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Review Paper

A Review of Youth Readiness in Smart Farming from A Structural Perspective

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Abstract: Youths, in and beyond Malaysia, play a significant role in spurring the expansion of conventional agriculture to smart agriculture. Smart agriculture utilises modern technologies to produce and increase the quality and quantity of agricultural products in farms. Agriculture technology should be able to attract digitally savvy and educated youths, especially university students. However, the youths' readiness to participate in both agriculture sectors is still a concern, especially from structural and external perspectives beyond the youth's agency. Hence, key research questions arose: What are the factors influencing youth readiness? How do those factors influence the youths? A structural approach to review qualitatively 158 past studies (between 2015 until 2025) on smart farming or smart agriculture sourced from Web of Science, SCOPUS and Google Scholar is conducted deductively and sociologically. The objective of the review is to identify and analyse structural and external factors. The factors discovered as socio-cultural, institutional, organisational, economic, and smart technology in nature are concerned with availability, accessibility, adequacy and sustainability issues about youth participation in smart agriculture. Specifically, the factors are family background; social and moral support; social networks and social capital; social perceptions of youths as young farmers; youth talent and development strategies; finance and credit facilities; regulatory and policy support; agriculture extension services; and smart agriculture technology and information communication technology. An implication is more research on youth human capital in smart farming and improved design and planning of effective conventional and smart farming policies and programmes for sustainable youth human capital in agriculture, particularly in Malaysia.

Keywords: Youth Readiness; smart farming; youth human capital; structural approach; sustainability

Introduction

Youths, in and beyond Malaysia, play a significant role in spurring the expansion of conventional agriculture to smart agriculture that utilises modern technologies to produce and increase the quality and quantity of

agricultural products in farms. Smart farming is a modern farming practice and method that utilises modern technologies like IoT, robotics, drones and AI to produce and increase the quality and quantity of agricultural products on farms. Hence, it should be able to attract human capital from digitally savvy and educated youths, especially university students. Smart agriculture is also known as precision agriculture, climate smart agriculture (Khalilia et al., 2024; Makau et al., 2022; Malamsha, 2024; Manalo et al., 2016; Mohd Amar Aziz et al., 2024) Digitalistion in the Malaysian food industry such as based on smart agriculture and smart farming is the solution to resolving food security and poverty issues in socio-economic development in Malaysia (see Anuja et al., 2023; Kam, 2023; Tham & Kam, 2023).

Societies with agriculture as an important economic sector implement their own distinctive agricultural and smart agricultural policies. The Malaysian government, for instance, has introduced National Agrofood Policy 2.0 (NAP 2.0) to encourage and increase youth participation in not just conventional agriculture but also smart agriculture, including smart farming. Institutions of higher learning in Malaysia have also offered agricultural degrees and conducted agricultural courses for university students. However, in Malaysia, common knowledge is claiming that youths' readiness to participate in conventional agriculture and smart agriculture is still a concern today despite the government's initiatives and the National Agrofood Policy 2.0 (2021-2030) to increase youth participation in smart farming (see Abu Dardak et al., 2020; Shaharudin & Rahim, 2020). Youth readiness and participation in smart agriculture and smart farming is mainly in terms of youth agropreneurship, youth agripreneurship or youth agrotechnopreneurship. Ra et al (2019) argued that high-tech youth agropreneurs can be created as the youths have the potential to replace aging farmers. As young farmers, they can embrace and accept modern agriculture to improve agricultural production and marketing, efficiently manage risks, and sustainably raise productivity and profitability (Ra et al., 2019).

Youths today should be able to learn and gain knowledge on internet technologies familiar to them, such as mobile phones, IoT (Internet of Things), cloud computing, big data, and satellite imagery, and apply them in agricultural production, processing, marketing, and other related agricultural activities. It is the hope of the nation that they can modernise traditional rural industries, increase rural employability, boost efficiency, increase productivity, reduce poverty, and increase earning capacity, especially in rural economies based on agriculture. The potential to become innovative rural agropreneurs is undoubtedly possible for the youths.

Many studies have been conducted in Malaysia and elsewhere on youth participation in conventional agriculture. However, to date, there are still few studies on youth participation in smart agriculture, including in smart farming. Nonetheless, several common themes appeared from all those studies about youths' intention, intended behaviour and readiness to participate in smart agriculture. One theme, for example, is about factors that cause lack of youth participation. Another related theme focusses on the factors that influence and attract youths' intentions, intended behaviour, and readiness to take part as farmers or smart farmers. Challenges and problems experienced by the youths are other themes. However, these themes do not show if external or structural factors beyond individual will influence the themes, namely factors for the lack of youth participation as well as influencing the youths. Thus, a research gap exists.

Considering the research gap, the authors of this paper decided to review those studies and the common themes, but from a structuralist approach instead. This structural approach to doing the literature review becomes a research gap not filled by those past studies on youth participation in conventional as well as smart agriculture. This structural approach, which to an extent is based on sociological perspective, is uncommonly used by most of the studies that have reviewed, studied and analysed either youth participation in conventional agriculture or smart agriculture. Two key research questions arose: What are the factors influencing the youth readiness? How do those factors influence the youths?

The structuralist approach conceptualised factors that are also external and able to influence or hinder youth participation in agriculture as "structural" in nature. This is because some of the factors are created or shaped by social relations (social networks) between the social actors related to those factors. Other factors are also "structural" because each factor is based on interlinking different elements, for instance, interlinking social norms and values, interlinking varying policies, interlinking various finance and credit facilities, and others.

Besides being structural, the factors are also external in nature because their influence or influence on youths is beyond the youths' self-control and self-will. This means that the factors are external because they are not personal in nature, i.e., the factors are not innate, not inborn and not inherent qualities of mind and character of the youths as individuals. In theoretical and sociological language, external structural factors are factors beyond human agency. These factors can influence the youths' knowledge, beliefs, thoughts, attitudes, and perceptions that will then influence their intended behaviour, and consequently, their readiness to become farmers and smart farmers. The following sections in this paper shall firstly discuss the methodology of the literature review, thereafter, followed by findings from the structural review and analysis of the factors. Briefly, the structural factors are socio-cultural, economic, institutional, organisational, and smart technology and information communication technology.

Methodology

This study employed a systematic literature review based on the structural approach to examine youth participation in smart farming and smart agriculture across Malaysia, Asia, Europe, and Africa. The review focused on 158 peer-reviewed journal articles and conference papers published in Web of Science, SCOPUS and Google Scholar between 2015 and 2025, a period marked by the rapid emergence of smart agriculture, precision farming, digitalisation and climate-smart agriculture.

1. Search Strategy

The search was conducted using three major databases: Web of Science, SCOPUS and Google Scholar. Keywords were developed based on four main conceptual clusters:

i. Youth-related terms: "youths," "young farmers," "students," "university students," "agropreneurs," "agripreneurs," "Generation Y."
ii. Participation terms: "participation," "engagement," "involvement," "adoption," "intention," "planned behaviour," "readiness," "awareness."
iii. Smart agriculture terms: "smart agriculture," "smart farming," "precision agriculture," "climate-smart agriculture," "digitalisation," "artificial intelligence," "innovative technology", "digital agriculture".
iv. Boolean operators (AND/OR) were applied to combine terms (e.g., "youth* AND (smart agriculture OR precision agriculture OR smart farming OR digital agriculture) AND participation"). Searches were carried out in titles, abstracts, and keywords.

2. Inclusion and Exclusion Criteria

The publication period of those studies is between 2015 and 2025. This period is selected due to the emergence of smart agriculture, smart farming, climate smart agriculture, precision agriculture or digital agriculture in agricultural societies in those years to increase agricultural productivity, efficiency, cost reduction, carbon emission reduction, and sustainability and increase socio-economic development and reduce poverty through smart technology and innovation. The ten years period also sees the rise of smart agriculture, smart farming, climate smart agriculture, precision agriculture and digital agriculture in developing and agricultural societies and the increasingly significant role of youths in smart agriculture; be they university students, fresh graduates, young farmers, researchers, or consultants. The role of youths is seen as more important than before to address declining farmers and increasing aging farmers over the recent years. These youths are of the millennial and Generation Y years.

Inclusion criteria:

i. Peer-reviewed journal articles or conference papers.
ii. Studies published between 2015–2025.

iii. Research that explicitly examined youth participation, engagement, intention, or adoption of smart framing, smart agriculture, precision agriculture or digital agriculture.
iv. Studies focusing on Malaysia, Asia, Africa, and Europe to provide both regional and comparative perspectives.
v. Both qualitative and quantitative studies.

Exclusion criteria:
i. Non-peer reviewed sources (e.g., reports, dissertations, blogs).
ii. Studies outside the 2015–2025 range.
iii. Papers that only discussed general smart farming, smart agriculture, precision agriculture and digital agriculture technologies without reference to youth or participation.
iv. Studies not written in English.

3. Screening and Selection Process
The first search yielded 158 records. After removing duplicates and applying inclusion/exclusion criteria, 64 articles were shortlisted for full-text review and thematic relevance checks.

4. Research Paradigm
The research paradigm that guided the methodology for the literature review is mainly structuralist in nature. This is because structural aspects, at times known as factors, are beyond individual control and free will, and hence, influence, shape and affect individual thoughts, beliefs, and behaviour. Therefore, this demonstrates that individual behaviours, i.e. the youths, are constantly influenced by the structures that are underlying and external in nature, i.e. people, culture, organisations and institutions that surround them. As such, the youths' personal beliefs, behaviours and action, namely on participation in smart farming or smart agriculture, are not intrinsic, innate, and inherent individual properties.

4. Analytical Approach
The analysis or review, based on the structuralist research paradigm, was able to capture deductively how external social, economic, institutional and cultural structures shaped youth participation in smart farming or smart agriculture. The analysis involved these processes:-
i. Extracting recurring themes across studies.
ii. Conceptualising these themes to uncover underlying structural and external factors.
iii. Interpreting how these factors influence youth intentions, behaviours and readiness toward smart agriculture.

The final themes identified were:
i. Factors contributing to the lack of youth participation in smart farming or smart agriculture.
ii. Factors influencing youth's planned behaviour, intention, and readiness on smart farming or smart agriculture participation.
iii. Challenges and barriers to youth participation in smart farming or smart agriculture.
iv. Recommendations for increasing youth participation in smart farming or smart agriculture.

The Findings and Discussion
This section is about findings from the review on several structural and external factors found to influence youths' intention, intended or planned behaviour and readiness to become smart farmers as well as agropreneurs or agrotechnopreneurs in smart agriculture and smart farming. Specifically, the factors are socio-cultural, economic, institutional, organisational, technology, smart technology and information communication

technology. Some of these factors are universal across cultures but some other factors are context specific, particularly in the socio-cultural sense.

Universal factors about youth participation in smart farming are economic factors such as capital resources, human resources and natural resources for youth participation in smart farming; formal social networking between the youths and government and private agencies, and the role of formal education and training by universities and agricultural training agencies for youth agricultural talent development. Governments, the private sector and agricultural extension agencies from all societies are urged to play a key direct role in this matter. In addition, most past studies emphasised, regardless of which societies and cultures, on formal and complex organisational role in youth motivation and talent development especially from the government, private sector, non-governmental organisations and agriculture related community organisations or association. Other prerequisites for the success of smart farming and youth involvement that are also similar across societies are smart technology and social media, preferably youth friendly tailored to youth specific needs. In comparison, some other factors are culturally and contextually specific and distinctive to specific societies and cultures. They are informal social networks, social capital and social networking; cultural values and norms; social values and social norms; family and friends' financial, moral and social support; customs and beliefs (tradition); trust; indigenous and traditional knowledge and practices; and land ownership. Table 1 on Thematic Synthesis in the following section summarised the findings and discussion.

1. Socio-Cultural Factors

Socio-cultural factors are social and cultural norms relating to smart agriculture and smart farming and youth participation; family background; moral and social support; formal and informal social networks that create social structures; social capital; customs and beliefs (tradition); trust and social perceptions of youths being farmers and smart farmers (see Chan et al., 2011; Chan, 2017a, 2017b; Afiqah Norizan & Chan, 2022, on social networks; Chan et al., 2020, on socio-cultural factors).

Social networks between youths and the government, universities, NGO (community organisations or farmers' association) and the private sector are important to encourage and motivate youths to venture into smart farming or agribusiness. Networks between these organisations themselves are equally important. These networks become social capital when agribusiness networks, "adult meaningful partnership", or collaboration or cooperation serve to mobilise asset bases such as human labour; adopt or intention to adopt smart farming technologies; knowledge sharing of smart agricultural production and smart farming technologies; transfer of agricultural knowledge; disseminate smart farming knowledge; smart farming skills development; training and mentoring of upstream and downstream agricultural activities and creation and expansion of young farmers' networks (Poungchompu & Phuttachat, 2023; Rathakrishnan et al., 2022; Sinturat et al., 2024; see also Manalo et al., 2016). Social network actors such as family members, government officials, farmers, friends, colleagues play a significant influencing role (Mohd Amar Aziz et al., 2024; Rathakrishnan et al., 2022).

Other socio-cultural factors are social norms and values, family education background, family occupational background and background, trust, gender relations, tradition and custom on land ownership and agricultural practices (see Chuang et al., 2019; Farayola et al., 2020; Poungchompu & Phuttachat, 2023; Malamsha, 2024; see Khalilia et al., 2024; Mohd Nur Fikri Waktu Saptu et al., 2020; Rathakrishnan et al., 2022; and Zaremohzzabieh et al., 2021). Some scholars termed social norms as "subjective norms" (Mohd Nur Fikri Waktu Saptu et al., 2020; Zaremohzzabieh et al., 2021). Indigenous knowledge, local traditional inherited knowledge, "citizen science" traditional customs and practices about agriculture is another socio-cultural factor in encouraging young people to participate in smart farming, according to some scholars (see Mburu, 2022). Age old agricultural knowledge passed down from old farmers to the younger generation is about agricultural methods, production, crop selection and post-harvest preservation methods. In short, socio-cultural factors are key aspects of the youths' social system. The youths face and experience the effects of these social-cultural features in their everyday lives, and hence, the effects and influence on their behaviour and readiness for smart agriculture or smart farming is expected and even inevitable.

2. Economic Factors

Economic factors are about productive resources to be utilised for smart agricultural activities, such as capital resources, human resources, and natural resources. These structural and external factors develop youths' perceptions, intention and planned behaviour in upstream and downstream smart agricultural ventures (Abu Dardak, Haimid, & Masdek, 2020; Chuang et al., 2019; Khalilia et al., 2024; Makau et al., 2022; Malamsha, 2024; Mburu & Maswabi, 2022; Mohd Amar Aziz et al., 2024; Mohd Nur Fikri Waktu Saptu et al., 2020; Oagunju, 2024; Poungchompu & Phuttachat, 2023; Shaharudin & Rahim, 2020; Singh & Singh, 2018; Sinturat et al., 2024; Zaremohzzabieh et al., 2021).

Capital resources are monetary capital, human capital, natural capital, and social capital. Finance and credit facilities (e.g. insurance schemes) are normally provided by the government, private sector such as agricultural banks in the form of loans, grants and subsidies (Makau et al., 2022; Mohd Amar Aziz et al., 2024). Human resources for smart farming are youth labour that provides non-monetary human capital such as knowledge, skills and experiences related to smart farming developed from formal and informal education and training in schools and institutions of higher learning and government or NGO's agricultural programmes (Abu Dardak, Haimid, & Masdek, 2020; Malamsha, 2024; Olagunju, 2024; Poungchompu & Phuttachat, 2023; Shaharudin & Rahim, 2020).

Specific knowledge and skills are about smart farming system creation, agricultural products and services management, branding, packaging and accreditation management, agribusiness networks administration, and accounting system and capital analysis skills for agribusiness planning, knowledge development and skills training on advanced and AI technology for smart farming, farming related decision-making, production and marketing management, product quality and consumer safety, and responsible farming (Sinturat et al., 2024). Natural resources that provide natural and physical capital such as arable land, agricultural equipment and machines, building, seeds, fertilizer, crop and others and others are usually provided by the government through its agricultural and land ownership policies as a way to assist impoverished but motivated youths to participate in smart agriculture (Makau et al., 2022; Malamsha, 2024).

Zaremohzzabieh et al. (2021) claimed that resource facilitating conditions are positively related to youths', i.e. students', intention to engage in agriculture when they graduate. If these conditions such as ease of access to financial institutions like e-banking, e-business and e-commerce exist, youths will have the intention and demonstrate planned behaviour to engage in agriculture, including smart agriculture (see Mohd Nur Fikri Waktu Saptu et al., 2020; Zaremohzzabieh et al., 2021). The review of these external and structural economic factors demonstrates the significance of monetary and non-monetary capital in motivating and influencing youths to become smart farmers. No doubt lack of monetary capital can greatly hinder youth participation in smart agriculture. However, non-monetary capital such as human capital and social capital can reduce the hindrance when they proved they can contribute by ensuring accessibility, availability, and sustainability of the monetary capital for the youths.

3. Institutional Factors

Institutional factors are about formal and informal norms and related values, and related practices set by the government, private sector and NGOs for agriculture and smart agriculture (see Ahmad Ashraf Ahmad Shaharudin & Mohd Amirul Rafiq Abu Rahim, 2020; Makau et al., 2022; Malamsha, 2024; Mburu & Maswabi, 2022; Mohd Nur Fikri Waktu Saptu et al., 2020; Norhasni Zainal Abidin & Syamsul, 2016; Poungchompu & Phuttachat, 2023; Rathakrishnan et al., 2022; Zaremohzzabieh et al., 2021, for Asian and African contexts). Hence, institutions are different from organisations but they are linked. Institutions are about formal regulatory framework that guide the operations of formal and complex organisations; they are policies, rules, regulations and other normative aspects related to smart agriculture and smart farming. Informal institutional norms, termed as "subjective norms" by some scholars are social or cultural norms that are concerned with traditional and heritable farming practices; particularly in rural areas (Mohd Nur Fikri Waktu Saptu et.al. 2020; Zaremohzzabieh et. al. 2021).

Some agricultural policies introduced by the government are for commercialisation and productization and must be in place to promote smart agriculture technology adoption among young farmers (re a, 2024; Mohd Amar Aziz et al., 2024). Related to those agricultural policies are policies and regulations on investment in digitalisation and tax and high cost of mobile services (Farayola et al., 2020). However, scholars urged these policies to be more youth friendly and tailored specific to meet the needs of the youths and young farmers. The policies and others must be accommodative, clear and understandable to the youths and available and accessible within their reach.

To reduce youth exodus in agriculture, policies should also be for improved wages and increased job security in the farming and agriculture industry (Ahmad Ashraf Ahmad Shaharudin & Mohd Amirul Rafiq Abu Rahim, 2020; see also Olagunju, 2024). Mohd Amar Aziz et al. (2024) argued that institutions especially in terms of rules and regulations must effectively support in easing conditions that can influence the youths' perceived use and perceived ease of use of climate smart technology in farming and agricultural activities. Besides policies and others, other structurally based institutional factors are the role of Government, private and NGO's extension and advisory officers to teach and influence youths about farming and smart farming (Mburu & Maswabi, 2022; Rathakrishnan et al., 2022). Those people are the farmers' "private advisors" (Mburu & Maswabi, 2022). Institutional support is effective if their agriculture extension services are accessible to the youths (Poungchompu & Phuttachat, 2023).

Universities and colleges play research and development role on agriculture research innovations, youth talent development, and smart farming strategies (Ahmad Ashraf Ahmad Shaharudin & Mohd Amirul Rafiq Abu Rahim, 2020). Rules and regulations concerning higher learning are about formal education, off site and on-site training in smart farming locations, mentorship, consultancy, and knowledge sharing and advisory and consultancy by offering accessible and available agricultural extension services on smart farming, offering agriculture related programmes, conducting seminars and workshops, offering higher education degrees, technical/vocational courses, school curriculum and others. They teach youths knowledge and skills on agriculture crop production skills, other technical or vocational skills, usage and application of smart farming, AI technology (digital literacy) and other technical and agriculture related soft skills. Other institutional factors are social security benefits and security, and safety issues related to smart farming. Policies concerning data protection and data privacy, intellectual property rights, ethical considerations for smart farming are mostly addressed by the government. Briefly, institutions, namely rules and regulations, as external and structural factors, are deliberately created by society to shape, influence, regulate and control individuals' behaviours and action in everyday social group living. Therefore, as far as smart agriculture is concerned, formal and informal rules and regulations, particular on youth friendly education and learning about smart agriculture can educate, regulate, and control the youths' mindsets, attitudes, behaviour, and so influencing their readiness in participation in smart agriculture.

4. Organisational Factors

Organisational factors are not about institutional factors but about the role of formal and complex public, private, non-governmental and community organisations in influencing youth participation in smart agriculture and smart farming. Institutions in the form of formal norms (rules and regulations) and informal social norms, however, do influence and determine organisational characteristics and operations.

It is clear then that institutions are not like organisations, conceptually and empirically, although they are intricately linked. Organisations are structural in nature because organisations consist of different interlinked entities (e.g. rules, regulations, internal structures, systems) to achieve a common goal or purpose. Organisations are, of course, external to the individuals and can exert a minimum or a considerable amount of influence upon the individuals in their everyday lives.

Government agencies, universities, the private sector and NGOs play a dominant role in spearheading youth participation on agriculture and smart agriculture such as conducting agricultural innovation research, implementing youth talent development strategies, programmes and conducting activities concerning youth

talent in agricultural entrepreneurial activities (see Chuang et al., 2019; Khalilia et al., 2024; Olagunju, 2024; Poungchompu & Phuttachat, 2023; Rathakrishnan et al., 2022; Ras Hussin & Margarita Peredaryenko, 2022).

Governmental efforts are also monumental for smart agriculture in other ways – improve access to internet and basic digital infrastructure and electricity; develop training programmes and workshops to develop technical skills and digital literacy among young farmers; establish grants, loans and subsidies to support young farmers; encourage collaboration between the government and stakeholders such as private sector; academia and civil society organisations, develop guidelines and regulations to ensure the ethical use of AI technologies in smart agriculture and conduct workshops; conferences and online forums to facilitate knowledge sharing and stakeholders collaboration to exchange best practices, lessons learned, and innovative ideas (Abu Dardak, Haimid, & Masdek, 2020; Farayola et al., 2022; Khalilia et al., 2024; Malamsha, 2022; Mburu & Maswabi, 2022; Olagunju, 2024; Ra, Mahfuzuddin, & Teng, 2019; Shaharudin & Rahim, 2020; Zaremohzzabieh et al., 2021).

Interorganisational collaboration between the government and universities, the private sector and NGOs is pertinent in youth smart agriculture participation (Ra et al., 2019; Makau et al., 2022; NDE–CTCN, 2023). According to Ra et al. (2019), the government also needs to set up public-private partnership with private sector such as industries to train youths with the "practical know-how and skills" required by knowledge intensive smart agriculture. The interlinked organisations need to prove they can offer opportunities for research, agricultural technologies and innovations, risk insurance, carbon emissions reduction, preservation and conservation, education, gender and adaptation systems (see Makau et al., 2022). Youths are constantly surrounded by and exposed to various formal and complex organisations, influencing them in many aspects of their daily lives and group living. Hence, formal organisations indeed play a key role in developing youth interest and readiness in participation for smart farming or smart agriculture. The government in collaboration with the private sector and agriculture related non-governmental organisations should consistently take the lead in developing and implement youth friendly education and training programmes that are easily accessible and available to the youths. Upon implementation, programme monitoring and assessment should be on a scheduled and planned basis. Only by doing so will sustain youth interest in smart agriculture in the long run.

5. Smart Farming Technology and Information Communication Technology (ICT) Factors

Smart farming technology and information communication technology aspects consist of hard technology and social media. They are indeed structural in nature due to interlinking technological elements for smart farming. Although non-human in nature, smart farming technologies are created and worked by humans. Therefore, the role of humans in enabling smart farming technologies to influence the readiness of the youths in smart farming is still acknowledgeable, namely the government, its agencies, the private sector, and farmers' organisations.

The ability of smart technology and information communication technology, through the effort of the government, universities or private agencies, to influence youth perceptions and readiness is by providing experiential knowledge and skills such as smart farming applications and IoT, drones, sensors, and big data and predictive analytics in schools, universities and colleges (see Chuang et al., 2019; Siti Rabiah Hamzah & Zanariah Mohd Nor, 2022; see also Khalilia et al., 2024). Consequently, the youths will show developed perceived usefulness and perceived ease of use of technology (see Chuang et al., 2019; Khalilia et al., 2024; Mohd Amar et al., 2024). The youths may even change their perception of intended behaviour in smart farming participation from reluctant to anticipated agricultural involvement. Government research institutions, such as Malaysian Agriculture Research and Development Institute (MARDI) in Malaysia, play a key role in transferring smart agriculture technology to young agropreneurs (Abu Dardak et al., 2022).

Available and accessible ICT infrastructure is an important physical capital needed for climate smart agriculture participation (see Farayola et al., 2020; Makau et al., 2022; Manalo et al., 2016; Mburu & Maswabi, 2022; Olagunju et al., 2024). The government must ensure high cost of ICT, poor network connectivity and ICT inaccessibility in the rural areas is avoided (Makau et al., 2022). Social media is the most common channel for youths to obtain, develop, give and spread information on upstream and downstream smart agriculture and

smart farming today. Youths can obtain and learn about agricultural production and farming, e-marketing, e-commerce, and retail for smart farming purposes. from diverse types of social media platforms. Commonly used types of social media platforms are Tik Tok, Instagram, REDNOTE, facebook, and YouTube. The discussion in this section shows that it is not so much about the hard aspects of smart technology and information communication in influencing youth participation in smart agriculture but it is about the influencing role of the social context within which the smart technology and information communication technology is located, created and developed. Therefore, to raise youth interest in smart agriculture or smart farming, creation, innovation and development of smart technology and information communication technology for smart farming must be strongly emphasised.

Table 1. Thematic synthesis table

Factor	Socio-cultural	Economic	Organisational	Institutional	Smart technology and information communication technology
Key Elements	1) Shared social and cultural norms relating to smart agriculture and smart farming and youth participation 2) Subjective norms 3) Moral and social support 4) Formal and informal social networks that create social structures 5) Social capital (trust, social network) 6) Customs and beliefs (tradition) 7) Social perceptions of youths being farmers and smart farmers 8) Behaviour and practices 9) Family education background 10) Family occupational background 11) Gender relations 12) Custom on land ownership and agricultural practices	1) Capital resources – money and physical assets 2) Human resources - human capital, social capital 3) Natural resources – from the natural environment.	1) Role of complex and formal organisations, public organisation (government agencies, universities) 2) Role of private organisations, 3) Role of agriculture related non-governmental organisations 4) Organisational rules and regulations, education and training programmes 5) Interorganisational collaboration between the government and universities, private sector and NGOs for youth smart agriculture participation	1) Formal and informal rules and regulations created by the society, organisations and community	1) Hard and soft aspects of the technology 2) Smart agriculture technology 3) Information communication technology - Social media
Supporting Studies	Poungchompu & Phuttachat, 2023 Rathakrishnan et al., 2022 Sinturat et al., 2024	Abu Dardak, Haimid, & Masdek, 2020 Chuang et al., 2019 Khalilia et al., 2024	Chuang et al., 2019 Khalilia et al., 2024 Olagunju, 2024 Poungchompu & Phuttachat, 2023	Ahmad Ashraf Ahmad Shaharudin & Mohd Amirul Rafiq Abu Rahim, 2020 Makau et al., 2022 Malamsha, 2024	Chuang et al., 2019 Siti Rabiah Hamzah & Zanariah Mohd Nor, 2022 Khalilia et al., 2024

	Manalo et al., 2016 Mohd Amar Aziz et al., 2024 Rathakrishnan et al., 2022 Chuang et al., 2019 Farayola et al., 2020 Malamsha, 2024 Khalilia et al., 2024 Mohd Nur Fikri Waktu Saptu et al., 2020 Zaremohzzabieh et al., 2021 Mburu, 2022	Makau et al., 2022 Malamsha, 2024 Mburu & Maswabi, 2022 Mohd Amar Aziz et al., 2024 Mohd Nur Fikri Waktu Saptu et al., 2020 Olagunju, 2024 Poungchompu & Phuttachat, 2023 Shaharudin & Rahim, 2020 Singh & Singh, 2018 Sinturat et al., 2024 Zaremohzzabieh et al., 2021 Mohd Amar Aziz et al., 2024 Makau et al., 2022	Rathakrishnan et al., 2022 Ras Hussin & Margarita Peredaryenko, 2022 Abu Dardak, Haimid, & Masdek, 2020 Farayola et al., 2022 Khalilia et al., 2024 Malamsha, 2022 Mburu & Maswabi, 2022 Olagunju, 2024 Ra, Mahfuzuddin, & Teng, 2019 Shaharudin & Rahim, 2020 Zaremohzzabieh et al., 2021 Ra et al., 2019 Makau et al., 2022 NDE–CTCN, 2023 Makau et al., 2022	Mburu & Maswabi, 2022 Mohd Nur Fikri Waktu Saptu et al., 2020 Norhasni Zainal Abidin & Syamsul, 2016 Poungchompu & Phuttachat, 2023 Rathakrishnan et al., 2022 Zaremohzzabieh et al., 2021 Mohd Amar Aziz et al., 2024 Farayola et al., 2020 Olagunju, 2024	Mohd Amar et al., 2024 Abu Dardak et al., 2022 Farayola et al., 2020 Makau et al., 2022 Manalo et al., 2016 Mburu & Maswabi, 2022 Olagunju et al., 2024
Implications	Emphasis on these socio-cultural aspects without conducting further analysis of the nature of the aspects, i.e. whether they are external or structural in nature or not	Studies mainly focused on these economic aspects without conducting further analysis of the nature of the aspects, i.e. whether they are external or structural in nature or not	Studies mainly emphasised on these organisational aspects without conducting further analysis of the nature of the aspects, i.e. whether they are external or structural in nature or not	Studies stressed on agricultural related and also AI related policies for research and innovation, wage and salary, commercialisation and productisation, without conducting further analysis of the nature of the aspects, i.e. whether they are external or structural in nature or not Policies are acknowledged by the studies as enacted in training and seminars through teaching, coaching, mentoring,	Main emphasis is on the smart technology and information communication technology aspects without conducting further analysis of the nature of the aspects, i.e. whether they are external or structural in nature or not, whether they have underlying social nature and social component

Conclusion

This literature review provides three key contributions to the understanding of youth participation in smart agriculture. First, it shows a critical research gap. While earlier studies have broadly discussed youths in agriculture, few have systematically examined youth engagement in smart agriculture. This review highlights the scarcity of focused empirical studies in this area, thereby underscoring the need for more targeted research.

Second, the review advances a structural and sociological perspective on youth participation. Unlike earlier works that emphasise individual agency or personal attributes, this study proves how socio-cultural, economic, institutional, organisational, technological, and ICT-related factors, all external and beyond individual control, significantly shape youth interest, intention, and readiness to become smart farmers. This is a novel theoretical contribution by shifting attention from intrinsic qualities to external structures and forces.

Third, the findings carry practical and policy implications. By confirming the limited participation of youths in smart agriculture and linking this to structural and external constraints, the review signals the urgent need for evidence-based interventions. Future empirical studies should inform policies and programmes that cultivate youth human capital in smart farming, thereby ensuring a sustainable agricultural workforce, supporting Malaysia's food security agenda, and aligning with the goals of the Fourth Industrial Revolution. Comparative studies on youth participation in rural and urban smart farming or smart agriculture areas can differentiate effects of different physical localities on smart farming intentions and motivation. A longitudinal study may be able to provide rich long term data useful for smart farming innovation and solutions and also policy making; however the possibility of study depends on sufficient research resources.

In sum, this review contributes to the literature by (i) filling a knowledge gap on youth in smart agriculture, (ii) reframing participation through a structural lens and (iii) charting directions for research and policy aimed at building a resilient new generation of smart farmers.

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