ISSN: 2458-8989

Natural and Engineering Sciences

NESciences, 2026, 11 (2): 140-152 doi: 10.28978/nesciences.262012

SOCIOECONOMIC AND ADAPTIVE DETERMINANTS OF SUSTAINABLE AGRICULTURAL DEVELOPMENT (SDG 2) IN THAILAND

Zhou Fei[1], Sukhumpong Channuwong[2*], Pensri Bangbon[3], Prapas Siripap[4], Ye Jia[5]

[1]Faculty of Management, Shinawatra University, Thailand. Email: pricechow@siu.ac.th, ORCID: https://orcid.org/0000-0002-3753-9224

[2]Faculty of Management, Shinawatra University, Thailand, Research Fellow, International Institute of Management and Business, Belarus. E-mail: kruprofessor@gmail.com, ORCID: https://orcid.org/0000-0002-4468-1683

[3]Faculty of Management, Shinawatra University, Thailand. Email: pensri.b@siu.ac.th, ORCID: https://orcid.org/0000-0002-3956-7149

[4]Faculty of Management, Shinawatra University, Thailand. Email: prapas.s81@gmail.com, ORCID: https://orcid.org/0009-0005-7155-9076

[5]Sichuan Top IT Vocational Institute, China. Email: yejia1213@sina.com, https://orcid.org/0009-0007-9152-887X

Abstract

This research aims to analyze the causal relationships among economic factors, institutional-social factors, adaptive capacity, and sustainable agricultural development (SDG 2) in Thailand. Data were collected from 320 farmers across Thailand using stratified random sampling. Structural Equation Modeling (SEM) was used to test the research hypotheses. The results of SEM analysis showed that economic factors exerted a significant direct effect on adaptive capacity ($\beta = 0.438$, $p < .001$), institutional-social factors had a significant direct effect on adaptive capacity ($\beta = 0.386$, $p < .001$), while adaptive capacity had a significant effect on sustainable agricultural development ($\beta = 0.517$, $p < .001$). Economic factors and institutional-social factors had a significant effect on sustainable agricultural development ($\beta = 0.368$, $p < .001$) and ($\beta = 0.326$, $p < .001$) respectively. The mediation analysis further demonstrated that adaptive capacity mediates the relationship between economic factors and sustainable agricultural development ($\beta = 0.368$, $p < .001$) and between institutional-social factors and sustainable agricultural development ($\beta = 0.326$, $p < .001$). These findings highlight that adaptive capacity serves as a critical mediating mechanism linking economic, institutional, and social factors to sustainable agricultural development in Thailand and provides practical guidance for achieving sustainable agricultural development).

Keywords:
Adaptive capacity; economic factors; institutional-social factors; sustainable agricultural development (SDG 2)

**Corresponding Author: Sukhumpong Channuwong, E-mail: kruprofessor@gmail.com*

Available online: 02/06/2026

Introduction

The agricultural industry in Thailand has served as a cornerstone of the national economy and social structure for a long time with more than ten million farming households depending on agriculture as their primary source of income (Office of Small and Medium Enterprises Promotion (OSMEP), 2023). Agriculture not only underpins the nation's economic productivity but also sustains rural livelihoods, food security, and ecological balance. Despite its foundational role, the sector has faced mounting pressures over recent decades, including rising production costs, volatile commodity prices in global markets, escalating climate change impacts, and progressive degradation of natural resources such as soil, water, and biodiversity (Faysse et al., 2022; Waqas et al., 2024). These compounding challenges underscore the urgent need to transition Thai agriculture toward a genuinely sustainable development trajectory.

Economic factors constitute the first critical dimension influencing sustainable agricultural development. Indicators such as income levels, financial security, production costs, and access to capital and markets collectively determine farmers' capacity to invest in and adopt sustainable production systems (Chang et al., 2024; Sarkar et al., 2021). When farmers possess stable incomes and adequate access to financial resources, they are more likely to experiment with sustainable technologies and shift toward more environmentally responsible production practices. Conversely, economic vulnerability constrains investment horizons and reinforces risk-averse behaviors that perpetuate conventional, resource-intensive farming.

Institutional and social factors represent a second critical domain. Government policy support, agricultural extension services, technology transfer systems, and community-based social networks collectively constitute an enabling environment that facilitates or constrains farmers' capacity for sustainable adaptation (Ebekozien et al., 2025; Barbosa, 2024; Mahaarcha & Sirisunhirun, 2023). Institutional theory posits that individuals and organizations conform their behaviors to the rules, norms, and expectations embedded in their institutional context (North, 1990, as cited in Barbosa, 2024), suggesting that robust institutional frameworks can meaningfully redirect farming behavior toward sustainability.

However, economic resources and institutional support alone may be insufficient to achieve sustainable agricultural outcomes if farmers lack the capacity to translate these inputs into adaptive action. Adaptive capacity—defined as the ability to adjust practices, manage risks, and leverage new knowledge and technologies—functions as a critical mediating mechanism that converts enabling conditions into sustainable outcomes (de Boon & Sandström, 2023; Masud et al., 2022). Without adequate adaptive capacity, even well-resourced and institutionally supported farmers may fail to make the transition to sustainable agriculture.

Sustainable agricultural development is a multidimensional concept encompassing economic viability, environmental stewardship, social equity, and long-term resilience (Ebekozien et al., 2025; Bathaei & Štreimikienė, 2023). This conceptualization aligns with the United Nations' Sustainable Development Goals (SDGs), particularly Goal 2 (Zero Hunger) and Goal 12 (Responsible Consumption and Production), which collectively prescribe an environmentally responsible and socially equitable trajectory for global agriculture (United Nations, 2015). Within the Thai context, advancing agriculture toward sustainability requires a nuanced understanding of the underlying factors that shape farmers' capacities, behaviors, and decisions.

Despite a growing body of literature on sustainable agricultural development, three significant research gaps remain. First, most existing studies examine economic factors or institutional-social factors in isolation rather than within an integrated framework. Second, few studies incorporate adaptive capacity as a mediating variable to explain how enabling inputs translate into sustainable outcomes. Third, empirical research in the Thai context employing Structural Equation Modeling (SEM) to test such integrated, multi-construct models remains limited; existing Thai agricultural studies tend to rely on descriptive or regression-based analyses that cannot simultaneously assess measurement validity and structural causality (Meechoovet & Siriwato, 2023; Mahaarcha & Sirisunhirun, 2023).

This study addresses these gaps by developing and testing a causal model that integrates socioeconomic and adaptive determinants including economic factors, institutional-social factors, adaptive capacity, and sustainable agricultural development in Thailand using structural equation modeling (SEM). The novelty of this study lies in three specific contributions: (1) the simultaneous integration of economic and institutional-social enabling conditions within a unified structural framework; (2) the empirical confirmation of adaptive capacity as a partial mediator between enabling conditions and sustainability outcomes; and (3) the application of full SEM—combining confirmatory factor analysis with structural path estimation—to the Thai agricultural context, providing methodological precision unavailable in prior regression-based studies in this domain.

Research Objectives

This study has two main objectives as follows:

1. To validate the latent constructs of economic factors, institutional-social factors, adaptive capacity, and sustainable agricultural development.
2. To examine the causal relationships among economic factors, institutional-social factors, adaptive capacity, and sustainable agricultural development in Thailand.

Research Hypotheses

H1: Economic factors have a significant direct effect on adaptive capacity of Thai farmers.
H2: Institutional-social factors have a significant direct effect on adaptive capacity of Thai farmers.
H3: Adaptive capacity has a significant direct effect on sustainable agricultural development in Thailand.
H4: Economic factors have a significant direct effect on sustainable agricultural development in Thailand.
H5: Institutional-social factors have a significant direct effect on sustainable agricultural development in Thailand.
H6: Adaptive capacity mediates the relationship between economic factors and sustainable agricultural development in Thailand.
H7: Adaptive capacity mediates the relationship between institutional-social factors and sustainable agricultural development in Thailand.

Literature Review

The present study investigates the causal relationships among socioeconomic and adaptive determinants, and sustainable agricultural development (SDG 2) in Thailand. The socioeconomic and adaptive determinants of sustainable agricultural development in this study included economic factors, institutional-social factors and adaptive capacity. The literature review integrates these research streams by synthesizing empirical evidence and theoretical frameworks that underpin the conceptual model.

Economic Factors and Sustainable Agriculture

Economic factors represent the foundational determinants of farmers' capacity and willingness to adopt sustainable agricultural practices. Scholars in agricultural economics have conceptualized economic factors along three principal dimensions: income stability and economic security, production cost-effectiveness, and access to capital and markets (Sarkar et al., 2021). Income stability refers to the degree to which agricultural earnings are sufficient, consistent, and capable of supporting both household sustenance and productive reinvestment. Farmers with stable incomes are significantly more likely to adopt sustainable farming practices than those with precarious livelihoods (Pang et al., 2025; Chang et al., 2024). Faysse et al. (2022), in their study of farm sustainability challenges in Thailand, found that financial stability is a direct predictor of farmers' willingness to invest in sustainable production systems. This finding underscores the argument that economic security is not merely a welfare outcome but also a precondition for behavioral change toward sustainability.

The burden of production costs—encompassing expenditures on inputs such as fertilizers, pesticides, seeds, and labor—is a critical constraint on Thai farmers' ability to transition to sustainable systems. Rising input costs have been identified as a primary barrier to adoption of sustainable practices across Southeast Asian agricultural contexts (Waqas et al., 2024). Reducing production costs and improving the cost-benefit ratio of sustainable technologies are therefore necessary conditions for enabling farmers to make the transition without compromising household economic viability.

Access to credit, financial services, and market channels enables farmers to invest in productive technologies and reach consumers willing to pay premiums for sustainably produced goods. Sarkar et al. (2021), employing SEM in a developing country context, demonstrated that farmers with superior access to capital and markets exhibit significantly higher levels of agricultural sustainability. This finding is corroborated by Chang et al. (2024), who confirmed that market access is a pivotal factor motivating the adoption of sustainable practices among rice farmers in Southeast Asia.

Institutional and Social Factors and Sustainable Agriculture

Institutional and social factors encompass the organizational structures, policies, and social networks that shape the context within which farmers operate. Institutional Theory, Social Capital Theory, and the Sustainable Livelihoods Framework collectively provide theoretical foundations for understanding how these factors influence agricultural sustainability (Barbosa, 2024; Mahaarcha & Sirisunhirun, 2023).

Government support mechanisms—including subsidies for sustainable inputs, agricultural insurance programs, price stabilization policies, and regulatory frameworks—are among the most influential institutional factors affecting sustainable agricultural development. Barbosa's (2024) systematic review of government support mechanisms found that comprehensive and well-targeted policy interventions produce significant positive effects on farmers' adoption of sustainable practices.

Agricultural extension services serve as primary conduits for disseminating knowledge, technology, and best practices to farming communities. Ma and Rahut (2024) demonstrated that farmers who receive training and technology transfer through extension systems exhibit substantially higher rates of sustainable practice adoption. The quality, relevance, and accessibility of extension services are therefore critical institutional factors that shape farmers' knowledge base and their capacity to implement sustainable techniques.

Social capital—manifested in the form of farmer cooperatives, community organizations, peer learning networks, and collective action groups—functions as a vital social resource that facilitates knowledge sharing, resource pooling, and collective problem-solving. Mahaarcha and Sirisunhirun (2023), in a study of irrigation governance in Thailand, found that social capital significantly influences farmers' participation in resource management and their propensity for cooperative behavior. Strong community networks thus amplify the effects of institutional support by creating horizontal channels of knowledge exchange and mutual reinforcement.

Adaptive Capacity

Adaptive capacity refers to the ability of individuals, communities, or systems to adjust to change, reduce vulnerability, and capitalize on emerging opportunities. Grounded in Resilience Theory and the Sustainable Livelihoods Framework, adaptive capacity is conceptualized as a critical intermediary between enabling conditions and sustainable outcomes (Masud et al., 2022; de Boon & Sandström, 2023).

The first dimension of adaptive capacity encompasses the flexibility to modify production systems in response to changing conditions—for example, adopting climate-resilient crop varieties, adjusting planting calendars, or transitioning to integrated farming systems (Shao et al., 2025). Nor Diana et al. (2022), in a systematic review of farmer adaptation strategies in Southeast Asia, identified production method modification as the most prevalent and impactful form of adaptive response among smallholder farmers facing climate-related risks.

The second dimension concerns farmers' ability to manage price volatility, natural disasters, climate variability, and production uncertainty. de Boon and Sandström (2023) demonstrated that farmers' perceived capacity to manage risks is a significant predictor of their willingness to adopt sustainable practices and to undergo the behavioral changes associated with sustainability transitions.

The third dimension encompasses openness to new knowledge, willingness to experiment with novel techniques, and the ability to apply innovations to enhance agricultural efficiency and sustainability. In the Thai context, Panpakdee and Simaraks (2023) found that learning capacity and innovation adoption are key indicators of social-ecological resilience in organic rice production systems in Northeastern Thailand, underscoring the centrality of this dimension to sustainable agricultural development.

Sustainable Agricultural Development

Sustainable agricultural development is a multidimensional construct that extends beyond simple productivity metrics to encompass economic, environmental, social, and long-term dimensions of performance (Bathaei & Štreimikienė, 2023). Economic sustainability refers to the capacity of farming households to generate stable and sufficient income and maintain competitive viability. Environmental sustainability encompasses responsible natural resource management and conservation of soil, water, and biodiversity (United Nations, 2015). Social sustainability refers to the vitality of farming communities, equitable access to opportunities, and farmers' quality of life (Pansuwong et al., 2023; Tonmeethip, 2021; Ubaydullaeva et al., 2026). Long-term sustainability refers to the capacity of the agricultural sector to persist, adapt, and develop continuously into the future, ensuring productive capacity for subsequent generations.

Integrating Economic Factors, Institutional-Social Factors, Adaptive Capacity, and Sustainable Agricultural Development

Although economic factors, institutional-social factors, adaptive capacity, and sustainable agricultural development have been studied individually, few studies have integrated these constructs into a comprehensive framework. Economic factors and institutional-social factors provide the enabling conditions, adaptive capacity acts as the operational mechanism, and sustainable agricultural development represents the ultimate outcome. This integrated perspective aligns with Resilience Theory, which emphasizes adaptive capacity as the critical intermediary between inputs and sustainable outcomes (Masud et al., 2022), and the Sustainable Livelihoods Framework, which highlights how economic and institutional resources translate into sustainable livelihood strategies (de Boon & Sandström, 2023; Nor Diana et al., 2022). Thus, this study addresses a research gap by empirically testing these four constructs together using SEM.

Conceptual Framework

Based on the research objectives and literature review, the conceptual model positions economic factors (ECON) and institutional-social factors (INST) as independent variables, adaptive capacity (ADAP) as the mediating variable, and sustainable agricultural development (SUST) as the dependent variable. The model incorporates both direct paths (ECON→SUST and INST→SUST) and indirect paths (ECON→ADAP→SUST and INST→ADAP→SUST), allowing examination of both the mediating role of adaptive capacity and any residual direct effects of enabling conditions on sustainability outcomes. Therefore, the research conceptual framework of this research was proposed (Figure 1).

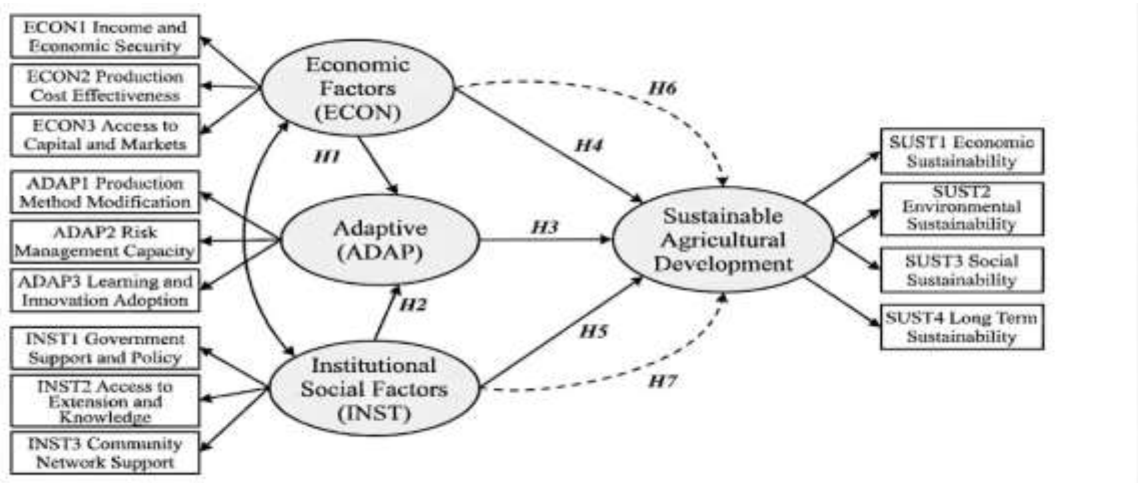

Figure 1. Conceptual framework of the study

Methodology

Research Design

This study adopted a quantitative research design, which is widely recognized as appropriate for testing theoretical models involving latent constructs and causal relationships. Quantitative research allows for the systematic collection and analysis of numerical data to test hypotheses and validate constructs, ensuring objectivity and replicability of results (Hair et al., 2019). The primary analytical technique followed a two-stage SEM approach: Confirmatory Factor Analysis was used to examine the measurement models—validating the latent constructs of economic factors, institutional-social factors, adaptive capacity, and sustainable agricultural development; and Structural Equation Modeling (SEM) was used to test the hypothesized causal relationships.

Population, Sample, and Sampling Method

The population used in this study comprised farmers in Thailand engaged in crop production, livestock farming, or integrated agriculture, who held primary decision-making responsibilities over their agricultural operations. The target respondents were owners or primary decision-makers of farm operations, as they are directly involved in decisions regarding production strategies, innovation adoption, and sustainability practices.

To determine an appropriate sample size, guidelines from SEM were followed. Hair et al. (2019) recommended a minimum of 200 respondents for reliable SEM estimation, while Kline (2015) emphasized that sample size should be at least ten times the number of observed variables in the model. Given that the research model encompasses 13 observed variables (three for ECON, three for INST, three for ADAP, and four for SUST), the target sample size was set at not less than 300 farmers, ensuring sufficient number of the sample size.

Stratified random sampling was implemented across five geographic regions of Thailand—Northern, Central, Northeastern, Eastern, and Southern—in proportion to the regional distribution of agricultural households documented by OSMEP (2023). Within each regional stratum, a comprehensive enumeration of eligible farming households was conducted in collaboration with provincial agricultural offices and community enterprise groups. Random selection was then applied within each stratum to identify individual respondents. This multi-stage stratified procedure ensured representativeness across geographic diversity and major agricultural subsector types including crop, livestock, and integrated agriculture.

Research Instruments

The research instrument was a structured questionnaire divided into five sections: (1) general demographic and farm-level information; (2) indicators of economic factors; (3) indicators of institutional-social factors; (4) indicators of adaptive capacity; and (5) indicators of sustainable agricultural development. All questions were assessed using a five-point Likert scale ranging from 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree).

The indicators of economic factors (ECON) were evaluated through three dimensions: income and economic security, production cost-effectiveness, and access to capital and markets. The indicators of institutional-social factors (INST) were measured through three dimensions: government support and policy, access to extension services and knowledge, and community network support. The indicators of adaptive capacity (ADAP) were measured through three dimensions following the Resilience Theory and Sustainable Livelihoods Framework: production method modification capacity, risk management capacity, and learning and innovation adoption capacity. The indicators of sustainable agricultural development (SUST) were assessed using four dimensions: economic sustainability, environmental sustainability, social sustainability, and long-term sustainability, drawing from Bathaei and Štreimikienė (2023) and the UN SDGs (United Nations, 2015).

To ensure content validity, the questionnaire was reviewed by three academic experts in agricultural management and two industry practitioners. Item Objective Congruence (IOC) values were computed, with all items exceeding the acceptable threshold of 0.50 (Rovinelli & Hambleton, 1977). Expert evaluations were conducted through individual written review, followed by a structured panel discussion to resolve any item-level discrepancies, ensuring the independence of expert judgments prior to reaching final consensus. Reliability was assessed through a pilot test with 30 farmers, yielding Cronbach's alpha values of 0.821 for economic factors (ECON), 0.813 for institutional-social factors (INST), 0.806 for adaptive capacity (ADAP), and 0.841 for sustainable agricultural development (SUST), all exceeding the 0.70 threshold, indicating satisfactory internal consistency (Nunnally & Bernstein, 1994).

Data Collection

Data were collected through two complementary modes: (1) field distribution in collaboration with provincial agricultural offices and community enterprise groups, and (2) online survey administration via secure digital platforms. Quality control measures included the elimination of duplicate responses, exclusion of questionnaires with more than 20% missing data, and pre-testing prior to full-scale data collection. A total of 320 valid questionnaires were obtained and included in the final analysis.

Data Analysis

Data were analyzed using AMOS 28.0 and SPSS 28.0 through a sequential multi-stage analytical procedure comprising: (1) descriptive statistics; (2) Confirmatory Factor Analysis (CFA) to assess construct validity and reliability; (3) Structural Equation Modeling (SEM) to test hypothesized causal relationships. Model fit was evaluated using multiple indices; the acceptable thresholds were: $\chi^2/df < 3.000$, CFI ≥ .90, TLI ≥ .90, RMSEA ≤ .08, and RMR ≤ .08 (Hair et al., 2019). Discriminant validity was assessed using both the Fornell–Larcker (1981) criterion and the Heterotrait-Monotrait (HTMT) ratio, with a conservative threshold of 0.85 (Henseler et al., 2015), to provide a more robust evaluation of construct distinctiveness than the Fornell–Larcker criterion alone.

Results

Demographic Profile of Respondents

A total of 320 valid responses were obtained, exceeding the recommended minimum. Stratified random sampling was employed to ensure representativeness across five geographic regions of Thailand and across major agricultural subsectors. The regional distribution of the sample was as follows: Northern region (n = 68, 21.3%), Central region (n = 62, 19.4%), Northeastern region (n = 74, 23.1%), Eastern region (n = 58, 18.1%), and Southern region (n = 58, 18.1%). In terms of farming type, crop farmers accounted for 52.5% of respondents (n = 168), livestock farmers for 22.8% (n = 73), and those engaged in integrated agriculture for 24.7% (n = 79), reflecting the diversity of Thai agricultural subsectors.

Measurement Model

The measurement model was rigorously evaluated using Confirmatory Factor Analysis (CFA) to ensure the empirical integrity of the latent constructs. The CFA results reveal that all 13 observed variables of the four latent variables were statistically significant ($p < 0.001$), with standardized factor loadings ranging from 0.748 to 0.868—exceeding the recommended threshold of 0.70. The average variance extracted (AVE) ranging from 0.617 to 0.647 exceeded the acceptable threshold of 0.50, and composite reliability (CR) ranging from 0.829 to 0.876 exceeded the recommended cutoff values of 0.70, thereby substantiating both convergent validity and construct reliability (Table 1).

Table 1. Construct, measurement items, factor loading, average variance extracted (AVE), and composite reliability (CR)

Construct	Measurement items	Factor loading	AVE	CR
Economic Factors (ECON)	Income & economic security (ECON1)	0.814	0.647	0.847
	Production cost-effectiveness (ECON2)	0.786		
	Access to capital & markets (ECON3)	0.829		
Institutional-Social Factors (INST)	Government support & policy (INST1)	0.796	0.628	0.837
	Access to extension & knowledge (INST2)	0.768		
	Community network support (INST3)	0.847		
Adaptive Capacity (ADAP)	Production method modification (ADAP1)	0.776	0.617	0.829
	Risk management capacity (ADAP2)	0.807		
	Learning & innovation adoption (ADAP3)	0.758		

Sustainable Agricultural Dev. (SUST)	Economic sustainability (SUST1)	0.748	0.637	0.876
	Environmental sustainability (SUST2)	0.837		
	Social sustainability (SUST3)	0.796		
	Long-term sustainability (SUST4)	0.868		

Discriminant validity

Discriminant validity was assessed using the Fornell–Larcker (1981) criterion by comparing the square root of the AVE for each latent construct with its correlations with other constructs. The results show that the square roots of AVE for economic factors (ECON), institutional-social factors (INST), adaptive capacity (ADAP), and sustainable agricultural development (SUST) are 0.807, 0.787, 0.781, and 0.794 respectively, which are all greater than their correlations with other latent constructs, confirming adequate discriminant validity (Table 2). Supplementary assessment using the Heterotrait-Monotrait (HTMT) ratio confirmed that all construct pairs remained below the 0.85 threshold (highest observed: ADAP–SUST = 0.712), providing additional evidence of satisfactory discriminant validity (Henseler et al., 2015).

Table 2. Correlation matrix of latent variables and square roots of AVE

Construct	ECON	INST	ADAP	SUST
Economic Factors (ECON)	**0.807**			
Institutional-Social Factors (INST)	0.512	**0.787**		
Adaptive Capacity (ADAP)	0.534	0.548	**0.781**	
Sustainable Agricultural Dev. (SUST)	0.521	0.537	0.556	**0.794**

Note. Diagonal values (bold) represent the square roots of AVE.

Results of Structural Equation Modeling (SEM)

The results of SEM analysis showed that the overall structural model demonstrated an excellent fit with the empirical data. The chi-square statistic was not statistically significant (χ^2 = 132.478, df = 125, p = 0.06), and the χ^2/df ratio was 1.882. Additional goodness-of-fit indices further supported the adequacy of the structural model: GFI = 0.936, NFI = 0.914, TLI = 0.941, CFI = 0.952, RMSEA = 0.054, RMR = 0.052. All indices met or exceeded commonly accepted thresholds, which confirmed that the proposed structural model provided a robust representation of the data (Table 3).

Table 3. Model fit indices of the structural model

Fit Index	Criterion	Obtained Value
χ^2	-	132.478
df	-	125
p-value	> 0.05	0.06
χ^2/df	< 3.00	1.882
GFI	> 0.90	0.936
NFI	> 0.90	0.914
TLI	> 0.90	0.941
CFI	> 0.90	0.952
RMSEA	< 0.08	0.054

RMR	< 0.08	0.052

The structural model confirmed all seven hypotheses. Economic factors (ECON) exerted a significant direct effect on adaptive capacity (ADAP) (H1: β = 0.438, p < .001), and institutional-social factors (INST) similarly had a significant direct effect on adaptive capacity (ADAP) (H2: β = 0.386, p < .001). Adaptive capacity exerted the strong direct effect on sustainable agricultural development (SUST) (H3: β = 0.517, p < .001). Additionally, economic factors exerted a significant positive effect on sustainable agricultural development (H4: β = 0.368, p < .001), and institutional-social factors similarly exerted a significant direct effect on sustainable agricultural development (H5: β = 0.326, p < .001).
The results of mediation analysis revealed that the indirect effect of economic factors (ECON) on sustainable agricultural development (SUST) through adaptive capacity (ADAP) (H6: β = 0.214, p < .001) and the indirect effect of institutional-social factors (INST) on sustainable agricultural development (SUST) through adaptive capacity (ADAP) (H7: β = 0.187, p < .001) were both statistically significant (Figure 2 and Table 4).

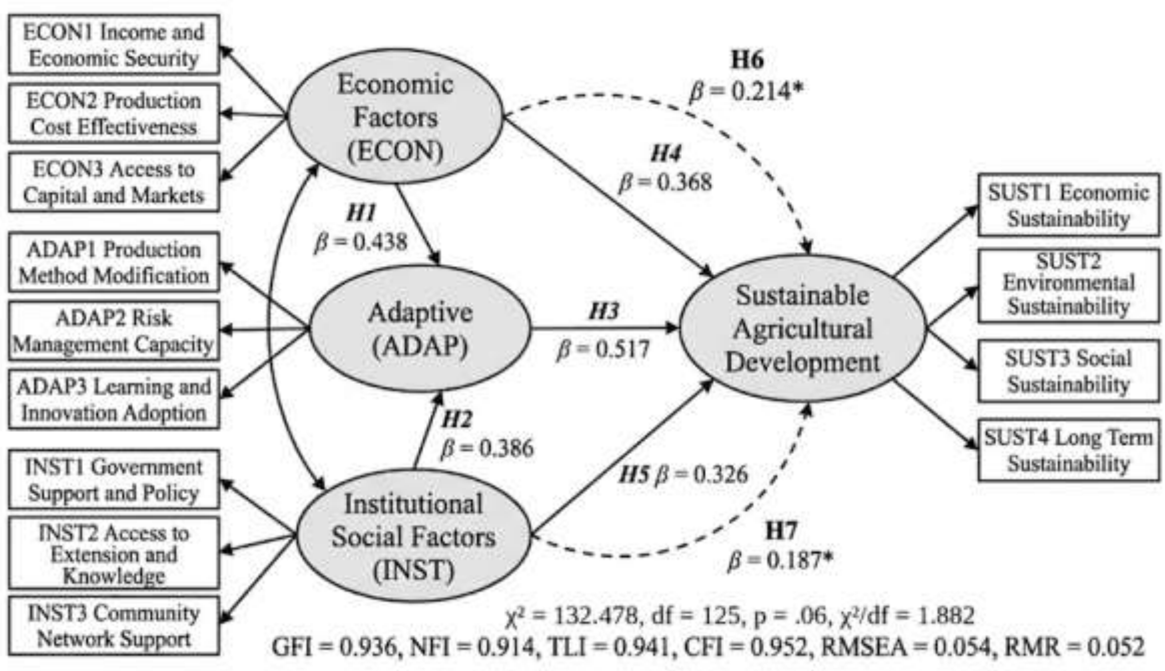

Figure 2. Standardized structural relationships among economic factors, institutional social factors, adaptive capacity, and sustainable agricultural development

Table 4. The results of the structural equation modeling analysis and hypotheses testing

Hypotheses	Path relationship	β	S.E.	t-value	p-value	Result
H1	ECON → ADAP	0.438	0.114	6.824	***	Supported
H2	INST → ADAP	0.386	0.101	6.158	***	Supported
H3	ADAP → SUST	0.517	0.132	7.948	***	Supported
H4	ECON → SUST	0.368	0.094	6.478	***	Supported
H5	INST → SUST	0.326	0.091	5.937	***	Supported
H6	ECON → ADAP → SUST	0.214	0.086	2.488	*	Supported
H7	INST → ADAP → SUST	0.187	0.079	2.367	*	Supported

Note: *** p < .001; * p < .05; β = standardized path coefficient; S.E. = standard error

Discussion

The structural equation modeling results indicate that economic factors had a positive effect on adaptive capacity. These findings suggest that the availability of financial capital and access to credit are primary drivers enabling farmers to invest in necessary adaptive technologies. Analytically, economic strength acts as a buffer against uncertainty, providing the 'financial flexibility' needed to pivot strategies during climate or market fluctuations. This aligns with Masud et al. (2022), who emphasized that economic readiness is a functional prerequisite for implementing adaptation strategies effectively.

The robust positive effect of economic factors on adaptive capacity corroborates established theoretical tenets. Financial stability serves as a critical 'investment buffer,' allowing farmers to navigate the risks inherent in experimenting with novel production methods, a view supported by Sarkar et al. (2021) and Chang et al. (2024). Within the Thai agricultural landscape, this mechanism is shaped by three distinct channels: first, access to agricultural credit that maintains household liquidity through production cycles; second, vulnerability to farm debt cycles that structurally restricts long-term investment planning; and third, exposure to commodity price volatility affecting major smallholder crops such as rice and cassava. Economic security therefore emerges not merely as a welfare indicator but as a structural prerequisite for the adaptive flexibility required for a sustainable agricultural transition. Policy interventions that strengthen agricultural credit access and income safety nets are thus likely to yield compound sustainability benefits through enhanced adaptive capacity (Channuwong, 2026).

Statistical analysis revealed that institutional factors have a positive effect on adaptive capacity. Robust institutional structures—such as government policies and local governance—serve as the 'scaffolding' for individual resilience by providing vital information and infrastructure. This result is consistent with Mahaarcha and Sirisunhirun (2023), whose research in Thailand highlighted that effective multi-level governance facilitates better resource management, which is fundamental to a farmer's capacity to adjust to systemic challenges.

The significant impact of institutional-social factors on adaptive capacity validates the core premise of Institutional Theory—that the quality of the organizational environment dictates individual behavior. Barbosa (2024) suggested effective government mechanisms are potent drivers of change; in Thailand, this is manifested through highly actionable pathways including extension services provided by the Department of Agriculture, cooperative-led knowledge sharing, and insurance programs that mitigate the financial exposure of smallholders. Critically, the results demonstrate that institutional inputs do not merely produce direct sustainability outcomes but operate primarily by bolstering a farmer's underlying adaptive capacity—an indirect pathway that carries significant policy implications. Investments in extension service quality, cooperative infrastructure, and community learning networks may yield greater long-term sustainability dividends than equivalent investments in direct financial transfers alone.

Empirical results demonstrated that adaptive capacity had a substantial positive effect on agricultural sustainability. As the strongest path in the model, it signifies that the ability to innovate is the most critical determinant of long-term outcomes. This finding is supported by de Boon and Sandström (2023) and Pang et al. (2025) who argued that sustainability transitions are fundamentally a question of perceived adaptive capacity. Consequently, enhancing a farmer's skill-set and flexibility is often more effective for ensuring environmental sustainability than providing direct subsidies alone.

Positioning adaptive capacity as the most powerful direct determinant of sustainable agricultural development represents a theoretically significant finding. It identifies adaptive capacity as the most proximate driver of sustainability outcomes, a result that resonates with the findings of Masud et al. (2022) and Panpakdee and Simaraks (2023) regarding the social-ecological resilience of organic rice systems in Thailand. The theoretical implication is clear: sustainability policy that focuses exclusively on resource provision—whether financial transfers or policy mandates—without simultaneously investing in the development of farmers' adaptive competencies is likely to produce suboptimal outcomes. Capacity development programs that enhance risk management skills, technology adoption, and learning orientations should be prioritized alongside conventional agricultural support mechanisms.

The SEM results also confirmed that economic factors exert a significant direct effect on sustainable agricultural development. This direct path underscores that financial stability is a foundational pillar for maintaining soil quality and purchasing eco-friendly inputs. This aligns with Barbosa (2024), who emphasized that economic incentives are essential for bridging the gap between traditional farming and sustainable modern practices. The result implies that the 'economic bottom line' remains a non-negotiable determinant of whether a green transition can be maintained long-term. The persistence of this direct effect—in addition to the indirect pathway through adaptive capacity—suggests a dual-channel model in which economic enabling conditions simultaneously build adaptive competencies (indirect path) and directly support sustainability outcomes (direct path), consistent with the Sustainable Livelihoods Framework's recognition of multiple resource-to-outcome pathways.

Institutional factors had a positive effect on sustainable agricultural development. From an analytical standpoint, institutions act as the 'normative glue' that binds individual actions to collective goals. This conclusion is consistent with Bangbon et al. (2023) and Faysse et al. (2022), who found that addressing farm sustainability in Thailand requires coordinated actions from institutional bodies. The results imply that strengthening local governance is vital for integrating institutional support directly into the agricultural value chain. Furthermore, the dual-pathway structure confirmed for institutional-social factors—both direct and mediated effects on sustainable agricultural development—indicates that policy interventions must address both the structural quality of institutions and farmers' capacity to utilize institutional resources. High-quality institutions that fail to build farmer capacity will produce partial sustainability gains at best.

Adaptive capacity significantly mediates the relationship between economic factors and sustainable agricultural development. This suggests a 'partial mediation' model where financial resources are most effective when transformed into 'adaptive capital,' such as technical skills. Ma and Rahut (2024) and Bangbon et al. (2026) confirmed that economic impacts are maximized when they target climate-resilient practices. Therefore, policy interventions should prioritize allocating resources toward capacity-building programs rather than mere direct financial relief.

Adaptive capacity also significantly mediates the relationship between institutional factors and sustainable agricultural development. This indicates that the value of institutional intervention lies in its ability to equip actors with the flexibility to navigate change. This finding resonates with Nor Diana et al. (2022), who underscored that institutional frameworks are most effective when they facilitate specific adaptation behaviors. For sustainability initiatives to be successful, actors must shift focus from compliance monitoring to the proactive development of human and social capital.

Conclusion

The results of this study revealed that economic factors and institutional factors significantly influenced adaptive capacity, while adaptive capacity positively influenced sustainable agricultural development. Furthermore, economic factors and institutional-social factors were found to exert significant direct positive effects on sustainable agricultural development. In addition, the mediation analysis demonstrated that adaptive capacity is a pivotal partial mediator in the relationship between both economic factors and institutional factors and sustainable agricultural development. Both direct effects of economic and institutional-social factors on sustainable agricultural development and tindirect effects channeled through adaptive capacity were confirmed, revealing a dual-pathway model in which enabling conditions simultaneously build farmers' adaptive competencies and directly support sustainability outcomes.

Conflict of Interest

The authors declared that they have no conflict of interest in writing and publishing this article.

Acknowledgement

The authors would like to express their gratitude to Shinawatra University for providing financial support in publishing this article.

References

1.Bangbon, P., Thongyam, P., Tongruang, R., Sun, R., Thoy, U., & Jia, Y. (2026). The role of renewable energy in advancing affordable and clean energy pathways towards a green and sustainable future in developing nations. *Acta Innovations, 60,* 96-108.

2.Bangbon, P., Channuwong, S., Amponstira, F., Rungsuk, A. & Snongtaweeporn, T. (2023). The influence of transformational leadership on organizational sustainability: A case study of business companies in Bangkok. *Journal of Namibian Studies, 33*, 4077-4095.

3.Barbosa, M.W. (2024). Government support mechanisms for sustainable agriculture: A systematic literature review and future research agenda. *Sustainability 16*(5), 2185.

https://doi.org/10.3390/su16052185
4.Bathaei, A., & Štreimikienė, D. (2023). A systematic review of agricultural sustainability indicators. *Agriculture, 13*(2), 241. https://doi.org/10.3390/agriculture13020241
5.Channuwong, S., Tongvijit, M., Photchanachan, S., Sun, R., & Jia, Y. (2026). Causal relationships among the factors influencing the competitive capability of Thai real estate companies based on the concept of sustainable cities and communities (UN SDG 11). *Acta Innovations, 60,* 81-95.
6.Chang, SHE., Benjamin, EO., & Sauer, J. (2024). Factors influencing the adoption of sustainable agricultural practices for rice cultivation in Southeast Asia: A review. *Agronomy for Sustainable Development, 44*(3), 27. https://doi.org/10.1007/s13593-024-00960-w
7.De Boon, A., & Sandström, C. (2023). To adapt or not to adapt, that is the question: Examining farmers' perceived adaptive capacity and willingness to adapt to sustainability transitions. *Journal of Rural Studies, 105,* Article 103165. https://doi.org/10.1016/j.jrurstud.2023.103165
8.Ebekozien A, Aigbavboa C, Hafez M, Samsurijan MS, Oke AE. 2025. Appraising sustainable and resilient physical infrastructure facilities in higher education institutions. *Facilities, 43*(13),1094–1113. https://doi.org/10.1108/F-12-2024-0173
9.Faysse, N., Phiboon, K., & Purotaganon, M. (2022). Which pathway to address interrelated challenges to farm sustainability in Thailand? Views of local actors. *Regional Environmental Change, 22,* Article https://doi.org/10.1017/s10113-021-01871-2
10.Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39–50. https://doi.org/10.1177/002224378101800104
11. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate data analysis (8th ed.). Cengage.
12.Hair, J.F., Black, W.C., Babin, B.J., & Anderson, R.E. (2019). *Multivariate data analysis. 8th ed.* Cengage, United Kingdom.Henseler, J., Ringle, C.M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal Academic Marketing Science, 43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8
13. Joshua, J., & Garces, C. (2026). Sustainable development goals and agricultural service subscriptions: Consumer behaviors in Cebu, Philippines. *Asian Journal of Agriculture,* 10(1), 1-9. https://doi.org/10.13057/asianjagric/g100101
14. Kline, R. B. (2015). *Principles and practice of structural equation modeling (4th ed.).* Guilford Press.
15. Likert, R. (1932). A technique for the measurement of attitudes. *Archives of Psychology, 22*(140), 1–55.
16. Mahaarcha, D., & Sirisunhirun, S. (2023). Social capital and farmers' participation in multi-level irrigation governance in Thailand. *Heliyon 9*(8): e18793. https://doi.org/10.1016/j.heliyon.2023.e18793 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*, Article 963465. https://doi.org/10.3389/fenvs.2022.963465
17. Meechoovet, Y., & Siriwato, S. (2023). Thailand's smart agriculture and its impacts on Thai farmers: A case study of smart agriculture in Ayutthaya, Thailand. *Asian Political Science Review, 7*(1), 1–17. https://doi.org/10.14456/apsr.2023.1
18. Nor Diana, M.I., Zulkepli, N.A., Siwar, C, & Zainol, M.R. (2022). Farmers' adaptation strategies to climate change in Southeast Asia: A systematic literature review. *Sustainability, 14*(6), 3639. https://doi.org/10.3390/su14063639
19. Nunnally, J.C., & Bernstein, I.H. (1994). *Psychometric Theory. 3rd ed.* McGraw-Hill, New York.
Office of Small and Medium Enterprises Promotion [OSMEP]. (2023*). SMEs in Thailand 2023: Status Report*. OSMEP, Bangkok.
20. Pang, K.K., Yu, J., Yin, Y., Liu, X., Zou, B., & Tang, S.J. (2025). Assessing the impact of nanotechnology on the well-being of human life. *Journal of Information Technological Management, 17*(1), 73–85. https://doi.org/ 10.22059/jitm.2025.99924
21. Panpakdee, C., & Simaraks, S. (2023). The social-ecological resilience indicators of organic rice production in Northeastern Thailand. *Organic Agriculture, 13,* 483–501. https://doi.org/10.1017/s13165-023-00441-6
22. Pansuwong, W., Photchanachan, S., & Thechatakerng, P. (2023). Social innovation: Relationships with social and human capitals, entrepreneurial competencies and growth of social enterprises in a developing country context. *Social Enterprise, 19(1), 51*-79. https://doi.org/10.1108/SEJ-02-2022-0014

23. Rovinelli, R. J., & Hambleton, R. K. (1977). On the use of content specialists in the assessment of content validity of objective tests. *Educational and Psychological Measurement, 37*(4), 825–829. https://doi.org/10.1177/001316447703700410
24. Sarkar, A., Azim, J. A., Asif, A. A., Qian, L., & Peau, A. K. (2021). Structural equation modeling for indicators of sustainable agriculture: Prospective of a developing country's agriculture. *Land Use Policy, 109,* Article 105638. https://doi.org/10.1016/j.landusepol.2021.105638
25. Shao H, Jin Q, Guo Y, Zhou F, Wider W, Lu L. (2025). The relationship between the structure of firms' human capital and corporate innovation performance. *PLoS ONE 20*(4), e0321388. https://doi.org/10.1371/journal.pone.0321388
26. Tonmeethip, K. (2021). Agricultural development in Thailand: Dimensions of community development and quality of life. *Journal of Development Studies, 4*(1), 132–162. https://so05.tci-thaijo.org/index.php/gvc-tu/article/view/252520
27. Ubaydullaeva, S., Sarybaev, M., Kaipnazarow., Djumageldiev, N., Saribaev, A., Reymbaev, R., Kuronov, M., & Musurmonkulov, O. (2026). Transformational environmental education by innovative approaches to teaching sustainability and biodiversity in the 21st century. *Natural and Engineering Sciences, 11*(1), 113-128. https://doi.org/10.28978/nesciences.161008.
28. United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development.* UN Publishing.
29. Waqas, M., Naseem, A., Humphries, U. W., Hlaing, P. T., Shoaib, M., & Hashim, S. (2024). A comprehensive review of the impacts of climate change on agriculture in Thailand. *Farming Systems, 3,* Article 100114. https://doi.org/10.1016/j.farsys.2024.100114