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Sustainable Farming Dynamics: Constraints, Motivators, and Farm Decisions Shape Farm Household Livelihood Security

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Abstract: In the context of mounting climate variability and agrarian distress, sustainable farming practices are widely acknowledged for their contribution to food security, ecological resilience, and the strengthening of rural livelihoods in India. However, their adoption among smallholder farmers continues to be relatively low. Drawing on the conceptual framework, the present study investigates how various motivators and constraints shape farmers' engagement with sustainable practices and influencing their livelihood security in Karnataka, India. Using survey data from 243 farm households across four administrative divisions, the research employed structural equation modeling to empirically evaluate the proposed direct effects and moderating relationships. It was found that economic and market constraints as well as knowledge and capacity deficits significantly hindered adoption, while positive motivators including premium pricing, environmental awareness and health consciousness facilitated adoption. Notably, behavioral factors did not operate independently but shaped how farmers' interpreted economic and institutional outcomes. Institutional support further enhanced the impact of adoption on livelihood security, emphasizing its moderating role. The findings highlighted the need for integrated policies that can address structural barriers, foster capacity-building, and strengthen institutional networks meanwhile harnessing behavioral drivers. These findings suggest that policy interventions focusing solely on incentives are unlikely to succeed unless they are aligned with farmers' behavioral orientations and supported by robust institutional mechanisms.

Keywords: Sustainable farming, Farmer's livelihood security, Organic farming, Knowledge and capacity, Economic and market constraints, positive motivators.

Introduction

Agriculture is a key to global food security and rural livelihoods, sustaining over 1.3 billion people worldwide and employing about 26.2% of the global workforce between 2000 and 2022 (FAO, 2024). In India, the sector plays an even more critical role, providing livelihoods to over 42.3% of the population while contributing 18.2% to the national GDP (FAO, 2024). Despite its importance, contemporary agricultural systems are increasingly strained by declining soil fertility, groundwater depletion, and heightened market volatility, challenges that disproportionately affect smallholder farmers (Khatri et al., 2024; Pandian et al., 2024). These interlinked pressures threaten both ecological sustainability and the economic security of rural households, giving rise to the need for identifying viable long-term agricultural pathways (Abd El-Ghani et al., 2025; Kareska, 2025).

Sustainable agriculture, including organic farming, has been widely promoted as a response to these challenges due to its potential to enhance ecosystem health, reduce external input dependence, and support long-term productivity (Gamage et al., 2023; Sahu & Pradhan, 2023). Reflecting growing consumer demand, the global organic food market

reached Euros 136 billion in 2023 (Golijan, 2025). In India, organic farming covers about 2.30 million hectares, indicating significant room for expansion (Willer et al., 2021). However, adoption among farmers remains uneven and limited, constrained by high certification costs, restricted market access, and inadequate access to training and technical knowledge (Wakweya, 2023).

Adoption decisions related to sustainable farming are shaped not only by economic and market conditions but also by farmers' knowledge and capacity, perceived incentives, behavioral orientations, and the enabling or constraining role of institutional support (Ramadan et al., 2025; Varyvoda et al., 2025). These factors interact rather than operate in isolation, influencing both the likelihood of adoption and its implications for household livelihood security (Varyvoda et al., 2025). A comprehensive understanding of these interactions is therefore essential for designing policy interventions that move beyond isolated incentives and address structural and behavioral constraints simultaneously (Kouchaky et al., 2025; Panpakdee & Hoaihongthong, 2025). Nevertheless, much of the existing literature examines selective determinants of adoption, such as market constraints (Bhujel & Joshi, 2024), knowledge and training gaps (Hariraj et al., 2025; Rizzo et al., 2024), or institutional support (Tanti et al., 2022) without adequately capturing the combined and moderating effects of these factors. This fragmented approach limits understanding of how constraints and motivators are mediated by farm-level decision-making and institutional contexts, particularly in developing-country settings. Addressing this gap, the present study investigates the combined influence of multiple constraints and motivators on the adoption of sustainable farming practices and farm household livelihood security in India. It further examines the moderating roles of farm decisions and institutional support within sustainable farming dynamics. By integrating economic, behavioral, and institutional dimensions into a single analytical framework, the study aims to generate insights that can inform policies seeking to simultaneously advance environmental sustainability, economic viability, and social well-being in farming communities.

Literature review and hypothesis formulation

An emerging literature indicates that the barriers to the realization of sustainable farming are significant in terms of market connectivity, lack of credit, and the high inputs. Touch et al. (2024) pointed to the direct negative effect of climate and economic stressors in destabilizing the livelihood security of smallholders. Goswami et al. (2023) discovered that the Indian Sundarbans are knowledge-intensive and resource-efficient integration strategies that could be leveraged to achieve sustainable results but are not used because of insufficient technical support. Likewise, knowledge and capacity gaps, such as institutional assistance, awareness, and deficiency in training, also weaken farmers' capabilities and motivation to accept sustainable production and usage (Hariraj et al., 2025; Rizzo et al., 2024).

Hypothesis 1 (H1): Economic and market constraints negatively *affect the adoption of sustainable farming practices.*

Hypothesis 2 (H2): Knowledge and capacity deficits positively affect the adoption of sustainable farming practices

On the contrary, Despotović et al. (2021) revealed that the greater the environmental awareness and knowledge, the greater the practices, such as biological pest control, mulching, and manure. Rezaei et al. (2025) discovered that the prospects of marketing health-oriented products, aided by the right of accessing extension services, attitude, and excellent environmental identity, inspire farmers to cultivate healthy products. In accordance with these aspects, the following hypothesis was proposed.

Hypothesis 3 (H3): Positive motivators for organic farming positively influence the adoption of sustainable farming practices.

An increasing evidence is found for the fact that sustainable agricultural activities increase livelihood security by reducing reliance on external inputs, by stabilizing income, and by increasing resilience.

Though the high input prices and inadequate capital were challenges to tribal Assamese farmers, Sharma and Mishra (2024) were able to find a 31% increase in the livelihood security of these farmers. Shinde et al. (2025) highlighted the role played by agricultural diversification wherein livestock, horticulture, and allied activities were integrated for enhancing resilience, food security, and income stability. Samuel et al. (2024) reported that NICRA interventions increased incomes by 40 percent in the drought-prone households in the drought years, compared to control villages. All these studies inferred that sustainable farming techniques, be it diversification or technology use, can positively build household livelihood security and these need to be facilitated by enabling capacity building, access to markets, and formulation of suitable policies.

Hypothesis 4 (H4): Sustainable farming practices are positively associated with increased farm household livelihood security.

Personal attitudes, experiences, and perceptions of risk possessed by farmers may play a significant part in mediating the effects of external motivators and restraints in determining acceptance of sustainable practices. Rizzo et al. (2024) found that adoption trajectories are defined by individual psychological characteristics such as perceived control, aversion to innovation, and environmental values, and environmentally oriented farmers were more prone to focus on sustainability rather than economic short-term benefits. Specific to the Indian context, Jha et al. (2022) suggested that the lack of adoption of sustainable agriculture is not only caused by structural factors, such as market uncertainty and lack of infrastructure, but also by the readiness and willingness of farmers to make changes. This signifies the importance of availability of guidance and individual perceptions of profitability. The overall results of these studies indicate that the strength and nature of relationships between the actual adoption of sustainable practices and external drivers is moderately influenced by risk-taking, experience, perceived control, and attitudes, which subsequently determine farmers' decisions.

Hypothesis 5 (H5a): Factors influencing farming decisions significantly moderates the relationship between economic & market constraints and the adoption of sustainable farming practices.

Hypothesis 5 (H5b): Factors influencing farming decisions significantly moderates the relationship between knowledge & capacity deficits and the adoption of sustainable farming practices.

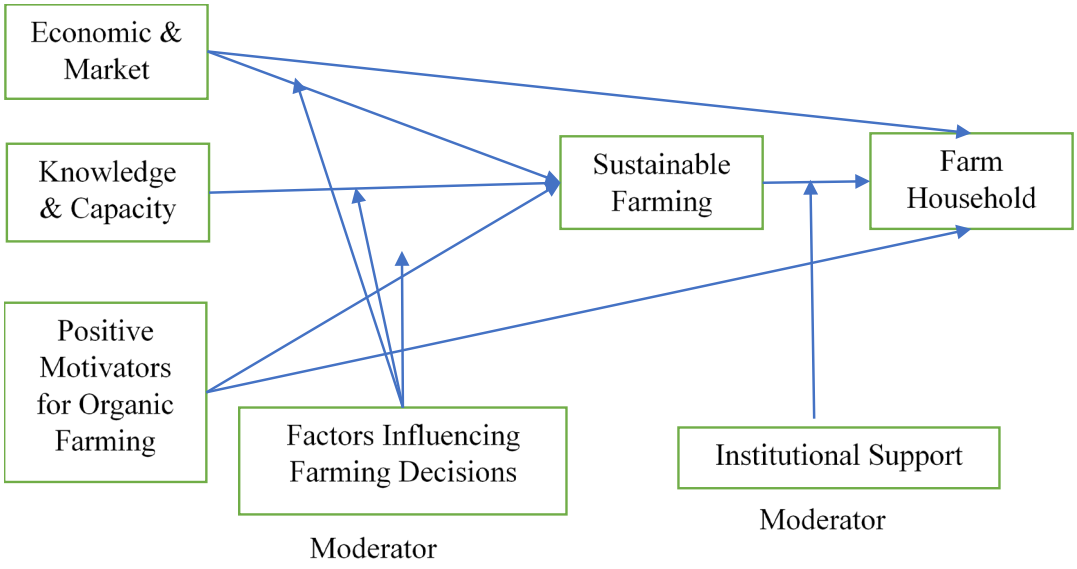
Hypothesis 5 (H5c): Factors influencing farming decisions significantly moderates the relationship between positive motivators for organic farming and the adoption of sustainable farming practices.

Government support, provided in the form of subsidies or financial aid, contributes towards the adoption of sustainable farming practices among farmers while simultaneously contributing to environmental protection (Barbosa, 2024). In addition, education-based support system and a good policy framework can also foster the livelihood benefits associated with sustainable farming practices by effectively addressing the barriers (Boros et al., 2025).

Hypothesis (H6): Institutional support significantly moderates the relationship between the adoption of sustainable farming practices and *farm household livelihood security*

The relationship among study variables was demonstrated via a conceptual framework (Figure 1), which was formulated on the basis of the proposed hypotheses.

Figure 1: Conceptual framework



Source: Developed by authors based on literature

Materials and Methods

Research design

Guided by deductive reasoning and a positivist philosophy, the study adopted an explanatory research design to develop and empirically test the hypotheses (Saunders et al., 2019). The study followed a cross-sectional empirical approach, in which a quantitative survey was used to collect primary data from the respondents.

Target population, sampling technique and gathering of data

The present study employed stratified random sampling to select 275 farmers who were engaged in either conventional or sustainable farming practices. Primary data was collected over a six-month period from July 2024 to December 2024 by administering questionnaires through offline mode. Respondents were approached at their farms, local markets, and community centers across four administrative divisions of Karnataka (Belagavi, Bengaluru, Gulbarga, and Mysore) (Figure 2). Participants were notified that their involvement in the study was entirely voluntary, that all of their responses would be treated with strict anonymity, and that the gathered data would be utilized exclusively for academic purposes. Totally, 250 responses were received and seven of them were incomplete responses. Therefore, the final sample for the study consisted of 243 valid responses. The adequacy of this sample size was first justified using the widely accepted "10-times rule" in Partial Least Squares Structural Equation Modeling (PLS-SEM), which recommends that the sample size should be at least ten times the maximum number of structural paths directed at any endogenous construct (Wagner & Grimm, 2023). In this study, the maximum number of paths directed at a single construct, namely Sustainable Farming Practices, was six, indicating a minimum required sample size of 60. This threshold is considerably lower than the actual sample size. Additionally, the inverse square root method (Kock & Hadaya, 2018) was applied as a more rigorous assessment. Assuming a minimum path coefficient of 0.2 and a 5% significance level, the required sample size was estimated at 97. Since the actual sample exceeds both criteria, it is deemed sufficient for robust and reliable analysis.

Figure 2: Study area map

Source: Internet

Research Instrument

In line with the earlier research concerning the adoption of sustainable agriculture (Erekalo et al., 2025; Mgomezulu et al., 2023; Rizzo et al., 2024), the researcher developed a questionnaire. It gathered the demographic profile (age, gender, education, landholding, farming type, farming experience) of the participants. The survey tool also comprised questions on livelihood security in farm households (8 items), sustainable farming practices (11 items), institutional support (4 items), farm decisions (7 items), positive motivators (9 items), knowledge and capacity shortages (3 items), and economic and market limits (8 items) (Appendix A). In order to assess these variables, responses to the questionnaire items were recorded using a Likert scale wherein 1 represented strong disagreement and 5 represented strong agreement, thereby rendering five levels. The measurement items were developed using existing literature, and content validity was assessed by three experts in the subject matter, and a pre-test conducted on 20 farmers in Karnataka for determining that the measurement items were understood and relevant.

The internal biases of the collected data were carefully addressed in various ways to enhance the internal validity and reliability of the dataset. The research instrument was created based on previously validated scales from existing literature, that helped to minimize measurement bias and ensure conceptual clarity of the constructs. Further, the questionnaire underwent rigorous reliability and validity assessments, while content validity was evaluated through expert review to ensure the relevance and appropriateness of the items used. A pilot test was conducted among 20 farmers to identify and refine ambiguous questions, thereby reducing potential verbal and textual biases raised. During the data collection process, identity of respondents was kept confidential so that they could answer the questions freely and honestly, reducing response bias. Additionally, the use of a Likert-scale format in the questionnaire reduced variability arising from subjective interpretation of responses. To further improve the data quality, data screening procedures were applied, such as the removal of incomplete or inconsistent responses. All these methodological steps in combination ensured that the dataset were reliable and suitable for subsequent statistical analysis and interpretation.

Data Analysis

The Statistical Package for Social Sciences (SPSS) software (version 24.0) was used to process and examine the gathered data. Frequency and percentage distributions were computed to assess the respondents' demographic profiles. The structural model and the measurement model were derived by employing the partial least squares structural equation modelling (PLS-SEM). The scale's reliability and validity were evaluated by the measurement model through average variance extracted (AVE), composite reliability (CR), Cronbach's alpha, and factor loadings. The Fornell–Larcker criterion was used to examine the discriminant validity, whereas R^2 and SRMR indices were used to assess the model's fitness. Subsequently, a bootstrapping procedure with 5,000 resamples was used to generate p-values, t-values and path coefficients, which were analyzed for testing the hypothesized associations, using the structural model.

Results

Demographics characteristics of participants

Table 1 shows the demographic features of 243 respondents. The majority of farmers in southern Indian were male (81.5%), while females accounted for 18.5%. Most respondents were aged above 31 years, with 37% between 31–45 years and 38.7% above 45 years, suggesting that middle-aged farmers dominate the farming sector in this study. More than half of the participants (56.8%) had only basic schooling and 18.5% had no formal education. This indicates that majority of the respondents had a relatively low educational background. With respect to annual income, 63% of participants earned between Rs. 60,000 and Rs.1,50,000, which signifies fiscal weakness of a significant number of farmers. Almost half of the respondents (48.6%) were involved in farming activities for more than 20 years, thereby signifying the overwhelming presence of seasoned practitioners. Smallholder farming was predominant as the distribution of farm size revealed that 43.2% had one to five acres of farm and 39.5% had less than one acre. Lastly, 59.3% adopted conventional farming and 40.7% were organic farmers. This finding evidenced that the penetration of organic cultivation systems was low in Karnataka. In general, the outcomes indicated that the study population comprised relatively low-income, male-dominated, and smallholder farming households. Further, organic farming systems were less predominant than traditional farming practices.

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Table 1: Demographic characteristics of the respondents (n=243)

Demographic parameters	Category	Sample size (n)	Percent (%)
Gender	Male	198	81.5
	Female	45	18.5
Age	Below 15 years	14	5.8
	15 to 30 years	45	18.5
	31 to 45 years	90	37
	Above 45 years	94	38.7
Education	No formal education	45	18.5
	Up to primary school	79	32.5
	Secondary school	59	24.3
	Graduate	42	17.3
	Postgraduate	18	7.4
Annual Income	Below 60000	47	19.3
	60000 to 100000	78	32.1
	100001 to 150000	75	30.9
	150001 to 200000	35	14.4
	Above 200000	8	3.3
Farming Experience	Less than 5 years	32	13.2
	5 to 10 years	46	18.9
	10 to 20 years	47	19.3
	More than 20 years	118	48.6
Farm Size	Less than 1 acre	96	39.5
	1 to 5 acres	105	43.2
	5 to 10 acres	33	13.6
	More than 10 acres	9	3.7
Farming Type	Organic farming	99	40.7
	Conventional farming	144	59.3

Source: Authors' own analysis

Measurement model

Reliability and validity

The examined constructs' discriminant validity, convergent validity, and composite reliability were the parameters for assessing the measurement model (Table 2). Cronbach's alpha (CA) was used to evaluate the internal consistency of the measurement items corresponding to each construct. Most of the constructs showed CA values great than 0.8, indicating good reliability of the questionnaire. The scale's strong reliability was ascertained since the composite reliability (CR) values for most constructs were found to be greater than 0.80 (Table 2).

The extent to which the underlying phenomena was precisely represented by the constructs was determined by evaluating construct validity via discriminant and convergent validities. As observed by Hair (2006), the assessment of convergent validity is contingent on the standardized factor loadings of individual indicators within each construct. In the present study, all measurement items exhibited factor loadings exceeding 0.5, thereby meeting the recommended criterion. Additionally, the average variance extracted (AVE) values were computed to further examine convergent validity across constructs (Engellant et al., 2016), with the accepted benchmark set at 0.5 or above (Ahmad et al., 2016). The AVE values for farm household livelihood security, factors influencing farming decisions, institutional support, sustainable farming practices, positive motivators for organic farming, knowledge & capacity deficits, and economic & market constraints, exceeded 0.5 in the present study. This finding depicted good convergent validity. The inner Variance Inflation Factor (VIF) of the measures were also measured to determine the existence of multicollinearity among constructs. No significant issues of collinearity were identified among the variables as the values were less than 5.

Table 2: Reliability and Validity Assessment

Constructs	Loadings	CA	CR	AVE	VIF
Economic & Market Constraints		0.843	0.883	0.562	
EMC: 2 Organic farming has higher production costs than conventional farming	0.650				1.622
EMC 3: Organic seeds and fertilizers are too expensive	0.630				1.586
EMC 5: My crop yield was low when I started organic farming	0.710				1.712
EMC 6: Conventional farming has higher yields compared to organic farming	0.719				1.701
EMC 7: There is low market demand for organic produce	0.861				2.626
EMC 8: There is not enough demand or good prices for organic products	0.888				2.945
Knowledge & Capacity Deficits		0.794	0.880	0.712	2.242
KCD 1: I lack the necessary knowledge and training for organic farming	0.890				2.242
KCD 2: I don't have enough knowledge or training about organic farming	0.896				2.389
KCD 3: I need training or education to improve my farming methods	0.736				1.360
Positive Motivators		0.901	0.927	0.719	
PM 1: Organic produce offers better prices in the market	0.784				1.74
PM 6: Government schemes or support encourages a change to organic farming	0.916				4.622
PM 7: Government subsidies and support	0.869				4.151
PM 8: Organic farming provides better long-term sustainability benefits	0.893				4.097
PM 9: Financial incentives impact my farming practices significant	0.766				1.759
Sustainable Farming Practices		0.910	0.925	0.555	
SFP 1: I grow different crops in different seasons to keep the soil healthy	0.829				4.215
SFP 2: I use natural methods, like neem or other local remedies, to control pests	0.839				4.32
SFP 3: I try to save water and use it carefully on my farm	0.770				2.355
SFP 4: I avoid using too many chemical fertilizers and pesticides on my farm	0.774				2.629
SFP 5: I do my farming practices that are good for the environment	0.703				1.965
SFP 7: I use drip irrigation to reduce water wastage	0.690				1.778
SFP 8: I use sprinklers to reduce water wastage	0.643				1.511
SFP 9: I prefer seeds that are naturally grown or certified as organic	0.797				2.634
SFP 10: I try to reduce waste by reusing farm by-products	0.636				2.454
SFP 11: I believe sustainable practices help me save money in the long run	0.739				3.183
Factors Influencing Farming Decisions		0.729	0.852	0.622	
FIFD 2: Market Demand	0.948				1.028

Constructs	Loadings	CA	CR	AVE	VIF
FIFD 4: Consumer Preference	0.854				2.011
FIFD 6: Pricing of produce	0.811				2.028
Institutional Support		0.760	0.680	0.515	
IS 1: I have easy access to government subsidies for sustainable farming practices.	0.679				1.001
IS 3: Certification processes for sustainable or organic products are well-supported and transparent.	0.755				1.001
Farm Household Livelihood Security		0.877	0.907	0.620	
FHLS 1: My household has enough food available throughout the year.	0.711				1.853
FHLS 2: The quality of food available to my family is good.	0.819				2.361
FHLS 3: I am satisfied with my household's overall standard of living.	0.726				1.938
FHLS 4: My children have access to adequate education and health services.	0.813				2.100
FHLS 5: I feel confident in my ability to provide for my family's needs from farming.	0.831				3.077
FHLS 6: The farming system I use provides a secure and stable livelihood for my household.	0.816				3.025

Source: Authors' own analysis (SEM output)

The Fornell–Larcker criterion was used to assess the discriminant validity (Table 3). In order to establish construct distinctiveness, the correlation coefficients among several constructs are required to remain below the square root of the AVE for each corresponding construct (Hair et al., 2010). The findings presented in Table 3 indicate that the square root of AVE values for all constructs varied between 0.718 for institutional support and 0.887 for farm household livelihood security. In all instances, these estimates were higher than the inter-construct correlation coefficients, thereby confirming that adequate discriminant validity was exhibited by each construct.

Table 3: Discriminant validity – Fornell–Larcker criterion

Constructs	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Economic & Market Constraints (1)	0.849						
Farm Household Livelihood Security (2)	0.584	0.887					
Factors Influencing Farming Decisions (3)	0.651	0.574	0.75				
Institutional Support (4)	-0.226	-0.222	-0.121	0.718			
Knowledge & Capacity Deficits (5)	0.786	0.728	0.69	-0.195	0.844		
Positive Motivators (6)	0.713	0.655	0.704	-0.152	0.732	0.848	
Sustainable farming Practices (7)	0.794	0.795	0.71	-0.207	0.788	0.775	0.845

Source: Authors' own analysis (SEM output)

Model Fitness

As shown in Table 4, the coefficient of determination (R^2) for sustainable farming was found to be 0.778 (adjusted R^2 = 0.762). This finding suggests that 77.8% of the variation in sustainable farming outcomes can be attributed to the set of independent variables, including positive motivators, knowledge & capacity deficits, and economic & market constraints. In a comparable manner, an R^2 value of 0.703 (adjusted R^2 = 0.684) was exhibited by farm household livelihood security, suggesting that the predictors included in the model explained approximately 70% of the variance in livelihood security. Collectively, these results demonstrate the model's substantial explanatory capability.

The Standardized Root Mean Square Residual (SRMR) was used for evaluating the model fit. SRMR values below the recommended cutoff threshold of 0.08 were yielded by the saturated model (0.075) and the estimated model (0.072). Therefore, a good model fit was determined (Table 4).

Table 4: Coefficient of determination and model fitness

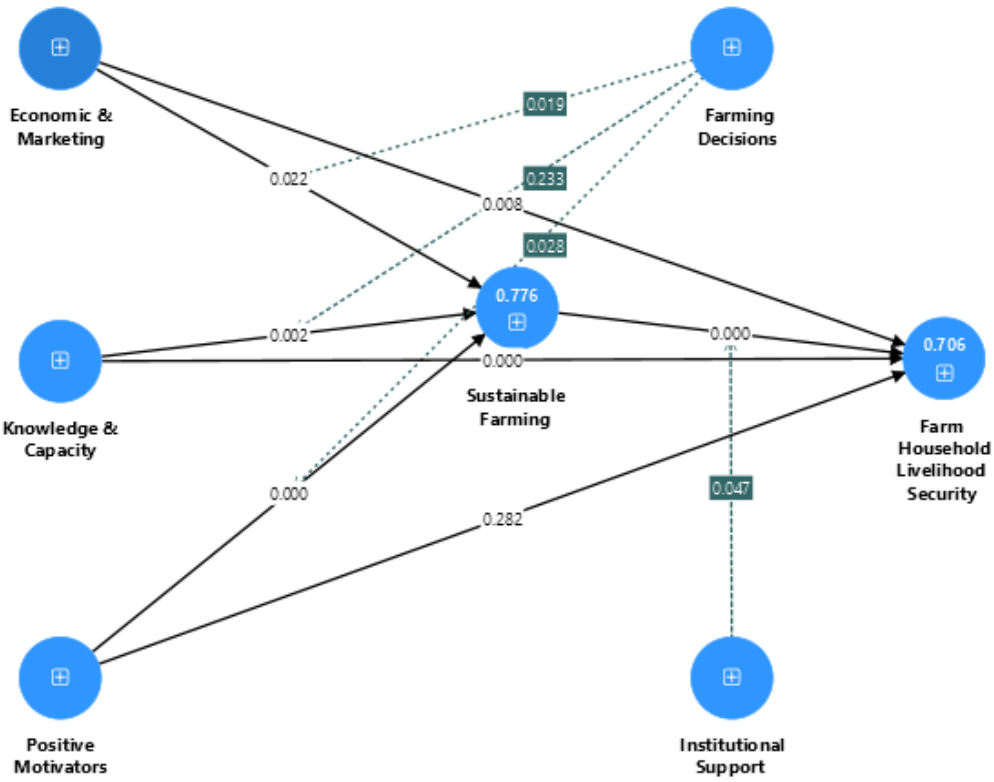
Variables	Coefficient of Determination (R2)	
	R2	**Adj. R2**
Farm Household Livelihood Security	0.703	0.684
Sustainable Farming	0.778	0.762
Model fit summary	**Saturated model**	**Estimated model**
SRMR	0.075	0.072

Source: Authors' own analysis (SEM output)

Structural Model

The hypothesized relationships among economic and market constraints, knowledge and capacity deficits, positive motivators, sustainable farming practices, livelihood security, farming decisions, and institutional support were assessed by testing the structural model (Figure 3).

Figure 3: Structural model for the study



Source: Authors' own analysis (PLS-SEM output)

As indicated in Table 5, economic and market constraints exerted a significant negative effect on the adoption of sustainable farming practices (t = -2.007, p < 0.05). Therefore, the hypothesis *H1: Economic and market constraints negatively affect the adoption of sustainable farming practices* was accepted. Similarly, the acceptance of sustainable farming practices was found to significantly and negatively affected by knowledge and capacity deficits (t = -2.911,

$p < 0.05$). Therefore, the hypothesis *H2: Knowledge and capacity deficits positively affect the adoption of sustainable farming practices* was accepted. The influence of positive motivators on the acceptance of sustainable practices was significant and positive ($t = 3.329$, $p < 0.001$). Hence, the hypothesis *H3: Positive motivators for organic farming positively influence the adoption of sustainable farming practices* was accepted. The effect of the adoption of sustainable farming practices on farm household livelihood security was positive and significant ($t = 5.543$, $p < 0.001$). Therefore, the hypothesis *H4: Sustainable farming practices are positively associated with increased farm household livelihood security* was accepted.

The moderating roles of farming decisions and institutional support were also investigated. According to Table 5, farming decisions significantly moderated the relationship between economic and marketing constraints and adoption of sustainable farming practices ($t = 2.071$, $p < 0.05$). Therefore, the hypothesis *H5a: Factors influencing farming decisions significantly moderates the relationship between economic & market constraints and the adoption of sustainable farming practices* was accepted. Similarly, farming decisions significantly moderated the association between positive motivators and acceptance of sustainable farming practices ($t = 1.904$, $p < 0.05$). *H5b: Factors influencing farming decisions significantly moderates the relationship between knowledge & capacity deficits and the adoption of sustainable farming practices* was accepted. On the contrary, it did not substantially moderate the association between knowledge and capacity deficits and acceptance of sustainable farming practices ($t = 0.728$, $p > 0.05$). Therefore, the hypothesis *H5c: Factors influencing farming decisions significantly moderates the relationship between positive motivators for organic farming and the adoption of sustainable farming practices* was rejected. Institutional support moderated the relationship between farm household livelihood security and acceptance of sustainable farming practices ($t = 1.678$, $p < 0.05$). Hence, the hypothesis *H6: Institutional support significantly moderates the relationship between the adoption of* sustainable farming practices and *farm household livelihood security* was accepted.

Table 5: Direct and moderating effects

Relationship	T-value	p-value	Decision
Direct effects			
Economic & Marketing -> Sustainable Farming	-2.007	0.022	Supported
Knowledge & Capacity -> Sustainable Farming	-2.911	0.002	Supported
Positive Motivators -> Sustainable Farming	3.329	0.000	Supported
Sustainable Farming -> Farm Household Livelihood Security	5.543	0.000	Supported
Moderating effects			
Farming Decisions × Economic & Marketing -> Sustainable Farming	2.071	0.019	Supported
Farming Decisions × Knowledge & Capacity -> Sustainable Farming	0.728	0.233	Not supported
Farming Decisions × Positive Motivators -> Sustainable Farming	1.904	0.028	Supported
Institutional Support × Sustainable Farming -> Farm Household Livelihood Security	1.678	0.047	Supported

Source: Authors' own analysis (SEM output)

Discussion

Consistent with contemporary global evidence, the findings of the present study demonstrate that the acceptance of sustainable farming is influenced by a complex interaction of behavioral and structural components. Market and economic limitations especially poor market connections, lack of credit, and high input prices, are substantial obstacles to adoption, particularly among smallholders. These results are consistent with recent studies in Africa and Asia that emphasize the role of structural barriers in a systematic decrease in the capacity of farmers to make transitions toward sustainability transitions (Malau et al., 2024; Nguyen-Thi-Kim et al., 2024; Sharma & Mishra, 2024). Equally important are knowledge and capacity deficits, including restricted access to technical support, extension, and training, which hinder awareness and confidence in sustainable practices (Gemtou et al., 2024; Thompson et al., 2024). Simultaneously, the research highlights the critical role of positive motivators in enabling adoption. Environmental

awareness, consumer needs of healthier foods, high-end pricing, and specific governmental stimulus are effective forces. The effects of these factors are amplified when such motivators are supported by enabling policy frameworks such as better market certification schemes, streamlined subsidy schemes, and climate-smart agriculture schemes (Ma & Rahut, 2024; Villalba et al., 2024). An increasing trend is observed in the adoption of sustainable and organic practices as a result of health and environmental motivation, especially by younger and better educated farmers (Gemtou et al., 2024; Liu & Liu, 2024; Thakur et al., 2024). In addition to the structural determinants, the moderating role of behavioral factors is evident. Aspirations, risk perceptions, and attitudes of farmers influence the manner in which they interpret their constraints and the way in which they respond to them. Recent studies affirm that farmers with higher aspirations or those with better sustainability-oriented identities exhibit a greater inclination to adopt and sustain such practices, even under economic pressure (Han & Niles, 2023; Maltby, 2024; Olagunju et al., 2025). Moreover, institutional support is a vital facilitating factor, which enhances the effect of adoption on livelihood security. Indian and global evidences indicate that collaborative networks, transparent subsidy provision, and robust extension services are the determining factors for ensuring resilience and scaling-up adoption (Masud et al., 2022). Collectively, the outcomes provide the significance of a multi-dimensional method for advancing sustainable agriculture. Institutional strengthening, behavioral interventions, and capacity building should be used to complement market incentives and financial reforms. Some recent studies indicate that institutional, behavioral, and economic perspectives need to be integrated to implement socially inclusive, resilient, and scalable approaches to sustainability (Erekalo et al., 2025; Rizzo et al., 2024; Srinatha et al., 2024).

The study outcomes carry significant implications for both agricultural policy formulation and practical implementation in Karnataka and beyond. First, the policy frameworks must focus on reducing the economic impediments by encouraging the establishment of efficient certification systems, availing affordable credit, and providing subsidies on organic inputs (Eti, 2025). Second, capacity building should be enhanced and the extension services should be customized as per the local circumstances, farmer training schedules, and learning platforms to overcome knowledge deficits among peers (Prajapati et al., 2025). Third, digital marketplace, branding of organic produce, and cooperatives should be institutionalized to render higher returns to farmers following sustainable practices (Kharel et al., 2022; Stringer et al., 2020). Fourth, behavioral interventions, such as social recognition of adopters, mentorship, and risk-sharing schemes, need to supplement the traditional economic incentives, because the psychology and decision-making of farmers can play an important role (May et al., 2019; Surendran et al., 2024). Lastly, institutional support should be scaled up with integrated interventions across private sector entities, NGOs, and government agencies. Bureaucratic hurdles must be minimized by means of inclusive and transparent support systems (Otundo, 2025).

Notwithstanding its contributions, the present study is subject to certain limitations. First, the analysis is confined to a single state in India, which may restrict the generality of the outcomes across varying agro-ecological settings. Future research studies should adopt cross-regional comparative research designs for capturing heterogeneity in adoption dynamics. Second, the dependence on self-reported survey responses might present a likelihood of response bias, particularly in assessing farmers' motivational drivers and attitudes. Third, although the study incorporates multiple explanatory factors, the constructs related to farmer decision-making and institutional support demonstrated comparatively weaker reliability, emphasizing the requirement for improved measurement instruments or mixed-methods approaches that integrate qualitative interviews with quantitative surveys. Finally, the cross-sectional design limits causal interpretation, indicating that longitudinal studies are necessary to explore sustained adoption pathways over a period.

Conclusion

The present study adds to the expanding body of scholarly literature on the adoption of sustainable farming practices by empirically analyzing how livelihood security and adoption consequences are determined by farmers' decision-making, which is influenced by several motivators and constraints in Karnataka, India. Adoption was hindered by structural barriers, particularly weak market linkages, limited credit access, and high input costs, while sustainable transitions were further restricted by insufficient training and knowledge gaps. Simultaneously, adoption was encouraged substantially by positive motivators, namely, government incentives, environmental awareness, and premium pricing. The role of psychological dimensions in determining adoption behavior was emphasized as the effects of these drivers were moderated by behavioral components, such as aspirations, attitudes, and risk perception. Moreover, the necessity of robust extension services, transparent subsidy systems, and efficient policy frameworks was emphasized since the livelihood benefits of sustainable practices were amplified by institutional support. Overall, it can be inferred that a multidimensional strategy integrating institutional strengthening, behavioral insights, and

financial reforms is required for cultivating socially inclusive and resilient farming systems and for advancing sustainable agriculture.

To ensure that the conclusions drawn from this study are robust and credible, several measures were undertaken to mitigate internal biases in the dataset. The use of validated measurement scales, along with prior reliability and validity assessments, helped ensure consistency and accuracy in capturing the constructs. Content validity was reinforced through expert review, while pilot testing minimized ambiguity and reduced potential verbal and textual biases. During data collection, respondent anonymity and confidentiality were maintained that encouraged more authentic responses and limited response bias. Furthermore, the application of a structured Likert-scale format enhanced response uniformity and reduced subjective variability. Statistical validation techniques, including reliability and model fitness assessments, further strengthened the integrity of the findings. Data screening procedures, such as the exclusion of blank responses, ensured that only high-quality data were analyzed. Despite these precautions, the possibility of bias due to self-reported and cross-sectional data cannot be entirely eliminated although SEM was employed to examine the hypothesized relationships. Therefore, the findings were interpreted with appropriate caution and the conclusions were made as observed associations rather than causal inferences. Overall, the systematic efforts to reduce internal biases contribute to the reliability and generalizability of the study's findings within the given research context.

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Appendix A

Interview schedule for the present study

Dear Sir/Madam,

I am conducting research on sustainable farming dynamics. I would highly appreciate if you can spare your time and participate in this survey. Please be assured that the data obtained by means of this questionnaire shall remain confidential and will be employed only for academic purposes.

Regards,

Poornima V

1. Section I - Demographics

1. Gender: Male □ Female □
2. Age: Below 15 years □ 15-30 □ 31-45□ Above 45 years □
3. Educational qualification: No formal education □ Up to primary school □ Secondary school □ Graduate □ Post-graduate □
4. Annual income: Below 60,000 □ 60,000-1,00,000 □ 1,00,001-1,50,000 □ 1,50,000 -2,00,000 □ Above 2,00,000 □
5. Farming experience: Less than 5 years □ 5 to 10 years □ 10 to 20 years □ More than 20 years □
6. Farm size: Less than 1 acre □ 1 to 5 acres □ 5 to 10 acres □ More than 10 acres □
7. Farming type: Organic farming □ Conventional farming □

Section II

Economic & Market Constraints

8. Please tick the appropriate box below to answer regarding the economic and market constraints.

SDA: Strongly Disagree; DA- Disagree; N-Neutral; A-Agree; SA-Strongly Agree

Sl. No	Statements	SDA	DA	N	A	SA
1.	The cost of transitioning to organic farming is too high					
2.	Organic farming has higher production costs than conventional					
3.	Organic seeds and fertilizers are too expensive					
4.	Economic challenges limit my ability to adopt sustainable farming					
5.	My crop yield was low when I started organic farming					
6.	Conventional farming has higher yields compared to organic farming					
7.	There is low market demand for organic produce					
8.	There are not enough demand or good prices for organic products					

Knowledge & Capacity Deficits

9. Please tick the appropriate box below to answer regarding the knowledge and capacity deficits.

SDA: Strongly Disagree; DA- Disagree; N-Neutral; A-Agree; SA-Strongly Agree

Sl. No	Statements	SDA	DA	N	A	SA
1.	I lack the necessary knowledge and training for organic farming					
2.	I don't have enough knowledge or training about organic farming					
3.	I need training or education to improve my farming methods					

Positive Motivators

10. Please tick the appropriate box below to answer regarding the matters which triggers positive motivations to adopt organic farming.

SDA: Strongly Disagree; DA- Disagree; N-Neutral; A-Agree; SA-Strongly Agree

Sl. No	Statements	SDA	DA	N	A	SA
1.	Organic produce offers better prices in the market					
2.	Market prices for organic produce are higher than conventional					
3.	Environmental concerns motivate me to consider organic farming					
4.	Health reasons make organic farming attractive					
5.	Increasing consumer demand for organic products motivates a change					
6.	Government schemes or support encourages a change to organic					
7.	Government subsidies and support					
8.	Government schemes or support encourages a change to organic farming					
9.	Organic farming provides better long-term sustainability benefits					
10.	Financial incentives impact my farming practices significant					

Sustainable Farming Practices

11. Please tick the appropriate box below to answer your sustainable farming practices.

SDA: Strongly Disagree; DA- Disagree; N-Neutral; A-Agree; SA-Strongly Agree

Sl. No	Statements	SDA	DA	N	A	SA
1.	I grow different crops in different seasons to keep the soil healthy					
2.	I use natural methods, like neem or other local remedies, to control pests					
3.	I try to save water and use it carefully on my farm					
4.	I avoid using too many chemical fertilizers and pesticides on my farm					
5.	I do my farming practices that are good for the environment					
6.	I use compost or animal manure to improve soil quality					

Sl. No	Statements	SDA	DA	N	A	SA
7.	I use drip irrigation to reduce water wastage					
8.	I use sprinklers to reduce water wastage					
9.	I prefer seeds that are naturally grown or certified as organic					
10.	I try to reduce waste by reusing farm by-products (e.g., crop stalks or husks)					
11.	I believe sustainable practices help me save money in the long run					

Farm Household Livelihood Security

12. Please tick the appropriate box below to answer livelihood security of farm houses.

SDA: Strongly Disagree; DA- Disagree; N-Neutral; A-Agree; SA-Strongly Agree

Sl. No	Statements	SDA	DA	N	A	SA
1.	My household has enough food available throughout the year.					
2.	The quality of food available to my family is good.					
3.	I am satisfied with my household's overall standard of living.					
4.	My children have access to adequate education and health services.					
5.	I feel confident in my ability to provide for my family's needs from farming.					
6.	The farming system I use provides a secure and stable livelihood for my household.					
7.	I have sufficient resources (land, water, livestock, equipment) to maintain my household's livelihood.					
8.	My household is free from debt or financial distress caused by farming.					

Factors Influencing Farming Decisions

13. Please tick the appropriate box below to answer regarding the factors influencing farming decisions

SDA: Strongly Disagree; DA- Disagree; N-Neutral; A-Agree; SA-Strongly Agree

Sl. No	Statements	SDA	DA	N	A	SA
1.	Cost of Production					
2.	Market Demand					
3.	Profitability					
4.	Consumer Preference					
5.	Yield on traditional is higher than Organic					
6.	Pricing of produce					
7.	Environmental Concern					

Institutional Support

14. Please tick the appropriate box below to answer regarding the institutional support you receive

SDA: Strongly Disagree; DA- Disagree; N-Neutral; A-Agree; SA-Strongly Agree

Sl. No	**Statements**	**SDA**	**DA**	**N**	**A**	**SA**
1.	I have easy access to government subsidies for sustainable farming practices.					
2.	Market access for organic and sustainable products is adequate and reliable.					
3.	Certification processes for sustainable or organic products are well-supported and transparent.					
4.	The existing regulations encourage farmers to adopt sustainable farming methods.					
5.	There is insufficient government support for organic farming					
6.	Government doesn't provide enough support for organic farming					
7.	It is hard to get organic certification for my farm					
8.	I need financial support for better farming practices					
9.	I need better connections to sell my farm produce					

Thank you for your response