to better understand their motivations and decision-making in adopting SFTs, particularly related to the agriculture sector. Further studies should also examine key barriers to adoption among young farmers, including individual, social, technological, institutional, knowledge, and economic factors. Additionally, future research should conduct region- or country-specific comparisons, as SFT adoption patterns and influencing factors may vary across different geographical contexts.

ACKNOWLEDGEMENT

This research was supported by the Putra IPM Grant (GP-IPM/2023/9769800), Universiti Putra Malaysia (UPM). The authors would like to express their sincere gratitude for the financial support provided, which made this study possible.

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