The Journal of Behavioral Science
2024, Vol. 19, Issue 2, 59–74

ISSN: 1906-4675 (Print), 2651-2246 (Online)

The Journal of Behavioral Science (TJBS)

Quantitative Research Article

Adoption Behavior of Solar Technology among Young Smart Farmers in Thailand

Anupong Khobkhet[1], Budsara Limnirankul[1]*, Prathanthip Kramol[1], Ruth Sirisunyaluck[1], and Juthathip Chalermphol[1]

Abstract

Background/Problem: The adoption of solar technology by young smart farmers (YSFs) in Thailand remains under-researched, despite its potential benefits for sustainable agriculture.
Objective/Purpose: This study aims to identify and analyze the factors influencing the adoption behavior of solar technology among YSFs in the upper northern region of Thailand.
Design and Methodology: Using a survey methodology, data were collected from 300 YSFs and analyzed using statistical tools and binary logistic regression to determine significant predictors of technology adoption.
Results: The findings reveal seven critical determinants of solar technology adoption: duration of YSF membership (β = .59, p = .01), agricultural experience (β = .47, p = .03), loan repayment frequency (β = .71, p < .01), land ownership (β = 1.03, p < .001), perceived benefits of solar energy (β = 2.57, p < .001), awareness of solar energy limitations (β = 2.19, p < .001), and perceived risks associated with solar energy (β = -.81, p = .01).
Conclusion and Implications: The study concludes that targeted educational programs in agricultural practices and financial management, coupled with interventions to address perceived barriers and risks, are essential to enhance the adoption of solar technology among YSFs. These findings provide valuable insights for policymakers, educators, and industry stakeholders in developing strategies to promote sustainable energy practices in agriculture, thus contributing to environmental sustainability and technological progress within the sector.

Author Affiliation
[1] Department of Agricultural Economy and Development, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand.

*Corresponding author e-mail:
budsara.l@cmu.ac.th
https://orcid.org/0009-0000-1633-8215

Article Information
Submitted: 14.02.24
Accepted: 20.05.24
Published: 31.05.24

Keywords
Young smart farmers, solar energy technology, adoption behavior, Thailand

The intersection of global energy dynamics and sustainable agricultural practices (Bathaei & Štreimikienė, 2023) marks a critical area of investigation within the behavioral sciences, particularly through the lens of renewable energy adoption among agricultural stakeholders (Maqbool et al., 2020). This study situates itself within the interdisciplinary fields of environmental and agricultural behavioral science by examining the factors influencing solar energy adoption among farmers in Thailand, leveraging the theory of planned behavior (TPB) (Ajzen, 1991) as its theoretical foundation. Thailand, with its abundant solar radiation and governmental incentives towards renewable energy (Aroonsrimorakot et al., 2020; DEDE, 2020), serves as an ideal case study for this exploration. Recent advancements in solar technology adoption within the agricultural sector indicate a positive trajectory, yet the underlying behavioral mechanisms remain underexplored. By integrating the TPB, this study aims to elucidate the motivational factors, attitudes and perceived behavioral controls that influence the decision-making process of these farmers. This research uses the attitude measurement method from previous research of Huijts et al. (2012) to know the level of attitude of farmers, where a good attitude is one of the factors that increase the opportunity to accept innovations together with other basic factors in the context of farmers being included as elements in this research (Moerkerken et al., 2023). The research further seeks to bridge the theoretical gap by identifying specific behavioral factors and dimensions that drive the adoption of solar energy, thus contributing original insights to the field of behavioral science.

Given the burgeoning interest in renewable energy technologies and their potential to revolutionize the agricultural sector, this research delves into the behavioral determinants of solar technology adoption in agriculture focusing on the YSFs in Thailand has yet to comprehensively examine the acceptance behavior characterizing this demographic. This nascent generation of agriculturists holds the potential to serve as an exemplary model and a pertinent educational benchmark for the broader farming community in forthcoming periods. By focusing on these pivotal areas, the study significantly contributes to the field of behavioral science. It offers pragmatic insights that could augment the uptake of renewable energy technologies among those engaged in farming, thereby aligning with, and promoting the objectives encapsulated in the United Nation’s sustainable development goal seven (United Nations, 2022). This goal advocates for the acceleration of global access to affordable, reliable, sustainable, and modern energy services (Walesiak & Dehnel, 2024)

Furthermore, comprehending and fostering the uptake of solar energy within the agricultural sector is imperative for a multitude of reasons. Primarily, this realization came to light a decade prior the shift towards renewable energy sources, such as solar power, is vital for the amelioration of climate change impacts, notably the reduction of greenhouse gas emissions and environmental degradation (Lyster, 2014). Analyzing the factors influencing the adoption of solar technology enables the identification of impediments and incentives that shape farmers' decisions to incorporate renewable energy solutions into their agricultural practices. This facilitates a tailored transition towards a sustainable energy paradigm within the realm of agriculture. Moreover, the endorsement of solar technology adoption can yield considerable economic advantages for the farming community (Wang et al., 2023). Implementation of solar energy systems has the potential to diminish operational energy expenses, augment energy self-sufficiency, and expand income sources, for instance, through the sale of surplus energy to the power grid (Dhonde et al., 2022). A thorough understanding of the determinants that either promote or deter the acceptance of solar technology can guide the formulation of targeted policies and support mechanisms that assist farmers in capitalizing on these economic prospects, thereby bolstering the fiscal robustness of the agrarian industry.

The investigation into solar technology adoption among agricultural communities is crucial for advancing rural development and social equality. Accessible and reliable energy resources are essential for agricultural efficiency, food security, and the sustenance of rural communities, yet many areas, particularly in developing nations, lack central electrical infrastructure (Ayana & Degaga, 2022). Research reveals a significant gap in understanding the socio-economic and educational dynamics influencing YSFs in Thailand. Studies typically overlook the interplay of educational backgrounds, financial behaviors, and attitudes towards solar energy, which critically shapes YSFs' decision-making processes. This oversight limits the potential for improving agricultural efficiency and rural development. By studying how farmers adopt and utilize solar energy, researchers can devise strategies to overcome energy accessibility challenges, strengthen rural societies, and foster inclusive growth, essential for reducing poverty and improving rural living standards. The purpose of this research was to analyze the drivers and barriers to solar technology adoption among YSFs and tailor interventions that promote a sustainable and resilient agricultural energy system, contributing to broader sustainable development goals.

Literature Review

The adoption of solar technology in agriculture represents a critical junction at which sustainable energy meets food production, aiming to enhance both efficiency and environmental stewardship. This literature review explores the behavioral determinants influencing solar technology adoption among young smart farmers in the upper northern region of Thailand, integrating insights from farmers' attitudes towards technology according to the model from factors influencing sustainable energy technology acceptance by Huijts et al. (2012) which is part of the theory of planned behavior (TPB) are adopted as the framework of the study.

Solar Energy in Agriculture

Utilization of solar energy is a significant innovation in agriculture (Tariq et al., 2021). Evaluating farmers' attitudes toward new agricultural technologies is crucial. It influences technology adoption and supports sustainable, eco-friendly farming practices (Gorjian et al., 2022). This evaluation is critical, as it not only highlights the perceived benefits and cost implications but also emphasizes the necessity of supporting infrastructure as pivotal factors influencing the decision to adopt solar technology. Furthermore, understanding these attitudes, both before and after the introduction of technological innovations, is vital for devising strategies that promote technology acceptance. This can enable the tailoring of technological advancements to meet the unique needs of specific farmer groups (Mohr & Kühl, 2021). In this context, this study seeks to provide a comprehensive analysis of the factors that influence farmers' decisions to adopt solar technologies, examining the role of educational interventions and policy incentives in facilitating this transition. By integrating empirical data and theoretical frameworks, the research aims to contribute to the broader discourse on technology adoption in agriculture, offering insights that could inform both practice and policy.

Theory of Planned Behavior (TPB) and Technology Adoption

The TPB provides a robust framework for analyzing the behavioral intentions behind the adoption of solar technology among farmers. It suggests that an individual's behavior is directly influenced by their intention to perform the behavior, which is in turn influenced by their attitude towards the behavior, subjective norms, and perceived behavioral control (Ajzen, 1991). In the context of promoting agriculture, it is advisable to focus specifically on the attitude component of the theory of planned behavior for applied studies and explanations. This approach allows for a targeted analysis of how farmers' attitudes toward innovations influence their decision-making and adoption behaviors (Gorton et al., 2008), these components translate to the farmers' attitudes towards solar technology, the influence of social norms and peer behaviors, and the perceived ease or difficulty of adopting such technologies. Previous studies have applied the TPB to understand the determinants of technology adoption in agriculture, highlighting its utility in identifying key psychological factors that motivate or deter adoption behaviors.

Young Smart Farmers

The concept of young smart farmers (YSFs) encapsulates a new generation of agriculturists who are technologically adept, open to innovation, and committed to integrating sustainable practices into their farming operations (Jansuwan & Zander, 2021). The YSF initiative, meticulously designed to enhance the agricultural business acumen of young farmers, follows a developmental methodology grounded in a farmer-centric (bottom-up) paradigm. This approach highlights the critical role of farmers in driving their own development, emphasizing the importance of knowledge dissemination and the creation of strong networks within the agricultural community as key avenues for advancement.

Since its inception in 2014, the program has been systematically implemented annually across all provinces by the department of agricultural extension in Thailand (Jansuwan & Zander, 2021). These individuals play a crucial role in the adoption of solar technology in agriculture, bridging traditional agricultural knowledge with modern technological advancements. Their attitudes and behaviors towards solar energy are shaped by various factors (Huijts et al., 2012)., including perceived benefits, perception of problems, outcome efficacy, perceived risks, and perceived opportunities, as identified in the literature.

In summary, the literature indicates that the adoption of solar technology in agriculture is influenced by a complex interplay of psychological, social, and economic factors. By leveraging the TPB and focusing on the attitude towards of YSFs, which factors may enhance the probability of adopting solar energy technology to uncover the nuanced determinants of solar technology adoption in the upper northern region of Thailand. Understanding these determinants is crucial for developing targeted strategies that promote the widespread adoption of solar energy in agriculture, contributing to the sustainability and productivity of the agricultural sector.

Research Objectives

This study examined the factors influencing the adoption behavior of solar technology among young smart farmers in the upper northern region of Thailand.

Selection of Research Variables

The researcher conducted a comprehensive review of relevant literature to identify key variables influencing the study. Table 1 presents the selected variables, strategically designed to capture a comprehensive range of factors influencing technology uptake. Age (X1) and education level (X2) are foundational demographic factors correlating with technology adoption, reflecting generational differences and cognitive openness. Membership duration in YSF (X3) and agricultural experience (X4) gauge community engagement and practical knowledge, influencing technology adoption. Household members (X5) and agricultural labor (X6) provide insights into labor dynamics affecting decision-making processes in farming operations. Financial variables, such as income from agriculture (X7), income outside of agriculture (X8), and loan repayment frequency (X9), reflect economic stability and investment capacity. Land ownership, both owned (X10) and rented (X11), affects the potential for installing solar infrastructure. Attitudinal factors like attitude towards perceived benefits (X12), problems perception (X13), outcome efficacy (X14), perceived risks (X15), and perceived opportunity (X16) shape behavioral intentions towards solar technology adoption. Collectively, these variables provide a holistic understanding of the drivers and barriers affecting solar technology adoption among young smart farmers in the upper northern region of Thailand.

Table 1

Summary of The Independent and Dependent Variables

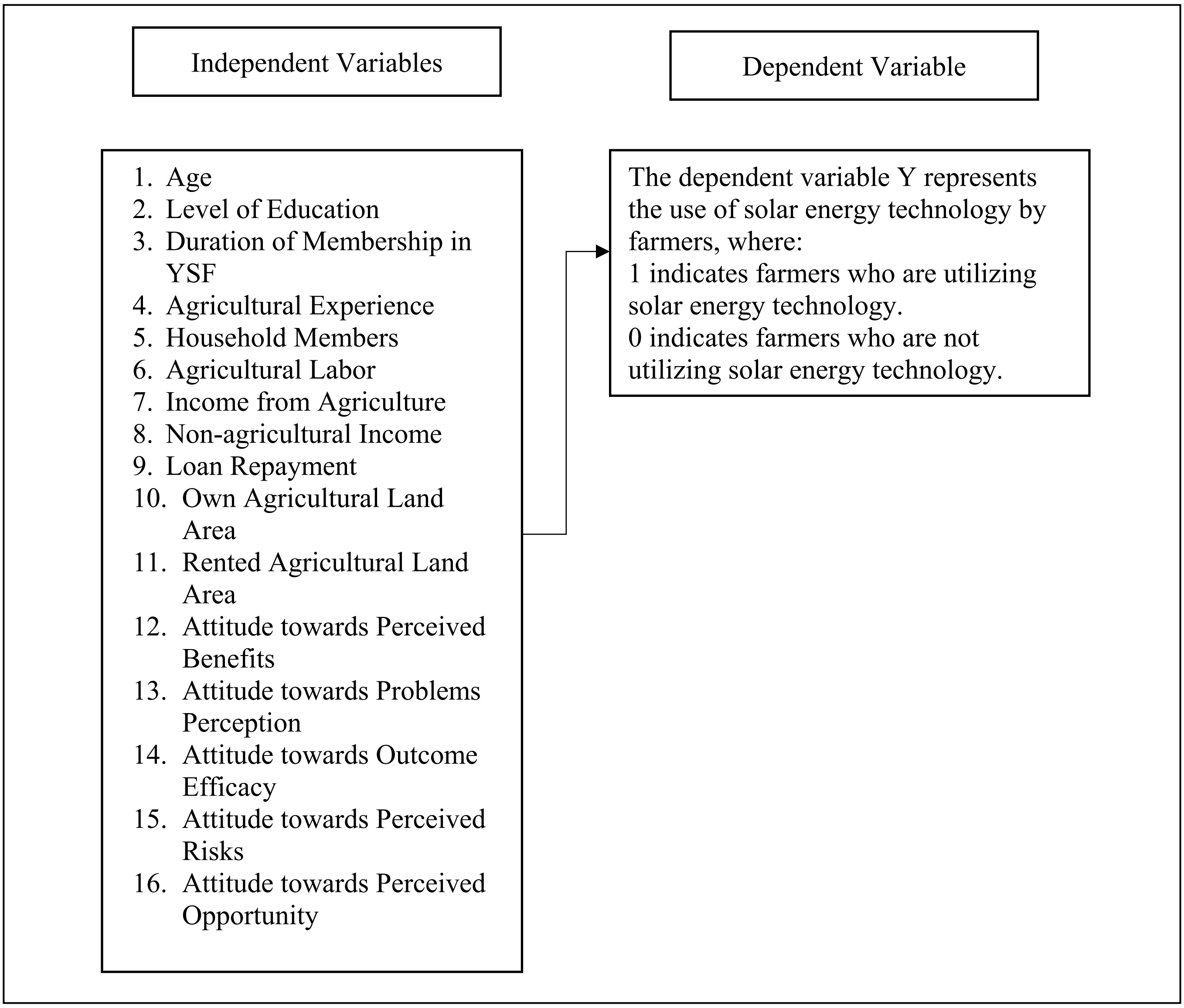
Variable	Description	Unit	Measurement	Source
Y	1 = Farmers using solar energy technology, 0 = Farmers not using solar energy technology	0,1	Dummy	(Rusliyadi et al., 2021)
X_1	Age	Years	Ratio scale	(Pathak et al., 2019)
X_2	Education level	Years	Ratio scale	(Granić, 2022)
X_3	Membership duration in YSF	Years	Ratio scale	(DrishtiIAS, 2022)
X_4	Agricultural experience	Years	Ratio scale	(Abnousi et al., 2020)
X_5	Household members	Number of people	Ratio scale	(Pathak et al., 2019)
X_6	Agricultural labor	Number of people	Ratio scale	
X_7	Income from agriculture	Thai Baht	Ratio scale	(Wu, 2022)
X_8	Income outside of agriculture	Thai Baht	Ratio scale	
X_9	Loan repayment frequency	Times/Year	Ratio scale	(Kiros, 2023)
X_{10}	Own agricultural land area	1,600 Sqm.	Ratio scale	(Pathak et al., 2019)
X_{11}	Rented agricultural land area	1,600 Sqm.	Ratio scale	
X_{12}	Attitude towards Perceived Benefits	Average score	Interval scale	(Huijts et al., 2012)
X_{13}	Attitude towards Problems Perception	Average score	Interval scale	
X_{14}	Attitude towards Outcome Efficacy	Average score	Interval scale	
X_{15}	Attitude towards Perceived Risks	Average score	Interval scale	
X_{16}	Attitude towards Perceived Opportunity	Average score	Interval scale	

Conceptual Framework

The researcher developed a conceptual framework to delineate the scope of this research, as illustrated in Figure 1.

Figure 1

Conceptual Diagram of The Model for Predicting the Factors Influencing the Adoption of Solar Energy.



Note. The left block contains all the independent factors, and the right block contains the dependent factors. In this study, the dependent variable Y indicates farmers' adoption of solar energy technology, where 1 signifies utilization and 0 non-utilization. This binary classification aids in distinguishing adopters from non-adopters, streamlining the analysis of factors influencing solar technology adoption in agriculture.

Method

Sample

Thailand is divided into 77 provinces, each with its own unique demographic and geographic characteristics. This research specifically targeted the upper northern region of Thailand, selecting eight provinces: Chiang Mai, Chiang Rai, Phrae, Nan, Phayao, Mae Hong Son, Lamphun, and Lampang. These provinces were chosen due to their active participation in the YSFs project, a factor that enhances the relevance of studying agricultural innovation adoption among farmers there.

The research focused on farmers who had previously participated in the young smart farmers (YSFs) project in the upper northern region of Thailand, encompassing eight provinces. The total population considered for this study included 1,193 registered individuals actively engaged in the training programs conducted by the department of agricultural promotion and development, Thailand, in 2019 (NDOAE, 2019). The sample comprised young agriculturists from the upper northern region who are involved in the YSF Project, which is supported by the department of agricultural extension under the ministry of agriculture and cooperatives. The ongoing participation of young farmers in annual training sessions illustrates their receptivity to governmental promotional efforts. This sampling framework, therefore, provides a basis for generalizing the findings to the broader demographic of the YSFs in Thailand, offering representative insights into the adoption of agricultural innovations across the nation.

The researcher formulated a sampling frame and determined the sample size using Taro Yamane's method (Yamane, 1973) at a 95% confidence level, with a maximum permissible margin of error set at 5%. Consequently, the sample size of YSFs in the upper northern region comprised 300 subjects. Utilizing a stratified sampling method, the researcher determined the proportion of samples in various provinces as detailed in Table 2. Subsequently, the study employed a simple random sampling technique, employing a lottery draw method without replacement, to achieve the desired number of participants across the provinces in the upper northern region.

Table 2

Number of Young Smart Farmers in the Upper Northern Region by Stratified Sampling.

Provinces	Population (*N*)	Sample (*n*)
Chiang Mai	229	58
Chiang Rai	213	54
Phrae	164	41
Nan	154	39
Phayao	45	11
Mae Hong Son	98	25
Lamphun	169	42
Lampang	121	30
Total	1,193	300

Data Collection

The sample included 300 YSFs participants, proportionally distributed across these provinces based on the total number of registered individuals actively engaged in the project. This selection allows for a focused investigation of agricultural practices within a significant subset of Thailand's agricultural community.

Research Instrument

A quantitative research instrument was designed to systematically collect, analyze, and interpret data to identify patterns and relationships (Creswell, 2012). Developed by the researcher, this structured questionnaire consists of two sections:

1) Basic information and context: This section collects data on the farmers' utilization of solar energy technology in agriculture. It categorizes responses as '1' for use and '0' for non-use, enabling a straightforward analysis of adoption rates.

2) Attitudes towards solar energy: This part assesses farmer attitudes using a 5-point Likert scale. it measures variables including perceived benefits, perception of problems, outcome efficacy, perceived risks, and perceived opportunity, which are crucial in understanding the motivational factors influencing technology adoption (Huijts et al., 2012).

The researcher selected variables from related studies, and the reliability of the questionnaire was assessed following a review by the committee and an advisor. Subsequently, the questionnaire underwent a pilot test with a group of 30 farmers whose characteristics mirrored those of the sample group. This reliability analysis centered on questions that pertained to factors influencing the acceptance of solar energy technology in agriculture by YSFs in the upper northern region of Thailand. The reliability was determined using the Cronbach's alpha coefficient formula, yielding a reliability coefficient of .91.

Data Analysis

In this study, data gathered from questionnaires and interviews are analyzed using the Statistical Package for the Social Sciences (SPSS for Windows). The primary analytical method employed is Binary Logistic Regression Analysis, which is well-suited for examining binary outcomes, such as a farmer's decision to either adopt or reject solar energy technology. This method models binary dependent variables—adoption versus non-adoption—based on multiple independent variables. These variables include attitudes.

Binary logistic regression is utilized to determine the likelihood of the dependent variable, which in this context is the adoption of solar technology by farmers, where '1' indicates adoption and '0' non-adoption. The model assesses the influence of sixteen independent variables pertinent to YSFs on the probability of technology adoption. The regression formula applied is $\text{Log}\left(\frac{p}{1-p}\right) = \beta_0+\beta_1X_1+\beta_2X_2+...+\beta_nX_n$, (Sreejesh et al., 2014). where "Log" represents the natural logarithm, "p" the probability of adopting the technology, "$\left(\frac{p}{1-p}\right)$" the odds ratio, β_0 the model's intercept, and β_1 through β_n the coefficients for variables such as age, level of education, duration of membership in YSF, experience in agriculture, number of household members, agricultural labor force, income from agricultural and non-agricultural sources, area of owned and leased agricultural land, frequency of loan repayments, and attitudes towards perceived benefits, problems, outcome efficacy, risks, and opportunities. Each variable elucidates different aspects that influence the farmers' decisions, thereby creating an exhaustive model of behavioral intention and actual adoption.

Results

General Information of Farmers

As can be seen from Table 3, The analysis of educational qualifications, agricultural education, and loan repayment statuses among 300 farmers reveals significant insights into their utilization of solar energy. Approximately 60.67% of the farmers hold bachelor's degrees, and there is a varied degree of solar energy adoption across different educational levels. Notably, those with agricultural education show a higher inclination towards solar energy adoption, at 84%. Furthermore, a greater percentage of solar energy users are found to have annual loan repayments compared to non-users. This observation suggests a nuanced relationship between financial obligations and the adoption of sustainable technologies. These findings indicate that educational background and financial status are critical factors in the decision-making process for adopting solar energy. This complex interplay warrants further investigation to understand the underlying motivations and barriers within this demographic, highlighting the need for tailored approaches in promoting sustainable technologies.

Table 3
Personal Data of YSF (Interval Scale)

Personal Data	Do not utilize. solar energy (*n* = 169)		Utilize solar energy. (*n* = 131)		Total (*n* = 300)	
	Samples	Percentage	Samples	Percentage	Samples	Percentage
Education						
High school	17	10.05	16	12.21	33	11.00
Diploma	19	11.25	30	22.90	49	16.33
Bachelor's Degree	109	64.50	73	55.73	182	60.67
Postgraduate degree	24	14.20	12	9.16	36	12.00
Educational Qualification						
Graduated in Agriculture	147	86.98	105	80.15	252	84.00
Did not graduate in Agriculture	22	13.02	26	19.85	48	16.00
Loan Repayment Status						
Repayable every year	63	37.27	65	49.61	128	42.66
Repayable some years	53	31.36	30	22.90	83	27.67
Not repayable	8	4.74	10	7.64	18	6.00
Not borrowing	45	26.63	26	19.85	71	23.67

In this study of 300 YSFs, a descriptive analysis reveals that the mean age is 37.77 years, with solar energy users being slightly older on average (38.43 years) compared to non-users (37.25 years). Users of solar energy also tend to have marginally longer tenures in the YSFs program, averaging 2.84 years compared to 2.67 years for non-users, and possess more agricultural experience (8.18 years versus 7.28 years). Economically, solar energy users report lower average incomes from both agricultural operations (4,850 USD) and non-agricultural work (4,674 USD) compared to non-users, who earn 5,489 USD and 4,907 USD, respectively. Additionally, solar energy users typically own more agricultural land, averaging 14.87 Rai, but lease less land (2.38 Rai) compared to non-users, who lease an average of 8.09 Rai. These findings paint a nuanced socioeconomic profile of farmers engaged in solar energy, highlighting key differences in age, experience, economic status, and land tenure between users and non-users of solar technology. Table 4 shows the personal data of YSFs.

Table 4
Personal Data of YSFs (Ratio Scale)

Personal Data	Do not utilize. solar energy (*n*=169)		Utilize solar energy. (*n*=131)		Total (*n*=300)	
	M	*SD*	*M*	*SD*	*M*	*SD*
- Age (years)	37.25	5.52	38.43	6.75	37.77	6.11
- Become a member of YSF (years)	2.67	1.47	2.84	1.67	2.75	1.56
- Agricultural Experience (years)	7.28	4.67	8.18	5.64	7.67	5.13
- Income in the Agricultural Sector (USD per year)	5,489.04	8,182.59	4,850.80	4,907.65	5,209.09	6,942.36
- Income outside the Agricultural Sector (USD per year)	4,907.85	8,546.88	4,674.79	13,563.64	4,805.30	11,003.67
- Own Agricultural Land Area (Rai)	9.15	12.89	14.87	10.87	11.64	12.36
- Leased Agricultural Land Area (Rai)	8.09	27.33	2.38	7.67	5.60	21.29

Note. * 1 Rai = 1,600 Square meters

Attitudes of Young Smart Farmers Towards Solar Energy Technology

The analysis of attitudes among young smart farmers toward solar energy technology reveals distinct differences between users and non-users. Users recognize more benefits of solar energy, expressing stronger agreement (*M* = 4.60, *SD* = .34) compared to non-users (*M* = 4.21, *SD* = .47). Additionally, while users are more aware of the problems associated with solar energy, they remain optimistic (*M* = 4.12, *SD* = .47); in contrast, non-users exhibit lower problem perception (*M* = 3.88, *SD* = .35). Users also show greater belief in their effectiveness in utilizing solar energy (*M* = 4.67, *SD* = .41), versus non-users (*M* = 4.38, *SD* = .61). Interestingly, both groups share the same average score for perceived risks (*M* = 3.51), though with greater variation among users (*SD* = .90) compared to non-users (*SD* = .60). Lastly, users tend to see more opportunities in solar energy (*M* = 4, *SD* = .68) as opposed to non-users (*M* = 3.86, *SD* = .57). These findings illustrate a complex interplay of benefits, risks, and opportunities, highlighting the influence of user experience and optimism on the adoption of solar technology.

The analysis indicates that both groups acknowledge the benefits of solar energy, with users demonstrating a more pronounced consensus on its advantages. This distinction is further evident in users' increased awareness of the problems associated with solar energy; however, they maintain a more optimistic outlook on its efficacy and potential opportunities compared to non-users. Interestingly, the perception of risks associated with solar energy shows no significant differences between the two groups, indicating a shared understanding of potential challenges.

Factors Influencing the Acceptance of Solar Energy Technology

As can be seen from Table 5, Testing independent variables that affect dependent variables. The logistic regression analysis revealed that seven out of sixteen independent variables significantly impact the acceptance of solar energy technology for agricultural use among YSFs at the .05 and .01 significance levels. The significant showed in duration of membership in YSF, experience in agriculture, loan repayment, own agricultural land, attitude towards perceived benefits, attitude towards problems perception and attitude towards perceived risks. The Exp (β) value indicates the change in the odds of the outcome occurring (in this case, the acceptance of solar energy technology) for a one-unit increase in the predictor variable, holding all other variables constant. The details of are discussed as follows.

1) Duration of membership in YSF: The odds of the event or decision being studied increase by 1.81 times with each additional unit of time spent as a member in YSF. This indicates a positive relationship between the length of membership and the likelihood of the outcome.

2) Experience in agriculture: For each unit increase in agricultural experience, the likelihood of the outcome increases by 1.61 times, suggesting that more experience in agriculture encourages the decision or even the model is predicting.

3) Loan repayment: The ability or the commitment to repay a loan more than doubles the likelihood of the outcome, with an odds ratio of 2.03. This shows a strong positive influence of loan repayment on the outcome.

4) Own agricultural land: Having ownership of agricultural land increases the odds of the outcome by 2.82 times, indicating a robust positive association between land ownership and the likelihood of the outcome.

5) Attitude towards perceived benefits: A positive attitude towards perceived benefits dramatically increases the odds of the outcome by 13.14 times, highlighting a very strong influence of this attitude on the decision or event.

6) Attitude towards problems perception: Individuals who have a higher perception of problems are 9.02 times more likely to experience the outcome, showing a significant positive relationship between problem perception and the outcome.

7) Attitude towards perceived risks: A negative attitude towards perceived risks decreases the odds of the outcome by a factor of .44, implying that risk aversion has a discouraging effect on the likelihood of the outcome.

It is important to note that the odds ratios (Exp(β)) are multiplicative factors for the odds of the outcome, not the percentage changes. An odds ratio greater than 1 indicates an increase in the odds of the outcome with each unit increase in the predictor, while an odds ratio less than 1 indicates a decrease. A linear model can be constructed to forecast the probability as follows:

$$Logit(y) = -20.38 + .31(X_1) - .12(X_2) + .59(X_3) + .48(X_4) - .18(X_5) - .64(X_6) + .23(X_7) - .08(X_8) + .71(X_9) + 1.04(X_{10}) + .31(X_{11}) + 2.58(X_{12}) + 2.20(X_{13}) + .21(X_{14}) - .82(X_{15}) - .32(X_{16})$$

Based on the aforementioned model, the likelihood of young smart farmers adopting solar energy technology can be predicted as: P (Accepting Technology) = $\frac{e^x}{1+e^x}$

$$\text{Where } X = -20.38 + .31(X_1) - .12(X_2) + .59(X_3) + .48(X_4) - .18(X_5) - .64(X_6) + .23(X_7) - .08(X_8) + .71(X_9) + 1.04(X_{10}) + .31(X_{11}) + 2.58(X_{12}) + 2.20(X_{13}) + .21(X_{14}) - .82(X_{15}) - .32(X_{16})$$

Should the probability (P) of accepting the technology be less than or equal to .05, it is anticipated that the agricultural solar energy technology will not be embraced.

Conversely, if the probability (P) of accepting the technology is greater than or equal to .05, it is anticipated that the agricultural solar energy technology will be adopted.

Table 5

Testing Independent Variables that Affect Dependent Variables

Independent variables in forecasting.	Logistic regression analysis model.					
	β	*SE*	Wald	*df*	Sig.	Exp (β)
1. Age	.31	.17	3.21	1	.07	1.36
2. Level of Education	-.12	.11	1.18	1	.28	.89
3. Duration of Membership in YSF	.59	.23	6.57	1	.010**	1.81
4. Experience in Agriculture	.48	.23	4.25	1	.039*	1.61
5. Household Members	-.18	.26	.47	1	.49	.84
6. Agricultural Labor	-.64	.33	3.65	1	.06	.53
7. Income from Agriculture	.23	.16	2.15	1	.14	1.26
8. Non-Agricultural Income	-.08	.15	.31	1	.58	.92
9. Loan Repayment	.71	.26	7.62	1	.006**	2.03
10. Own Agricultural Land	1.04	.21	24.38	1	.000***	2.82
11. Leased Agricultural Land	.31	.24	1.72	1	.19	1.36
12. Attitude towards Perceived Benefits	2.58	.60	18.59	1	.000***	13.14
13. Attitude towards Problems Perception	2.20	.68	10.58	1	.001***	9.02
14. Attitude towards Outcome Efficacy	.21	.41	.27	1	.61	1.23
15. Attitude towards Perceived Risks	-.82	.33	5.99	1	.014*	.44
16. Attitude towards Perceived Opportunity	-.32	.29	1.20	1	.27	.73
Constant	-20.38	3.74	29.64	1	.000***	.00

Note. $*p < .05$, $**p < .01$, $***p < .001$. Hosmer and Lemeshow test: Chi-square = 51.72, *df* = 8, Sig. (*P*-value) = .13 (Hosmer & Lemeshow, 2000). Omnibus Tests of Model Coefficients: Chi-square = 117.72, Sig. = .000 (Cohen et al., 2003). Model Summary: -2 Log likelihood = 293.34a, Cox & Snell R Square = .33, Nagelkerke R Square = 0.44 (Nagelkerke, 1991).

Discussion

This research investigated the critical factors influencing the adoption of solar energy among young smart farmers (YSFs) in the upper northern region of Thailand. The study examined the complex interplay between educational backgrounds, financial behaviors, and attitudes towards solar energy, and how these factors collectively influence the decision to adopt solar technologies. Utilizing a survey research methodology with a sample of 300 YSFs, the data was analyzed using statistical tools and binary logistic regression analysis. The results revealed that seven independent variables significantly impact the adoption of solar technology among these farmers.

The duration of membership in YSF program significantly impacts the adoption of solar energy technology, with each additional year of membership increasing the odds of adoption by 1.81 times. This suggests that prolonged engagement in the YSF program fosters a favorable environment for accepting innovative practices, likely due to enhanced communal learning and the development of robust social networks within the agricultural community. This finding corresponds with Chikouche et al. (2018), who highlight the role of communal learning and social networks in the diffusion of innovative technologies and is supported by Cui and Wang (2023), who observed that sustained interaction within farming groups boosts technology adoption rates by facilitating knowledge exchange and reducing uncertainties about new practices. These studies underscore the importance of social dynamics and peer influence in shaping attitudes towards technology adoption among farmers.

Experience in agriculture suggests that each additional unit of agricultural experience increases the likelihood of adopting solar energy technology by a factor of 1.61. This enhancement suggests that more experienced farmers are better able to understand and appreciate the benefits of new technologies, leading to a higher propensity to adopt solar energy. This correlation is supported by the diffusion of innovations theory by Chen and Li (2022), which argues that individuals with more experience are likely to be early adopters because they can effectively evaluate and integrate new technologies. Similarly, Rumjaun and Narod (2020) note that experienced farmers accelerate the adoption process by learning not only from their own experiences but also vicariously through the successes and failures of their peers, highlighting the critical role of experiential knowledge in the diffusion of new technologies within agricultural communities.

The research found that the capacity or commitment to repay loans significantly influences technology adoption, more than doubling the likelihood of accepting solar energy technology, with an odds ratio of 2.03. This substantial impact suggests that loan repayment capability is a strong predictor of technology acceptance, potentially because it reflects a farmer's financial stability and proactive financial management. This correlation may be due to farmers who consistently manage their financial obligations, such as loan repayments, being more likely to invest in and adopt new technologies, which indicates a readiness to embrace changes that may enhance efficiency and profitability. This finding aligns with studies conducted in other contexts, such as a study on loan repayment performance in Ethiopia, which explored various factors affecting the ability of micro and small enterprises to repay loans (Kiros, 2023). Similarly, research by Rasouli et al. (2023) suggests that farmers engaged with solar energy might exhibit a different financial risk profile than typically characterized, indicating a unique intersection between financial management practices and sustainable technology adoption.

Ownership of agricultural land: Possessing agricultural land substantially increases the likelihood of technology adoption, with a multiplier effect of 2.82 on acceptance odds. This suggests that land ownership not only provides the necessary space for installing solar technology but also indicates a level of economic stability and investment capacity essential for embracing capital-intensive innovations (Sukumaran et al., 2022). Similar findings have been observed in other countries; notably, larger farm sizes, which demand more energy, often require significantly more land for wind or solar energy generation—up to 5 to 20 times the initially estimated space, as seen in the United States (Harvard, 2018).

Attitude towards perceived benefits: It was found that a positive attitude towards the perceived benefits of solar technology dramatically increases the likelihood of its adoption, enhancing the odds by 13.14 times. This substantial influence likely stems from the decisive role that favorable perceptions of outcomes play in shaping behavioral intentions, as posited by the theory of planned behavior (Ajzen, 1991). This theory suggests that individuals are more inclined to engage in specific behaviors when they view the outcomes positively. This finding is consistent with similar studies, such as those by Massresha et al. (2021), which confirm that positive attitudes towards the benefits of technology significantly propel farmers to embrace innovations. These studies collectively underscore the critical impact of attitudinal factors on the decision-making process regarding technology adoption in agricultural settings.

Attitude towards problems perception: It was found that individuals who have a heightened perception of problems are 9.02 times more likely to adopt solar technology, indicating a significant positive relationship between problem perception and technology acceptance. This correlation may be because individuals who recognize potential issues are more proactive in seeking and adopting innovative solutions, which is essential in the context of new technology deployment. This finding aligns with Alam et al. (2021), who noted that farmers aware of issues are more likely to pursue novel technologies. Similarly, research by Qazi et al. (2019) indicates that a lack of public awareness serves as a substantial barrier to the acceptance of renewable energy technology, suggesting that a greater awareness of problems can lead to more informed and effective decision-making processes. These studies collectively emphasize the crucial role of problem recognition in driving technology adoption across different contexts.

Lastly, a negative attitude towards perceived risks reduces the likelihood of technology acceptance by a factor of 0.44, indicating that risk aversion significantly impedes the adoption of new technologies. This may be because individuals who perceive higher risks are less likely to engage with new innovations due to concerns over potential negative outcomes. This finding is supported by Habib and Hamadneh (2021), who identify perceived risk as a critical barrier in the adoption process, noting that it is a major factor in the rejection of innovations. Similarly, Spiegel et al. (2021) observed that increased perceived risks can delay decision-making and decrease the likelihood of adopting agricultural technology. These studies highlight the consistent role of risk perception in influencing technology acceptance across various contexts and geographical locations.

Limitations

This study is constrained to an analysis of young smart farmers who have participated in a government-sponsored training program. While the findings are generalizable to YSFs across Thailand, given that the project encompasses participants nationwide, they may not extend to the broader population of farmers who have not engaged in this specific government training. Therefore, the results should be interpreted with caution when considering their applicability to the general farming population, which may not share the same exposure to or benefits from such structured programs.

Implications for Behavioral Science

This research delves into the behavioral factors influencing young smart farmers' acceptance of solar energy technology in Thailand’s upper northern region, integrating the theory of planned behavior and Huijts et al.'s (2012) model to analyze intrinsic motivations and external influences on sustainable technology adoption. It identifies key factors such as membership duration in the YSF program, agricultural experience, loan repayment frequency, land ownership, perceived benefits, awareness of limitations, and perceived risks as significant determinants of technology acceptance. These findings illuminate the psychological, economic, and environmental aspects critical to decision-making processes and offer behavioral scientists’ insights into fostering technology adoption. The study employs binary logistic regression, showcasing a methodological approach for predicting technology acceptance behaviors and providing a framework for future research across various domains. Practical guidelines proposed include enhancing technology exposure, leveraging experience, facilitating financial access, promoting land utilization, communicating benefits, addressing risks, and utilizing social media for knowledge dissemination. The new contribution of this study lies in its comprehensive analysis of how attitudes, experiences, and external factors interrelate to influence the acceptance of innovative technologies among YSFs. It uniquely combines empirical insights with the application of the theory of planned behavior to predict technology adoption behaviors. Furthermore, the study extends behavioral science by providing targeted strategies that enhance the adoption of sustainable agricultural practices, thereby supporting both environmental sustainability and technological advancement in the farming sector. This integrative approach not only elucidates the multifaceted determinants of technology adoption but also offers practical guidelines for promoting sustainable development within agricultural communities.

Conclusion

This research investigates the adoption of solar technology among young smart farmers in Thailand's upper northern region, revealing that prolonged membership in the YSFs program, agricultural experience, financial stability, and positive attitudes towards solar technology significantly influence early adoption. Key factors such as loan repayment capability and land ownership are vital, providing the necessary means and space for investment in solar technology. Additionally, the study highlights the crucial role of social engagement, experiential knowledge, and positive perceptions of solar technology's benefits in promoting early adoption, while noting that risk aversion can impede it. Based on these findings, the research proposes a comprehensive strategy to foster solar technology adoption, which includes educational programs to highlight the benefits and practical use of solar energy, financial incentives such as tailored financial products, subsidies, and grants to alleviate initial costs, and community engagement through peer learning networks and mentorship programs. This strategy also emphasizes strategic communication to counter misconceptions and showcase the economic, environmental, and social benefits of solar technology, utilizing technology and social media to engage and inform the tech-savvy generation of farmers. By addressing these educational, financial, communal, and perceptual aspects, the strategy aims to create a conducive environment for solar technology adoption among YSFs, thereby supporting sustainable agricultural practices and contributing to environmental sustainability and technological progress in farming. These insights provide valuable guidance for policymakers, agricultural services, and stakeholders in developing targeted support and intervention strategies to enhance agricultural sustainability and efficiency in Thailand and potentially beyond.

Acknowledgements: The authors express their sincere appreciation to the Provincial Agriculture Office in Thailand's upper northern region for their indispensable assistance and to the young smart farmers (YSFs) for their vital contributions and insights that greatly enriched this study on solar energy technology adoption in agriculture.

Declarations

Conflicts of Interest: The authors declare no conflicts of interest.

Ethical Approval Statement*:* This study has been certified for ethical consideration in research according to the ethical guidelines for human research standards. The certification was granted by the Research Ethics Committee for Human Research, Chiang Mai University, Thailand. Project ID: CMUREC No. 65/115, Dated: 22 August 2022.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Alam, S. S., Ahmad, M., Othman, A. S., Shaari, Z. B., & Masukujjaman, M. (2021). Factors affecting photovoltaic solar technology usage intention among households in Malaysia: Model Integration and Empirical Validation. *Sustainability*, *13*(4), 1773. https://doi.org/10.3390/su13041773

Aroonsrimorakot, S., Laiphrakpam, M., & Paisantanakij, W. (2020). Solar panel energy technology for sustainable agriculture farming- A review. *International Journal of Agricultural Technology*, *16*(3), 553–562. https://www.thaiscience.info/Journals/Article/IJAT/10992842.pdf

Ayana, O. U., & Degaga, J. (2022). Effects of rural electrification on household welfare: A meta-regression analysis. *International Review of Economics*, *69*(2), 209–261. https://doi.org/10.1007/s12232-022-00391-7

Bathaei, A., & Štreimikienė, D. (2023). Renewable energy and sustainable agriculture: Review of indicators. *Sustainability*, *15*(19), 14307. https://doi.org/10.3390/su151914307

Chen, X., & Li, T. (2022). Diffusion of agricultural technology innovation: Research progress of innovation diffusion in Chinese agricultural science and technology parks. *Sustainability*, *14*(22), 15008. https://doi.org/10.3390/su142215008

Chikouche, S., Bouziane, A., Bouhouita-Guermech, S. E., Mostefai, M., & Gouffi, M. (2018). Innovation diffusion in social networks: A survey. In A. Amine, M. Mouhoub, O. Ait Mohamed, & B. Djebbar (Eds.), *Computational intelligence and its applications: Advances in Information and Communication Technology*. Springer. https://doi.org/10.1007/978-3-319-89743-1_16

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203774441

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson Education. http://repository.unmas.ac.id/medias/journal/EBK-00121.pdf

Cui, L., & Wang, W. (2023). Factors affecting the adoption of digital technology by farmers in China: A systematic literature review. *Sustainability*, *15*(20), 14824. https://doi.org/10.3390/su152014824

DEDE. (2020). *Thailand's energy situation*. Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy. https://webkc.dede.go.th/testmax/sites/default/files/Thailand%20Alternative%20Energy%20Situation%202020.pdf

Dhonde, M., Sahu, K., & Murty, V. V. S. (2022). The application of solar-driven technologies for the sustainable development of agriculture farming: A comprehensive review. *Reviews In Environmental Science And Bio/technology*, *21*(1), 139–167. https://doi.org/10.1007/s11157-022-09611-6

DrishtiIAS. (2022). Attitude: Content, structure and function. *Drishti IAS*. https://www.drishtiias.com/to-the-points/paper4/attitude-content-structure-and-function

Gorton, M., Douarin, E., Davidova, S., & Latruffe, L. (2008). Attitudes to agricultural policy and farming futures in the context of the 2003 CAP reform: A comparison of farmers in selected established and new Member States. *Journal of Rural Studies*, *24*(3), 322–336. https://doi.org/10.1016/j.jrurstud.2007.10.001

Gorjian, S., Ebadi, H., Jathar, L. D., & Savoldi, L. (2022). Chapter 1 - Solar energy for sustainable food and agriculture: Developments, barriers, and policies. In S. Gorjian & P. E. Campana (Eds.), *Solar energy advancements in agriculture and food production systems* (pp. 1–28). Academic Press. https://doi.org/10.1016/B978-0-323-89866-9.00004-3

Granić, A. (2022). Educational technology adoption: A systematic review. *Education and Information Technologies*, *27*(7), 9725–9744. https://doi.org/10.1007/s10639-022-10951-7

Habib, S., & Hamadneh, N. N. (2021). Impact of perceived risk on consumers technology acceptance in online grocery adoption amid COVID-19 pandemic. *Sustainability*, *13*(18), 10221. https://doi.org/10.3390/su131810221

Harvard, G. (2018). *Large-scale wind power has its down side*. Harvard Gazette. https://news.harvard.edu/gazette/story/2018/10/large-scale-wind-power-has-its-down-side/

Hosmer, D. W., & Lemeshow, S. (2000). *Applied logistic regression* (2nd ed.). Wiley. https://doi.org/10.1002/0471722146

Huijts, N. M. A., Molin, E. J. E., & Steg, L. (2012). Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renewable and Sustainable Energy Reviews*, *16*(1), 525–531. https://doi.org/10.1016/j.rser.2011.08.018

Jansuwan, P., & Zander, K. K. (2021). Getting young people to farm: How effective is Thailand's young smart farmer programme? *Sustainability*, *13*(21), 11611. https://doi.org/10.3390/su132111611

Abnousi, V. K., Karantemiris, K., & Doulis, A. G. (2020). Agricultural cooperatives and acceptance of technological innovation. In E. Krassadaki, G. Baourakis, C. Zopounidis, & N. Matsatsinis (Eds.), *Operational Research in Agriculture and Tourism.* Cooperative Management, Springer. https://doi.org/10.1007/978-3-030-38766-2_1

Kiros, Y. (2023). Loan repayment performance and its determinants: Evidence from micro and small enterprises operating in Dire-Dawa, Ethiopia. *Journal of Innovation and Entrepreneurship*, *12*(1), 5. https://doi.org/10.1186/s13731-023-00271-6

Lyster, R. (2014). Renewable energy in the context of climate change and global energy resources. In P. Babie & P. Leadbeter (Eds.), *Law as change: Engaging with the life and scholarship of adrian bradbrook* (pp. 83–110). University of Adelaide Press. http://www.jstor.org/stable/10.20851/j.ctt1sq5xcn.9

Maqbool, R., Deng, X., & Rashid, Y. (2020). Stakeholders' satisfaction as a key determinant of critical success factors in renewable energy projects. *Energy, Sustainability and Society*, *10*(1), 28. https://doi.org/10.1186/s13705-020-00259-0

Massresha, S. E., Lema, T. Z., Neway, M. M., & Degu, W. A. (2021). Perception and determinants of agricultural technology adoption in North Shoa Zone, Amhara Regional State, Ethiopia. *Cogent Economics & Finance*, *9*(1), 1956774. https://doi.org/10.1080/23322039.2021.1956774

Moerkerken, A., Duijndam, S., Blasch, J., van Beukering, P., & van Well, E. (2023). Which farmers adopt solar energy? A regression analysis to explain adoption decisions over time. *Renewable Energy Focus*, *45*, 169–178. https://doi.org/10.1016/j.ref.2023.04.001

Mohr, S., & Kühl, R. (2021). Acceptance of artificial intelligence in German agriculture: An application of the technology acceptance model and the theory of planned behavior. *Precision Agriculture*, *22*(6), 1816–1844. https://doi.org/10.1007/s11119-021-09814-x

Nagelkerke, N. J. D. (1991). A note on a general definition of the coefficient of determination. *Biometrika*, *78*(3), 691–692. https://doi.org/10.1093/biomet/78.3.691

NDOAE. (2019). *Minutes of meetings seminars*. Office of Agricultural Promotion and Development, Region 6, Chiang Mai. http://ndoae.doae.go.th/documents.php

Pathak, H. S., Brown, P., & Best, T. (2019). A systematic literature review of the factors affecting the precision agriculture adoption process. *Precision Agriculture*, *20*(6), 1292–1316. https://doi.org/10.1007/s11119-019-09653-x

Qazi, A., Hussain, F., Rahim, N. A., Hardaker, G., Alghazzawi, D., Shaban, K., & Haruna, K. (2019). Towards sustainable energy: A systematic review of renewable energy sources, technologies, and public opinions. *IEEE Access*, *7*, 63837–63851. https://doi.org/10.1109/ACCESS.2019.2906402

Rasouli, M., Ayough, A., Khorshidvand, B., & Alemtabriz, A. (2023). Evaluating risk factors in solar energy investments: A strategic approach for Iran's market. *Solar Energy*, *262*, 111884. https://doi.org/10.1016/j.solener.2023.111884

Rumjaun, A., & Narod, F. (2020). Social learning theory-Albert Bandura. In B. Akpan, & T. J. Kennedy (Eds.), *Science education in theory and practice*. Springer. https://doi.org/10.1007/978-3-030-43620-9_7

Rusliyadi, M., Ardi, Y., & Winarno, K. (2021, November 18-20). Binary logistics regression model to analyze factors influencing technology adoption process vegetable farmers case in Central Java Indonesia. *Proceedings of the international symposium Southeast Asia vegetable* (pp. 460–470). Yogyakarta, Indonesia. https://doi.org/10.2991/978-94-6463-028-2_48

Spiegel, A., Britz, W., & Finger, R. (2021). Risk, risk aversion, and agricultural technology adoption-a novel valuation method based on real options and inverse stochastic dominance. *Q Open*, *1*(2), 1–26. https://doi.org/10.1093/qopen/qoab016

Sreejesh, S., Mohapatra, S., & Anusree, M. R. (2014). Binary logistic regression. In *Business research methods* (pp. 189-204). Springer. https://doi.org/10.1007/978-3-319-00539-3_11

Sukumaran, S., Sudhakar, K., Yusop, A. F., Kirpichnikova, I., & Cuce, E. (2022). Solar farm: Siting, design and land footprint analysis. *International Journal of Low-Carbon Technologies*, *17*, 1478–1491. https://doi.org/10.1093/ijlct/ctac107

Tariq, G. H., Ashraf, M., & Hasnain, U. S. (2021). Solar technology in agriculture. In A. Fiaz & S. Muhammad (Eds.), *Technology in agriculture* (p. 20). IntechOpen. https://doi.org/10.5772/intechopen.98266

United Nations. (2022). *The sustainable development goals report*. United Nations. https://unstats.un.org/sdgs/report/2022/

Walesiak, M., & Dehnel, G. (2024). Progress on SDG 7 achieved by EU countries in relation to the target year 2030: A multidimensional indicator analysis using dynamic relative taxonomy. *PLoS One*, *19*(2), e0297856. https://doi.org/10.1371/journal.pone.0297856

Wang, J., Li, W., Haq, S. U., & Shahbaz, P. (2023). Adoption of renewable energy technology on farms for sustainable and efficient production: Exploring the role of entrepreneurial orientation, farmer perception and government policies. *Sustainability*, *15*(7), 5611. https://doi.org/10.3390/su15075611

Wu, F. (2022). Adoption and income effects of new agricultural technology on family farms in China. *PLoS One*, *17*(4), e0267101. https://doi.org/10.1371/journal.pone.0267101

Yamane, T. (1973). *Statistics, an introductory analysis* (2nd ed.). Harper & Row. https://www.sciepub.com/reference/180098