International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 889-908



INTERNATIONAL JOURNAL OF INNOVATION AND INDUSTRIAL REVOLUTION (IJIREV)
www.gaexcellence.com/ijirev

THE ROLE OF CLIMATE-SMART AGRICULTURE PRACTICES AND ADOPTION FACTORS IN ENHANCING SUSTAINABLE AGRICULTURE PRODUCTION: EVIDENCE FROM MALAYSIA AND THE SUSTAINABLE DEVELOPMENT GOALS

Zeeshan Tariq[1], Au Yong Hui Nee[2*], Abdelhak Senadjki[3]

[1] Teh Hong Piow Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Kampar, Malaysia.
zeeshantariq@1utar.my https://orcid.org/0000-0002-5343-5062
[2] Teh Hong Piow Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Kampar, Malaysia.
auyonghn@utar.edu.my https://orcid.org/0000-0002-3337-213X
[3] Teh Hong Piow Faculty of Business and Finance, Universiti Tunku Abdul Rahman, Kampar, Malaysia.
abdelhak@utar.edu.my https://orcid.org/0000-0002-4302-4091
[*]Corresponding Author

Article Info:

Article history:
Received date: 22.07.2026
Revised date: 18.08.2026
Accepted date: 09.09.2026
Published date: 30.09.2026

To cite this document:

Tariq, Z., Au Yong, H. N., & Senadjki, A. (2026). The Role of Climate-Smart Agriculture Practices and Adoption Factors in Enhancing Sustainable Agriculture Production: Evidence from Malaysia and the Sustainable Development Goals. *International Journal of Innovation and Industrial Revolution, 8*(26), 889-908.

Abstract:

Climate change continues to undermine agriculture resilience, as achieving sustainable agriculture production remains priority in Malaysia. This examines the determinants of climate smart agriculture (CSA) adoption among Malaysian agriculture producers and evaluates its contribution to sustainable agriculture production. A conceptual framework has developed by incorporating key enabling factors including farmer's acceptability, trialability and access to ICT as predictors in CSA adoption for sustainable agriculture production. With a quantitative approach data were collected from 409 agriculture producers across multiple Malaysian states and analysed using SmartPLS 4.1. The measurement model demonstrated acceptable reliability and validity. Structural model results reveal that farmer's acceptability, trialability shown insignificant influence and access to ICT significant influence on sustainable agriculture production respectively. Furthermore, CSA adoption as mediator employs a significant influence on sustainable agriculture production. The findings highlight the critical role of resources and accessibility in promoting CSA practices. This study delivers empirical evidence to inform policymakers, stakeholders and agriculture producers in strengthening support mechanisms to accelerate CSA practices and enhance sustainable agriculture production in Malaysia aligned with

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 889-908

SDG 2 (Zero Hunger) and SDG 12 (Ensuring Sustainable Production and Consumption).

DOI: 10.35631/IJIREV.826053

Keyword:

Access To ICT, CSA Practices, Farmer's Acceptability, Sustainable Agriculture Production, Trialability.

© The authors (2026). This is an Open Access article distributed under the terms of the Creative Commons Attribution (CC BY NC) (http://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact ijirev@gaexcllence.com.

Introduction

The primary source of food in the world is agriculture. Throughout history, it has been essential to the growth of developments. The United Nations (UN) projects that by 2050, there will be 2 billion more people on the planet than there are now 7.8 billion, which means that by the end of the century, the world would need to accommodate roughly 11 billion people (De Wrachien et al., 2021). Sustainable agriculture production must rise to satisfy the world's population growth. However, the Food and Agriculture Organization of the United Nations (FAO) considers that the challenges of hunger removal and food security do not essentially require an increase in agricultural production (Hedden et al., 2021), if agricultural production systems become more sustainable (Niggli et al., 2023). Technology must be fully used achievable, to realize the principles of sustainable agriculture.

Believing on facts that every country agriculture sector plays a significant part in providing its people with food security (Kumar, 2024). A worldwide agricultural commodity is the production of food and other non-food items. How and where these items are dispersed depends on several factors, including climate, soil quality, economic laws and technological improvements (Cassani & Gomez-Zavaglia, 2022). Approximately 50% of the global population is associated with agriculture sector. Asia produces 90% of the world's food, and more than 80% of that is consumed by Asian countries. The world's top five agricultural producers including China, India, Indonesia, Bangladesh and Vietnam are also consumers. Malaysia imports between 30 and 40 % of its food needs from other countries (Dorairaj & Govender 2023). As currently Malaysian government often emphasises agricultural industry, maybe because it is strategically vital as the country's food to reduce dependency on imports (Ab Samat et al., 2022). By offering training, financial support, and technological and managerial advancements to support fluctuations on the ground, these approaches will assist agriculture producers in modernising their farm for better outcome and executing CSA

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 889-908

practices (Moonga et al., 2025). To achieve the Sustainable Development Goals (SDGs), such as SDG 2 Zero Hunger and SDG 12 Ensuring Sustainable Production and Consumption, a more sustainable agriculture production system needs to be changed (Hoek et al., 2021).

The interconnected issues of climate variation and sustainable agriculture production call for significant agricultural transformations (Mpogole, 2025). Climate resilient agricultural diversification, climate resilient crop varieties, conservation agriculture, water management strategies, integrated pest control and nutrient management are some of the CSA practices used in several Asian countries. Other Asian nations are utilising these CSA practices to encourage sustainable agriculture production (Nguyen et al., 2025). However, fruits, vegetables, and grains are crucial for ensuring national food security (Dardak, 2020). One of Malaysia's biggest issues in the agriculture sector is that agriculture producers do not executing CSA practices at an advanced level (Aziz et al., 2024). This has initiated a workforce scarcity and a fall in sustainable agriculture production (Mohamad & Hassim, 2023). The focus of Malaysia's national food production and self-sufficiency discussion is agricultural production (Tan et al., 2024). If Climate Smart Agriculture practices are not given more provision, Malaysia goes the risk of declining food security (Khan et al., 2024)

Farmers' acceptability and level of technology utilisation are associated with increases in agricultural production output (Ong et al., 2025). The readiness of agriculture producers to adopt CSA practices is still not well considered. agriculture producers' perceptions of risk and cost are linked together. Opportunities for producing agriculture sustainably are limited and it is difficult to fully assess agriculture producers' preparedness for executing CSA practices (Nyang'au et al., 2021). Access to trialability is restricted, particularly in areas where there is a significant communication gap state that agriculture producers may encounter several problems in their efforts to become more motivated to execute CSA practices to provide sustainable food (Aziz et al., 2024). Technological problems contain inadequate access to ICT practices and a restricted execution of CSA practices (Pawlak & Kołodziejczak, 2020). Agriculture remains a fundamental support of Malaysia's socioeconomic development, contributory significantly to country livelihoods, national food resource and economic stability (Mohd Yusoff et al., 2025). However, the segment is increasingly confronted by difficult challenges arising from climate variability which rising food need (Firdaus et al., 2020). Therefore, the objective of this study to focus CSA practices which enhances sustainable agriculture production through different factors in Malaysian agriculture sector.

Literature Review

Farmer Acceptability, CSA Practices & Sustainable Agriculture Production

The welfare of small-scale agriculture producers either for short-term or long-term initiatives, it is necessary to understand the costs and advantages of various CSA practices for efficient outcomes (Mekonnen, 2024). To focus on climate change and sustainable agriculture production, the Association of Southeast Asian Nations (ASEAN) emphasized the importance of implementing CSA practices (Zheng et al., 2024). Farmers perspectives on the acceptability of implementing CSA practices and concentrating on improving sustainable agriculture production (Panyasit et al., 2024). Farmers acceptability reflects their capacity, readiness and willingness to embrace CSA practices and respond favorably to climate change (Belay et al., 2022). Farmers participate more in the execution of CSA practices. CSA practices are more likely to be adopted by agriculture producers who are more aware of the effects of climate

change, as farmers' adoption behavior is more important in CSA adoption (Atta-Aidoo et al., 2023). Agriculture producers' approach toward acceptability are influenced by peer pressure and social learning, which enable them to fulfil sustainable agriculture production targets (Ramborun et al., 2020). A mediated relationship is theoretically supported in which farmers' acceptability increases the likelihood of CSA practices and adoption of CSA practices enhances sustainable agriculture production.

Trialability, CSA Practices & Sustainable Agriculture Production

Before a technology is adapted on a large scale, it must first be tested on a small scale (Valizadeh et al., 2023). Trialability offers a chance for experiential learning, allowing agriculture producers to comprehend how a new technology functions under circumstances (Kirungi et al., 2023). Trialability considered as agent tool to CSA practices in which agriculture producers communicate their experiences with their fellows through at initial phase (Kwapong et al., 2024). Agriculture producers have been enabling to test new CSA practices on a small scale, lowering risk, encouraging confidence and promoting wider adoption all of which support the shift to more resilient, effective and environmentally friendly agriculture structures in which trialability enhances sustainable agriculture production (Kirungi et al., 2023). In the context of adoption of CSA practices, trialability plays an essential role because CSA practices often involve changes in crop management, soil practices and irrigation systems that agriculture producers may hesitate to adopt without prior testing. The influence of trialability on sustainable agriculture production is therefore expected to occur primarily to CSA practices adoption rather than as a purely direct effect (Senyange, 2022).

Access To ICT, CSA Practices & Sustainable Agriculture Production

Using contemporary agricultural technology and innovations, such as inorganic fertilizers, pesticides, foods, high yield production, land management and irrigation techniques, the primary objective of adopting CSA practices is to establish resilient systems and high agricultural productivity (Katkar et al., 2026). Precision agricultural tools, digital platforms, and smartphone apps help agriculture producers to execute CSA practices (Gemtou et al., 2024). Companies that provide hi-tech irrigation, weather forecasting software and farm management apps create new sources of income in agribusiness (Obi & Maya, 2021). Adoption of CSA practices is also encouraged by peers, and agriculture producers are more open to long-term implementation (Kassa & Abdi, 2022). However, a lack of information, awareness and training hinders the adoption of CSA practices, which has a detrimental impact on sustainable agriculture production (Karimi & Ataei, 2024). Since mobile applications to sensor-based systems, the range of ICT applications is vast and ever-evolving (Liu et al, 2021). However, there are significant obstacles in the way of investing in digital infrastructure that can unlock ICT's potential (Khan et al., 2021). Small scale agriculture producers are expected to find advanced ICT instruments costly. Agriculture producers' inability to use ICT effectively is vulnerable by their lack of technical expertise (Odeyemi et al., 2022). Access to ICT helps as a tool for training and development with a highlighting on enhancing agriculture producers' ability to produce food in a sustainable way (Hasan et al., 2023). Access to ICT delivers seasonal climate prospects, early warning systems and real-time weather forecasts. This aids agriculture producers in planting and reaping while avoiding climate associated hazards (Selvam and Al-Humairi, 2023). Agricultural producers that have access to ICT can adopt best practices and innovations that improve production and sustainability (Raza et al., 2020). Access to ICT helps as a tool for training and development with a highlighting on enhancing

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 889-908
agricultural producers ability to produce food in a sustainable way (Hasan et al., 2023). Though, the access of ICT to sustainable agriculture production is not purely direct rather, it functions through the adoption of improved and adaptive farming approaches such as CSA practices (Ma & Rahut, 2024).

Theoretical Foundation

This study has been grounded in established theory which explain the relationship between factors, CSA practices and sustainable agriculture production. Theory of Access (Peluso & Ribot, 2020) provides a theoretical foundation for explaining farmers acceptability has provided the opportunity to agricultural producers for sustainable agriculture production (Mutea et al., 2020). Theory of access interpret that agriculture producers having the farmers acceptability are encouraged to adopt CSA practices for sustainable agriculture production (Tariq et al., 2026). Access to ICT enables agriculture producers to adopt CSA practices that improve productivity, resource-use proficiency and climate resilience. Access to ICT accelerates the dissemination of agricultural knowledge, increases agriculture producers' awareness of CSA practices and enhances perceptions of the comparative advantage and observability of CSA practices. Therefore, CSA practices function as the behavioural mechanism in which ICT access influences sustainable agriculture production (Aliyu et al., 2024; Mgomezulu et al., 2024). Theory of access also describes the indirect relationship between trialability and sustainable agriculture production through CSA practices. Trialability is an important access mechanism because it determines agriculture producers avail the trial opportunity on small scale without disruptions and on successful results got further extensions. Trialability facilitates agriculture producers to access that support the acquisition of CSA practices. However, trialability alone do not directly increase sustainable agriculture production. Their benefits are realised only when agriculture producers avail the opportunity to adopt CSA practices that improve production efficiency and environmental sustainability. Trialability reduces the constraints associated with adopting new agricultural technologies, thereby increasing agriculture producers' willingness to invest in CSA practices leading to sustainable agriculture production (Calo et al., 2016; Mensah, 2020).

Adoption of CSA practices is main where IVS connects through mediator to meet SFP. Without CSA practices agriculture production cannot achieved (Begna & Wakweya, 2025). According to the theory of access, agriculture producers' capability to advantage from CSA practices by providing complementary institutional resources such as technical knowledge, financial incentives, infrastructure and extension services. Based on the literature and theories the developed hypothesis either accepted or rejected as below on behalf this study checked in Malaysian context.

Conceptual Framework

The conceptual framework of this study is built around five key variables and is informed by access theory as shown in figure 1. To begin with, the capacity to optimize the factors, assess them, and use them effectively, which is causes to sustainable agriculture production (Movilla-Pateiro et al., 2021). Second, platform/ practices awareness indicates the awareness of CSA practices with the benefits of utilization (Agyekum et al., 2024). The outcome variable of the study, sustainable agriculture production represents the perceived ability of agricultural producers to optimize CSA adoption (Tay, 2024). In line with access theory lens, the three factors are viewed as farmers acceptability, trialability and access to ICT can enhance an

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972 IJIREV
Volume 8 Issue 26 (September 2026) PP. 889-908

agricultural producer's productivity. The theory of access reinforces the role of accessibility of resources in encouraging the CSA practices platform awareness. The model allows comparative analysis of factors between CSA practices and SFP. This study highlighted and focused that the adoption of CSA practices and its outcomes on SFP. This outcome is different because access theory indicates that the accessibility of resources different at different regions. This research also confirms this conclusion by stating that the levels of adoption CSA practices differ at different regional agriculture producers (Maspan & Halimoon, 2024; Ng et al., 2025).

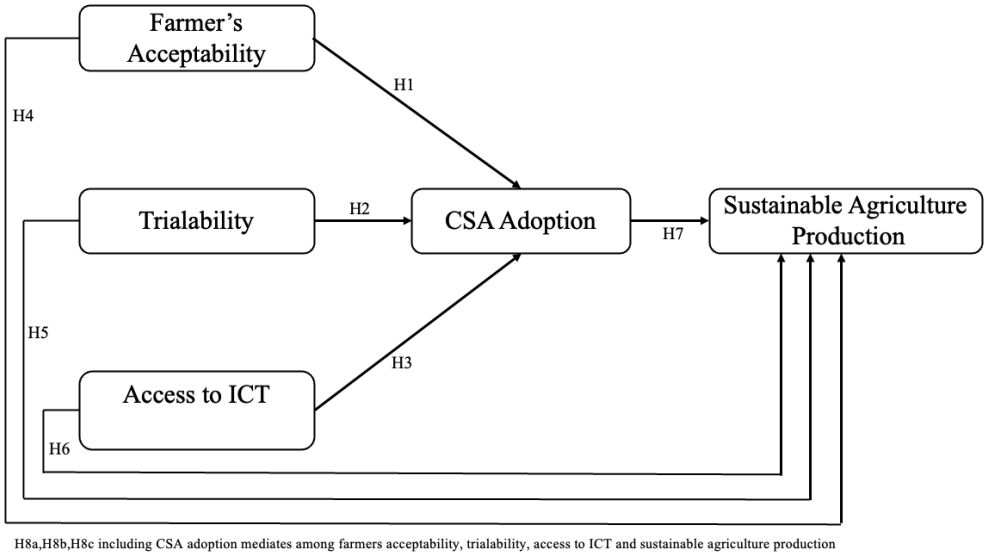


Figure 1. Conceptual Framework Illustrating the Relationship Among Factors, CSA Adoption and Sustainable Agriculture Production

Material & Methods

This paper applied a quantitative, cross-sectional research design below a positivist paradigm, which supports objective measurement and statistical analysis. The focus was to investigate the influence of factors on sustainable agriculture production in Malaysia's agriculture sector. Specially, the perceptions of agriculture producers about CSA practices. A non-probability purposive sampling technique was used to reach agricultural producers which involved in agriculture sector across Malaysia. Around one million agricultural producers in Malaysia are involved in agriculture sector (Ali et al., 2020), further official statistics report got by Jebatan Pertanian Malaysia. Purposive sampling has been chosen because this study has required specific characteristics as targeted group. This technique has widely applied in social sciences research considering is to gather insights from respondents who can provide the most relevant information on the research questions (Etikan et al., 2016; Hair et al., 2017).

Moreover, total of 409 valid responses was collected out of 650, consisting of agricultural producers which meet the threshold value which is 384 determined formulas by using Krejcie and Morgan's (1970). This sample exceeds the minimum threshold for PLS-SEM**,** as recommended (Hair et al., 2017). Data were collected using a structured questionnaire developed based on validated scales adapted from prior studies as the questionnaire constructs. The multiple constructs of each variable directed at latent construct including sustainable agriculture production, CSA adoption, farmers acceptability, trialability and access to ICT respectively (Aziz et al., 2024, Masud et al., 2017, Zulqarnain et al., 2020, Adnan et al., 2017

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972 IJIREV
Volume 8 Issue 26 (September 2026) PP. 889-908

and Duang-Ek-Anong et al., 2019). All the items have been used a 5-point Likert scale ranging from 1 Strongly Disagree to 5 Strongly Agree. Primarily, a pilot test with 30 participants was conducted to ensure the clarity, reliability, and face validity of the items. The Cronbach's alpha values for all constructs exceeded the recommended threshold of 0.70, validating internal consistency.

Data Analysis Procedure

Data were analysed using SmartPLS 4.1, ensuing a two-stage approach, an established PLS-SEM procedure. In the first phase, the measurement model was evaluated to the reliability and validity of the constructs. This has been comprised examining internal consistency reliability through Cronbach's alpha and composite reliability, convergent validity using average variance extracted (AVE) and discriminant validity using together the Fornell-Larcker criterion. This has been involved the analysis of internal consistency reliability through Cronbach alpha and composite reliability, convergent validity through average variance extracted (AVE) and discriminant validity by the Fornell-Larcker criterion. In the second stage, the structural model was evaluated to test the hypothesised relationships among variables. This involved analysing path coefficients**,** coefficient of determination (R^2) and predictive relevance (Q^2) values, as well as effect sizes (f^2) to determine the strength of each predictor. Additionally, a moderating Analysis was conducted to compare the structural relationships thereby assessing the moderating effect. This has been followed the suggestions of Hair et al. (2020) for strong SEM modelling in social science research and management studies. The research has been approved by the relevant ethics committee of the university. The research was voluntary, and respondents were guaranteed anonymity and confidentiality. Digital knowledge consent was taken prior to the start of the survey.

Results and Discussion

This section describes the measurement model validity and reliability while providing the researchers with knowledge on the demographic profile. The summary of respondent's demographic profile is presented in tables.

Table 1: Summary of demographic Profile

		No. of Respondents	Percentage %
Gender	Male	339	83%
	Female	70	17%
Marital Status	Single	218	53%
	Married	191	47%
Ethnic Group	Malay	214	52%
	Chinese	120	29%
	Indian	40	10%
	Others	35	9%
Monthly Income of Farmer	< RM 2000	173	42%
	RM 2001-3000	206	50%
	RM 3001-4000	12	3%
	RM 4001-5000	14	4%
	>RM 5000	4	1%

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 889-908

No. of year experience	01-5 year	112	27%
	06-10 year	187	46%
	11-15 year	99	24%
	>15 year	11	3%
Location (States) of agricultural producers	1) Kedah	54	13%
	2) Kelantan	49	12%
	3) Selangor	75	18%
	4) Perak	70	17%
	5) Pahang	55	13%
	6)Negeri	39	10%
	7) Johor	31	8%
	8) Malacca	8	2%
	9) Perlis	5	1%
	10) Terengganu	7	2%
	11) Sabah	3	1%
	12) Sarawak	4	1%
	13) Penang	9	2%

Table 3 shows that all constructs demonstrate acceptable internal consistency and convergent validity. Cronbach's alpha values exceed the recommended 0.70 threshold, while composite reliability (CR) values range from 0.83 to 0.92, indicating high reliability (Hair et al., 2017). Additionally, average variance extracted (AVE) values for all constructs are above 0.50, confirming convergent validity.

Table 2: Reliability and Convergent Validity of Constructs

Constructs	Alpha	CR	AVE
CSA Adoption	0.848	0.898	0.689
Farmers Acceptability	0.878	0.916	0.733
Access to ICT	0.866	0.903	0.652
Sustainable Agriculture Production	0.806	0.866	0.564
Trialability	0.864	0.916	0.785

Additionally, table 4 shows the Fornell Larcker criterion used to assess discriminant validity. The square roots of the AVEs (diagonal values) for each construct are greater than corresponding inter-construct correlations, indicating adequate discriminant validity (Fornell & Larcker, 1981).

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972 IJIREV
Volume 8 Issue 26 (September 2026) PP. 889-908

Table 3 Discriminant Validity - Fornell-Larcker Criterion

	CSA adoption	Farmers Acceptability	Access to ICT	Sustainable Agriculture Production	Trialability
CSA adoption	0.830				
Farmers Acceptability	0.290	0.856			
Access to ICT	0.342	0.168	0.807		
Sustainable Agriculture Production	0.366	0.133	0.722	0.751	
Trialability	0.420	0.204	0.150	0.142	0.886

Table 4: R^2, Q^2, and Effect Size (f^2) of the Structural Model

Construct/ Path	R^2	Q^2	f^2	Effect Size
Sustainable agriculture production	0.54	0.51		
Farmers Acceptability → Sustainable agriculture production			0.04	Small Effect
Trialability→ Sustainable agriculture production			0.09	Small Effect
Access to ICT → Sustainable agriculture production			0.16	Medium Effect

Table 3 shows the model's explanatory and predictive capability. The R^2 value for sustainable agriculture production is 0.54, indicating substantial variance explained by the predictors. The Q^2 value of 0.51 confirms strong predictive relevance. Effect size (f^2) analysis displays access to ICT awareness has the largest impact ($f^2 = 0.16$, medium), followed by farmers acceptability ($f^2 = 0.09$, small) and trialability ($f^2 = 0.04$, small), supporting the relative importance of these predictors within the model.

Table 5: Structural Model Assessment, Direct Effects

H	Relationship	Coefficients (β)	T values	P values
H1	Farmer's Acceptability -> CSA Adoption	0.176	4.021	0.000
H2	Trialability -> CSA Adoption	0.345	7.797	0.000
H3	Access to ICT-> CSA Adoption	0.261	6.061	0.000
H4	Farmer's Acceptability -> Sustainable Agriculture Production	0.020	0.562	0.574

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 889-908

H5	Trialability -> Sustainable Agriculture Production	0.018	0.480	0.631
H6	Access to ICT -> Sustainable Agriculture Production	0.677	20.929	0.000
H7	Adoption of CSA Practices -> Sustainable Agriculture Production	0.148	3.549	0.000

The results presented in table 5 confirms the significance results of H1 (β-value = 0.176, t-value = 4.021, p-value = 0.000) relationship in between farmer's acceptability and adoption of CSA practices as agriculture producers willing to adopt CSA practices (Atta-Aidoo et al., 2023). Second the results confirm the significance of H2 (β-value = 0.345, t-value = 7.797, p-value = 0.000) relationship in between trialability and adoption of CSA practices as agriculture producers having the trialability opportunities for adoption of CSA practices initially on small scale afterwords on successful results can adopt for long term (Kirungi et al., 2023). Third the results confirm the significance of H3 (β-value = 0.261, t-value = 6.061, p-value = 0.000) relationship in between access to ICT and adoption of CSA practices. It has been shown that access to ICT quite helpful in adoption of CSA practices (Waje et al., 2024). From theory perspectives if agriculture producers having access of ICT can be more engaged to adopt CSA practices.

Fourth the results confirm the insignificance of H4 (β-value = 0.020, t-value = 0.562, p-value = 0.574). There is an insignificant relationship between farmer's acceptability and sustainable food production and as agriculture producers can not directly produce sustainable food factors unless they have the support of other factors which indirectly involved for sustainable agriculture production (Castellini et al., 2025). The results shown that farmer's acceptability is insufficient to produce sustainable production outcomes without actual implementation and access to complementary resources. Agriculture producers must also access other factors including access to financial resources, agricultural inputs, extension services, technology, market opportunities and infrastructure before acceptability attitudes can be transformed into sustainable food production (Rust et al., 2022). Therefore, while agriculture producers may readily accept CSA innovations, they may still lack the practical means to implement these practices effectively and consistently. Consequently, agriculture producers are deficient in irrigation facilities, machinery, technical training or affordable financing may remain unable for sustainable production (Thottadi et al., 2024). This explains why farmer's acceptability alone did not significantly predictive sustainable food production. Fifth the results confirm an insignificance of H5 (β-value = 0.018, t-value = 0.480, p-value = 0.631). There is an insignificant relationship between trialability and sustainable food production as agriculture producers not directly produce sustainable agriculture production through trialability directly as other factors need to be considered (Zec Vojinovic et al., 2025). Trialability has been widely recognized as an important determinant of innovation adoption, the present findings suggest that the opportunity to experiment with CSA practices is insufficient to improve sustainable food production among Malaysian agriculture producers. Accessibility in providing agriculture producers with trialability opportunities of CSA practices does not ensures meaningful expected outcome (Autio et al., 2021). Agriculture producers may participate in demonstration pilot projects, yet still lack complementary resources such as financial capital, technical knowledge, technology, irrigation facilities, extension services and market access necessary to convert trial experiences into sustain developments in agricultural productivity (Davis et al.,

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 889-908

2021). Trialability provides only initial exposure to innovation rather than the actual capability to achieve sustainable food production.

Sixth the results confirm the significance of H6 (β-value = 0.677, t-value = 20.929, p-value = 0.000). There is a significant association between access to ICT and sustainable food production and supported as ICT majorly can contribute sustainable food production (Chandio et al., 2022). Access to ICT enhances sustainable agriculture production primarily through timely access to climate change and information. According to perception of theoretical framework having the access of ICT agriculture producers practicing mobile platforms, digital services and online extension networks in better position to make decisions regarding crop selection, water irrigation scheduling, pest control and soil management ultimately influence core pillars of sustainable agriculture production (Simwinga et al., 2024). Seventh the results confirm the significance of H7 (β-value = 0.148, t-value = 3.549, p-value = 0.000) relationship in between adoption of CSA practices and sustainable food production. There is a significant relationship between adoption of CSA practices and sustainable agriculture production. this endorses that CSA practices for ensuring long-term food security while maintaining environmental sustainability. The theory of access emphasises that multiple access mechanisms operate simultaneously. CSA practices serve as the operational pathway that enables agricultural producers to transform diverse forms of access and innovation for sustainable agriculture production. This theoretical explanation supports CSA practices transmit to sustainable agriculture production (Begna & Wakweya, 2025).

Table 6: Structural Model Results, Mediation Effects (VAF)

H	Relationships	Formula Outcome	Decision
H8a	Farmers acceptability -> Adoption of CSA Practices -> Sustainable Agriculture Production	52%	Partial mediation
H8b	Trialability-> Adoption of CSA Practices -> Sustainable Agriculture Production	5%	No mediation
H8c	Access to ICT -> Adoption of CSA Practices -> Sustainable Agriculture Production	71%	Partial mediation

Further mediation effects (VAF) threshold result and justified as shown in table 5 there is partial mediation of H8a = 52%. From theoretical perspectives and earlier studies show that agriculture producers can adopt the CSA practices. But for sustainable agriculture production there is partial contribution as only these criteria not enough to meet sustainable agriculture production goals. (Feng & Zailani, 2025; Teklewold & Mekonnen, 2020) There is no mediation of H8b = 6%. As CSA practices shows no mediation role in between trialability and sustainable agriculture production. From theoretical view and earlier studies perspectives, the current data set of agriculture producers do not have the access of CSA practices at trial basis to meet sustainable agriculture production goals. The partial mediation of H8c = 56% as agricultural producers may use ICT for operational decisions (timing of planting, pest alerts, input pricing,

irrigation scheduling) that improve sustainability outcomes independently (Mollel et al., 2025). From theoretical and earlier studies perspective CSA practices are supporting directly ICT but to some extended not fully mediate the in between access to ICT and sustainable agriculture production (Ma & Rahut, 2024; Renzaho et al., 2025).

Conclusion and Implications

The results of this study show that farmers acceptability, trialability and access to ICT significantly affect the adoption of CSA practices in Malaysia**.** This result recommends that when agricultural producers perceive CSA practices as acceptable, compatible with their existing farming systems and easy to experiment with on a limited scale, they are more likely to adopt such practices. Also, access to ICT shows a critical role by refining agricultural producers' awareness, information access, and technical knowledge about innovative agricultural techniques. This result is reliable with the access theory, which highlights that accessibility to resources such as access to ICT encourage agricultural producers to adopt CSA practices for sustainable agriculture production. Furthermore, the substantial outcome of ICT access emphasises the growing importance of digital agriculture in assistant climate resilience. Access to mobile phones, internet based advisory services, weather prediction systems and digital extension platforms enables agricultural producers to make informed assessments and improve the adoption of CSA practices. This finding supports with prior studies that identified access to ICT as a major enabler of sustainable agriculture production in developing economies. This result recommends that the association between these factors and sustainable agriculture production is expected indirect and mediated over CSA practices. Once CSA practices are fully incorporated into agriculture operations, which ultimately contribute to sustainable agriculture production. Therefore, the non-significant indirect relationship provisions the argument that CSA adoption acts as a key mediating mechanism between innovation related factors and production sustainability results.

From the perspective of the theory of access, different resources perform different functions within agricultural production systems. Access to ICT operates as a knowledge-based access instrument that directly improves agriculture producers decision-making and production management. However, access to ICT functions primarily as an enabling resource whose benefits are realised when agriculture producers invest in and adopt CSA practices. CSA adoption contributes to sustainable agriculture production at an advanced level. Practically, this study initially focusing agriculture producers then valued implications for agricultural stakeholders and policymakers by highlighting the necessity for critical interventions that advance agriculture sector with approach toward farmer's acceptability, ICT infrastructure and trialability opportunities. Supportive agricultural extension capabilities and increasing awareness of CSA advantages can additionally support adoption among agricultural producers. Moreover, CSA adoption would provision to sustainable agricultural development methodologies which support with national food security plans and SDG goals specifically SDG 2 zero hunger SDG 12 responsible consumption and production.

Despite its contributions, current research recognizes various limitations, including contextual and methodological limitations that may assume generalizability. Future research is revived to employ longitudinal plans, mixed-method methodologies or comparative investigates across regions to improve the long-term effectiveness of CSA practices in improving sustainable agriculture production. As this study included limited respondents from East Malaysia. Further current research may also investigate further mediating and moderating variables, such as

climate risk perception, institutional trust and market convenience to develop understanding of CSA adoption behavior. In assumption, Climate-Smart Agriculture indicates a sustainable and strategic path for help Malaysia's food production systems of Malaysia. By focusing strategic adoption determinants and enhancing institutional support, CSA practices can significantly add to sustainable food security, resilient agriculture and the bigger accomplishment of the sustainable development goals in Malaysia.

Acknowledgements:	The authors would like to express their gratitude to the FIELDS project partners who contributed to the conducting and reporting of the survey.
Funding Statement:	This research project has been carried through Universiti Tunku Abdul Rahman, below the grant No. Universiti Tunku Abdul Rahman Research Fund (UTARRF) 6552/0166, Oct 2025 - Sep 2026.
Conflict of Interest Statement:	There is no conflict of interest disclosed by the authors. The funders were not involved in the study's design, data collection, analysis or interpretation, manuscript writing or decision to publish the findings.
Ethics Statement:	This study was conducted in accordance with ethical research standards. All procedures involving human participants were reviewed and approved by the UTAR, approval number 6552/0166. Informed consent was obtained from all participants prior to data collection. Participation was voluntary, and respondents were assured of confidentiality and anonymity. The data collected were used solely for academic purposes.
Author Contribution Statement:	All authors contributed significantly to the development of this manuscript. Au Yong Hui Nee was responsible for the conceptualization, methodology, and overall supervision of the study. Abdelhak Senadjki handled data collection, analysis, and interpretation of results. Zeeshan Tariq contributed to the literature review, drafting, and critical revision of the manuscript. All authors read and approved the final version of the manuscript prior to submission.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 8 Issue 26 (September 2026) PP. 889-908

References

Ab Samat, N. H., A. R. Saili, Z. Yusop, F. Abdul Fatah, and A. S. A. Aziz. 2022. "Factors affecting selection of rice among the consumer in Shah Alam, Selangor." In *IOP Conference Series: Earth and Environmental Science*, vol. 1059, no. 1, p. 012005. IOP Publishing.

Adnan, Nadia, Shahrina Md Nordin, Imran Rahman, and Amir Noor. 2017. "The impacts and visions of the green fertilizer technologies (GFT) Adoption behaviour among Malaysian paddy farmers." *World Journal of Science, Technology and Sustainable Development* 14, no. 4 : 336-354.

Agyekum, T. P., Antwi-Agyei, P., Dougill, A. J., & Stringer, L. C. (2024). Benefits and barriers to the adoption of climate-smart agriculture practices in West Africa: A systematic review. Climate Resilience and Sustainability, 3(3), e279. https://doi.org/10.1002/cli2.79

Ali, Muhammad, Norsida Man, Melissa Muharam Farrah, and Siti Zobidah Omar. 2020. "Factors influencing behavioral intention of farmers to use ICTs for agricultural risk management in Malaysia." *Pakistan Journal of Agricultural Research* 33, no. 2 : 295.

Aliyu, U. S., Cavusoglu, B., Hassanie, S., Abba, S. I., Sammen, S. S., & Kisi, O. (2024). Food, energy, and water security sustainability; an asymmetric approach for achieving sustainable development goals. Discover Sustainability, 5(1), 1-19. https://doi.org/10.1007/s43621-024-00557-z

Atta-Aidoo, Jonathan, Philip Antwi-Agyei, Andrew John Dougill, Christopher Elaigwu Ogbanje, Edmund Kyei Akoto-Danso, and Samuel Eze. 2022. "Adoption of climate-smart agricultural practices by smallholder farmers in rural Ghana: An application of the theory of planned behavior." *PLoS Climate* 1, no. 10 : e0000082.

Autio, A., Johansson, T., Motaroki, L., Minoia, P., & Pellikka, P. (2021). Constraints for adopting climate-smart agricultural practices among smallholder farmers in Southeast Kenya. Agricultural Systems, 194, 103284. https://doi.org/10.1016/j.agsy.2021.103284

Aziz, Mohd Amar, Noor Hadzlida Ayob, Nor Azira Ayob, Yarina Ahmad, and Kamaruddin Abdulsomad. 2024. "Factors influencing farmer adoption of climate-smart agriculture technologies: Evidence from Malaysia." *Human Technology* 20, no. 1: 70-92.

Begna, T., & Wakweya, R. B. (2025). Climate-Smart Agriculture: Effect of Climate Change on Food Security and Its Mitigation Strategies. International Journal of Agronomy, 2025(1), 9972955.

Belay, Abrham, Christopher Oludhe, Alisher Mirzabaev, John W. Recha, Zerihun Berhane, Philip M. Osano, Teferi Demissie, Lydia A. Olaka, and Dawit Solomon. 2022. "Knowledge of climate change and adaptation by smallholder farmers: evidence from southern Ethiopia." *Heliyon* 8, no. 12.

Calo, A., & De Master, K. T. (2016). After the incubator: Factors impeding land access along the path from farmworker to proprietor. Journal of Agriculture, Food Systems, and Community Development, 6(2), 111-127. http://dx.doi.org/10.5304/jafscd.2016.062.018

Cassani, Lucía, and Andrea Gomez-Zavaglia. "Sustainable food systems in fruits and vegetables food supply chains." *Frontiers in nutrition* 9 (2022): 829061.

Castellini, Greta, Sara Romanò, Valentina Maria Merlino, Filippo Barbera, Chiara Costamagna, Filippo Brun, and Guendalina Graffigna. 2025. "Determinants of consumer and farmer acceptance of new production technologies: A systematic review." *Frontiers in Sustainable Food Systems* 9: 1557974.

Chandio, Abbas Ali, Narayan Sethi, Devi Prasad Dash, and Muhammad Usman. 2022. "Towards sustainable food production: what role ICT and technological development can play for cereal production in Asian–7 countries?" *Computers and Electronics in Agriculture* 202: 107368.

Dardak, Rozhan Abu. "Overview of agricultural trade in Malaysia.2020. " *The FFTC Journal of Agricultural Policy. Special issue: Plans and Experiences to Improve Agricultural Trade in the Asia Pacific Region*: 60-68.

Davis, K., Gammelgaard, J., Preissing, J., Gilbert, R., & Ngwenya, H. (2021). Investing in farmers: Agriculture human capital investment strategies (Vol. 4). Food & Agriculture Org. https://doi.org/10.104060/cb7134en

De Wrachien, Daniele, Bart Schultz, and Mudlagiri B. Goli. 2021. "Impacts of population growth and climate change on food production and irrigation and drainage needs: A world-wide view." *Irrigation and Drainage* 70, no. 5: 981-995.

Dorairaj, Deivaseeno, and Nisha T. Govender. 2023. "Rice and paddy industry in Malaysia: Governance and policies, research trends, technology adoption and resilience." *Frontiers in Sustainable Food Systems* 7: 1093605.

Duang-Ek-Anong, Somsit, Soonthorn Pibulcharoensit, and Thanawan Phongsatha. 2019. "Technology readiness for Internet of Things (IoT) adoption in smart farming in Thailand." *Int. J. Simul. Syst. Sci. Technol* 20: 1-6.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. American Journal of Theoretical and Applied Statistics, 5(1), 1–4. https://doi.org/10.11648/j.ajtas.20160501.11

Feng, X., & Zailani, S. (2025). The antecedents of the willingness to adopt and pay for climate-smart agricultural technology among cooperatives in China. *Sustainability*, *17*(1), 19.https://doi.org/10.3390/su17010019

Firdaus, R. R., Leong Tan, M., Rahmat, S. R., & Senevi Gunaratne, M. (2020). Paddy, rice and food security in Malaysia: A review of climate change impacts. Cogent Social Sciences, 6(1), 1818373.

Gemtou, Marilena, Konstantina Kakkavou, Evangelos Anastasiou, Spyros Fountas, Soren Marcus Pedersen, Gohar Isakhanyan, Kassa Tarekegn Erekalo, and Serafin Pazos-Vidal. 2024. "Farmers' transition to climate-smart agriculture: A systematic review of the decision-making factors affecting adoption." *Sustainability* 16, no. 7 : 2828.

Hair Jr, J. F., Matthews, L. M., Matthews, R. L., & Sarstedt, M. (2017). PLS-SEM or CB-SEM: updated guidelines on which method to use. International Journal of Multivariate Data Analysis, 1(2), 107-123.

Hair Jr, Joe F., Matt C. Howard, and Christian Nitzl. 2020. "Assessing measurement model quality in PLS-SEM using confirmatory composite analysis." *Journal of business research* 109 : 101-110.

Hasan, Md Atik, Mahinur Begum Mimi, Liton Chandra Voumik, Miguel Angel Esquivias, and Mamunur Rashid. 2023. "Investigating the interplay of ICT and agricultural inputs on sustainable agricultural production: an ARDL approach." *Journal of Human, Earth, and Future* 4, no. 4: 375-390.

Hedden, Steve, Barry Hughes, Dale Scott Rothman, Alanna J. Markle, and Joel Maweni. 2021. "Ending hunger in Africa: The elimination of hunger and food insecurity on the African continent by 2025-conditions for success." *Available at SSRN 3941433*.

Hoek, Annet C., Shirin Malekpour, Rob Raven, Eli Court, and Emily Byrne. 2021. "Towards environmentally sustainable food systems: decision-making factors in sustainable food production and consumption." *Sustainable Production and Consumption* 26 : 610-626.

Karimi, Hamid, and Pouria Ataei. 2024. "An analysis of the perceived effectiveness and upscaling potential of climate-smart agriculture interventions in the Sistan Plain, Iran." *Journal of Cleaner Production* 460: 142582.

Kassa, Bamlaku Ayenew, and Abera Tilahun Abdi. 2022. "Factors influencing the adoption of climate-smart agricultural practice by small-scale farming households in Wondo Genet, Southern Ethiopia." *Sage Open* 12, no. 3 : 21582440221121604.

Katkar, Tejasvini Rahul, Bhavana Santosh Pansare, S. Bathrinath, S. Selvakanmani, Komal Dhanraj Deshmukh, and Shripad Joshi. 2026. "Climate-smart agriculture: Leveraging precision-farming technologies for sustainable food security." In *Computational Techniques in Precision Agriculture*, pp. 161-172. CRC Press.

Khan, Nawab, Ram L. Ray, Hazem S. Kassem, Sajjad Hussain, Shemei Zhang, Muhammad Khayyam, Muhammad Ihtisham, and Simplice A. Asongu. 2021. "Potential role of technology innovation in transformation of sustainable food systems: A review." *Agriculture* 11, no. 10: 984.

Khan, Nuzhat, Mohamad Anuar Kamaruddin, Usman Ullah Sheikh, Muhammad Paend Bakht, and Mohd Norzali Haji Mohd. 2024. "Climate-smart agriculture: a path to sustainable food production." *Journal of Natural Science Review* 2, no. Special. Issue : 130-147.

Kirungi, Diana, Brian Senyange, Joshua Wesana, Haroon Sseguya, Xavier Gellynck, and Hans De Steur. 2023."Entrepreneurial and attitudinal determinants for adoption of Climate-smart Agriculture technologies in Uganda." *Cogent Food & Agriculture* 9, no. 2 : 2282236.

Kumar, Lukeshwar. 2024. "The role of agriculture in economic development." *Journal of Environmental Agriculture and Agroecosystem Management* 1, no. 1: 62-68.

Kwapong, Nana Afranaa, Stephen Whitfield, Jane Ambuko, Daniel Adu Ankrah, and Frans Swanepoel. 2024. "Using participatory videos in understanding farmers experiences with climate smart agricultural practices: reflections from Ghana." *Frontiers in Sustainable Food Systems* 7: 1282993.

Liu, Wei, Xue-Feng Shao, Chia-Huei Wu, and Ping Qiao. 2021. "A systematic literature review on applications of information and communication technologies and blockchain technologies for precision agriculture development." *Journal of Cleaner Production* 298 : 126763.

Ma, W., & Rahut, D. B. (2024). Climate-smart agriculture: adoption, impacts, and implications for sustainable development. *Mitigation and Adaptation Strategies for Global Change*, *29*(5), 44. https://doi.org/10.1007/s11027-024-10139-z

Maspan, R., & Halimoon, N. (2024). Adoption of Malaysia Good Agricultural Practices (Mygap) by Crop Producers in Peninsular Malaysia. Available at SSRN 4743722. https://dx.doi.org/10.2139/ssrn.4743722

Masud, M. M., Akhtar, R., Al Mamun, A., Uddin, M. S., Siyu, L., & Yang, Q. (2022). Modelling the sustainable agriculture management adaptation practices: Using adaptive capacity as a mediator. Frontiers in Environmental Science, 10, 963465.

Mekonnen, A. B. 2024. "Adoption of Climate-smart Agricultural Practices Among Smallholder Farmers and Implications for Climate Change Adaptation in Southern Ethiopia (Doctoral dissertation, University of Nairobi)." PhD diss., Doctoral dissertation, University of Nairobi.

Mensah, H. (2020). Climate change resilience: lessons from local climate-smart agricultural practices in Ghana. Energy, Ecology and Environment. https://doi.org/10.1007/s40974-020-00181-3

Mgomezulu, W. R., Edriss, A. K., Machira, K., Pangapanga-Phiri, I., Chitete, M., Mambosasa, M., ... & Mnthambala, F. (2024). Understanding spillover effects of sustained adoption

of sustainable agricultural practices on household resilience to food shocks: Evidence from Malawi's sustainable food systems program. Journal of Agriculture and Food Research, 16, 101099. https://doi.org/10.1016/j.jafr.2024.101099

Mohamad, Mafuzah, and Jady Hassim. 2023. "Malaysian Dependency on Foreign Workforce: The Economic Implication Post Covid-19." *European Proceedings of Finance and Economics*.

Moonga, Arthur, Andrew Shepherd, and Lucia da Corta. 2025. "Financial Inclusion and CSA Adoption-Enhancing the Resilience of Smallholder Farmers to Climate Change in Zambia."

Movilla-Pateiro, L., Mahou-Lago, X. M., Doval, M. I., & Simal-Gandara, J. (2021). Toward a sustainable metric and indicators for the goal of sustainability in agricultural and food production. Critical reviews in food science and nutrition, 61(7), 1108-1129. https://doi.org/10.1080/10408398.2020.1754161

Mpogole, Hosea. 2025. "Navigating the nexus between agricultural transformation, food security, and climate change in rural development in Tanzania." *Rural Planning Journal* 1 : 1-14.

Mutea, E., Rist, S., & Jacobi, J. (2020). Applying the theory of access to food security among smallholder family farmers around North-West Mount Kenya. Sustainability, 12(5), 1751. https://doi.org/10.3390/su12051751

Ng, T. H., Lim, Y. S., Lye, C. T., Amran, A., & Tay, M. J. (2025). Understanding the challenges of community supported agriculture in Malaysia: farmers' perspectives. Applied Economics Letters, 32(20), 3009-3013. https://doi.org/10.1080/13504851.2024.2360650

Nguyen, Hang Thi Thuy, Thi Quynh Anh Le, Mai Chiem Tuyen, and Pham Xuan Hung. 2025. "A review of climate-smart agriculture in Asia: Critical achievements, key challenges, and potential prospects." *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS)* 126, no. 1 : 25-42.

Niggli, Urs, Martijn Sonnevelt, and Susanne Kummer. 2023. "Pathways to advance agroecology for a successful transformation to sustainable food systems." *Science and innovations for food systems transformation* : 341-359.

Nyang'au, Jared O., Jema H. Mohamed, Nelson Mango, Clifton Makate, and Alex N. Wangeci. 2021. "Smallholder farmers' perception of climate change and adoption of climate smart agriculture practices in Masaba South Sub-county, Kisii, Kenya." *Heliyon* 7, no. 4.

Obi, Ajuruchukwu, and Okuhle Maya. 2021. "Innovative climate-smart agriculture (CSA) practices in the smallholder farming system of South Africa." *Sustainability* 13, no. 12 : 6848.

Odeyemi, Olubukola Motunrayo, Lisa Kitinoja, Neeru Dubey, Solange Musanase, and Gurbinder Singh Gill. 2022. "Preliminary study on improved postharvest practices for tomato loss reduction in Nigeria, Rwanda and India." *African Journal of Science, Technology, Innovation and Development* 14, no. 6 : 1500-1505.

Ong, Ying Qian, Suzana Shahar, Hasnah Haron, Nurul Fatin Malek Rivan, Hamdan Mohamad, Musaalbakri Abdul Manan, Wan Zunairah Wan Ibadullah et al. 2025. "Strengthening salt reduction policy for Malaysia through proposed maximum salt targets of selected processed food groups." *Scientific Reports*15, no. 1 : 17385.

Panyasit, Kamoltip, Montri Singhavara, Jenasama Srihirun, Supreeya Wangsathian, and Sakkarin Nonthapot. 2024. "A study to assess the readiness of rice farmers to use agricultural technology for production in Nong Khai Province, Thailand." *Int. J. Innov. Res. Sci. Stud* 7: 607-617.

Pawlak, Karolina, and Małgorzata Kołodziejczak. 2020. "The role of agriculture in ensuring food security in developing countries: Considerations in the context of the problem of sustainable food production." *Sustainability* 12, no. 13: 5488.

Peluso, N. L., & Ribot, J. (2020). Postscript: A theory of access revisited. Society & Natural Resources, 33(2), 300-306.

Qange, S., Mdoda, L., Nontu, Y., Mabitsela, M. M., & Gidi, L. S. (2025). Evaluating the impact of adopting conservation agriculture on farm returns of smallholder vegetable farmers in the Eastern Cape Province: implication for extension services. *Frontiers in Sustainable Food Systems*, *9*, 1605561.

Ramborun, Vagish, S. Facknath, and B. Lalljee. 2020. "Moving toward sustainable agriculture through a better understanding of farmer perceptions and attitudes to cope with climate change." *The Journal of Agricultural Education and Extension*26, no. 1: 37-57.

Raza, A.; Tong, G.; Sikandar, F.; Erokhin, V.; Tong, Z. Financial literacy and credit accessibility of rice farmers in Pakistan: Analysis for Central Punjab and Khyber Pakhtunkhwa regions. Sustainability 2023, 15, 2963.

Renzaho, A., Abdulai, R., Rahaman, K. S., Das, S. K., Noor, R., Salami, B., & Chitekwe, S. (2025). The impact of sustainable organic agriculture on food security in sub-Saharan Africa: a mixed methods systematic review with meta-analysis. *Agriculture & Food Security*, *14*(1), 1-22.

Rust, N. A., Stankovics, P., Jarvis, R. M., Morris-Trainor, Z., de Vries, J. R., Ingram, J., ... & Reed, M. S. (2022). Have farmers had enough of experts? Environmental management, 69(1), 31-44. https://doi.org/10.1007/s00267-021-01546-y

Selvam, Avines Panneer, and Safaa Najah Saud Al-Humairi. 2023. "The impact of iot and sensor integration on real-time weather monitoring systems: A systematic review."

Senyange, Brian. "Farmer's entrepreneurial mindset and the intention to adopt climate-smart agriculture: the case of coffee farmers in greter Luwero, Uganda." PhD diss., Ghent University, 2022.

Simwinga, G. M., Shemi, A. P., & Moyo, P. (2024). Integrating ICT Solutions for Sustainable Agriculture: Addressing Food Security in the Face of Climate Change. *Zambia ICT Journal*, *8*(1), 20-23.

Tan, Mohd Zulhelmi Syafuddin, Ahmad Naqiyuddin Bakar, and Yarina Ahmad. 2024. "Malaysian Government's Unified Approach to Address National Food Security." *Environment-Behaviour Proceedings Journal* 9, no. SI22 : 383-388.

Tariq, Zeeshan, Au Yong Hue Nee, and Abdelhak Senadjki. 2026. "Factors affecting the adoption of Climate Smart Agriculture (CSA) practices for sustainable food production in Malaysia." In *IOP Conference Series: Earth and Environmental Science*, vol. 1592, no. 1, p. 012016. IOP Publishing.

Tay, M. J., Ng, T. H., & Lim, Y. S. (2024). Fostering sustainable agriculture: An exploration of localised food systems through community supported agriculture. Environmental and Sustainability Indicators, 22, 100385. https://doi.org/10.1016/j.indic.2024.100385

Teklewold, H., & Mekonnen, A. (2020). Weather at different growth stages, multiple practices and risk exposures: panel data evidence from Ethiopia. *Climate Change Economics*, *11*(02), 2050009.

Thottadi, B. P., & Singh, S. P. (2024). Climate-smart agriculture (CSA) adaptation, adaptation determinants and extension services synergies: a systematic review. Mitigation and Adaptation Strategies for Global Change, 29(3), 22. https://doi.org/10.1007/s11027-024-10113-9

Valizadeh, Naser, Sara Jalilian, Zeynab Hallaj, Samira Esfandyari Bayat, Dariush Hayati, Khadijeh Bazrafkan, Nazanin Kianmehr, and Morteza Akbari. 2023. "Encouraging

adoption of green manure technology to produce clean rice product." *Scientific reports* 13, no. 1 : 8690.

Waje, Samuel Semma, Berhanu Kuma Shano, Solomon Zena Walelign, and Workineh Asmare Kassie. 2024. "The effect of agricultural information provision on smallholders' technology adoption and yield: experimental evidence from Ethiopia." *Frontiers in Sustainable Food Systems* 8 : 1421442.

Wang, Z., Dai, Y., Yang, L., & Yu, Z. (2025). Barriers to Climate-Smart Agriculture Adoption in Northeast China's Black Soil Region: Insights from a Multidimensional Framework. *Agriculture*, *15*(21), 2236. https://doi.org/10.3390/agriculture15212236

Yusoff, Rahmawati Mohd, Sharifah Zubaidah Syed Abdul Kader, Azhani Arshad, Akmal Hidayah Halim, Mohd Rilizam Rosli, and Siti Mahfudzoh Mohd Hafiz. 2025. "A Strategic Proposal for Enhancing Malaysia's Economy through National Food Security Initiatives." *Environment-Behaviour Proceedings Journal* 10, no. SI28 : 149-154.

Zec Vojinović, Melita, Ana Čehić Marić, and Milan Oplanić. 2025. "Factors influencing farmers' adoption and willingness to accept sustainable production practices in Istria County, Croatia." *Journal of Central European Agriculture* 26, no. 2 : 495-509.

Zheng, Hongyun, Wanglin Ma, and Quan He. 2024. "Climate-smart agricultural practices for enhanced farm productivity, income, resilience, and greenhouse gas mitigation: a comprehensive review." *Mitigation and Adaptation Strategies for Global Change* 29, no. 4 : 28.

Zulqarnain, Norsida Man, Juwaidah Sharifuddin, Muhammad Roslan, and Salim Hassan. 2020. "Factors influencing attitude towards technology adoption among permanent food production park (PFPP) program participants in west Malaysia." *Journal of Agricultural Science and Technology* 10, no. 20 : 89-97. https://doi.org/10.17265/2161-6264/2020.02.004

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 8 Issue 26 (September 2026) PP. 889-908

Appendix (A)

Questionnaire Items
Sustainable agriculture production
I believe CSA practices will ensure sufficient sustainable agriculture production. I believe that CSA practices enhance sustainable agriculture production by promoting resilience to climate change. I believe CSA practices will reduce disease outbreaks agriculture production. I believe CSA practices can produce high-quality food output. I believe CSA practices will ensure sufficient sustainable agriculture production.
Climate Smart Agriculture Practices
I believe that adopting CSA practices benefits agricultural production while preserving the environment. I ensure that water resources are efficiently utilized when adopting CSA practices. I am using CSA practices to protect the agriculture production from impact of climate change. I am willing to promote the advantages of CSA adoption for agriculture growth to peers. I believe that adopting CSA practices benefits agricultural production while preserving the environment.
Farmer's Acceptability
I feel acceptability is become necessary for all of us. I believe the adoption of CSA practices can guarantee the quality and quantity of farm production. I believe the adoption of technology can increase agriculture production. To me, technology is needed. I feel acceptability is become necessary for all of us.
Trialability
There are agencies that allow farmers to try out CSA practices before adopting. I would be more inclined to adopt CSA practices if I had the chance to test them first. I will be more confident in adopting CSA practices if initial trial opportunities are provided. I believe CSA practices are easy to test on small scale before full adoption. There are agencies that allow farmers to try out CSA practices before adopting.
Access to ICT
I believe access to ICT can improve my ability to manage climate risk. I believe that access to ICT helps me to learn about new farming techniques. I have learnt CSA practices through access to ICT. I prefer to have access to ICT specialist for farming. I believe by latest access of ICT tools can improve farm production.