The Development of a Model for Farmers' Intention to Use Low-Carbon Agricultural Technology in Mianyang City, Sichuan Province, People's Republic of China*

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Abstract

This study employed a mixed-methods research design with the following objectives: (1) To study the level of importance of subjective norms, information and access to information, perceived ease of use, perceived benefits of using technology, and the intention to adopt environmentally friendly technology. (2) To examine the relationships between subjective norms, information and access to information, perceived ease of use, perceived benefits of using technology, and their impact on the intention to adopt environmentally friendly technology. And (3) To explore the model of intention to use environmentally friendly technology. For the quantitative phase, the sample consisted of 500 farmers selected through accidental sampling from five districts of Mianyang: (1) Peicheng District, (2) Anzhou District, (3) Santai County, (4) Yanting County, and (5) Pingwu County. Data were collected using questionnaires and analyzed through descriptive statistics, inferential statistics, and structural equation modeling. For the qualitative phase, the participants included 25 farmers drawn from the same five districts, selected through snowball sampling. Data were collected using semi-structured interviews and analyzed through content analysis.

The findings revealed that: (1) the latent variable with the highest level of importance was the intention to adopt low-carbon technologies, followed by perceived usefulness, perceived ease of use, information and access to information, and subjective norms; (2) the factor most strongly associated with the model of farmers' intention to adopt low-carbon technologies in Mianyang was subjective norms, followed by information and access to information, perceived ease of use, and perceived usefulness; and (3) the newly developed causal structural model influencing farmers' intention to adopt low-carbon technologies in Mianyang comprised five components, with the number of observed variables increased from 12 to 15 by adding items consistent with theoretical criteria. Organize activities to enhance

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knowledge and support from community leaders. The government should create learning centers and a digital platform with incentives.

Keywords: Intention to Use Low-Carbon Technology; Perceived Benefits of Using Technology; Perceived Ease of Use of Technology; Subjective Norms

Introduction

The development of industries, science, and technology over the past four decades, while bringing about significant progress and changes in various dimensions, has also had a widespread impact on the world's natural resources and the environment. The United Nations recognized these challenges and established the Millennium Development Goals (MDGs) in 2000 as a framework to address issues such as poverty, hunger, disease, illiteracy, gender inequality, and environmental degradation. Although many of these goals were not achieved by 2015, they served as a foundation for the establishment of the Sustainable Development Goals (SDGs), which were adopted in 2015, encompassing 17 goals, 169 targets, and 232 indicators (Purvis et al., 2019).

In the environmental dimension, SDGs emphasize the sustainable management of natural resources, particularly forest resources, agricultural systems, and food security. Reports from the Food and Agriculture Organization (FAO) and the World Meteorological Organization (WMO) indicate that agriculture and livestock farming are significant sources of greenhouse gas emissions, accounting for more than 30% of global emissions. This includes processes such as production, the use of chemical fertilizers, land-use changes, and livestock activities with cattle, especially beef and dairy cattle, contributing substantial methane emissions. At the same time, the growing demand for food is expected to increase greenhouse gas emissions unless there is a shift towards more sustainable production methods.

In response to the challenges of climate change, the United Nations initiated the United Nations Framework Convention on Climate Change (UNFCCC) and later developed the Kyoto Protocol, a legally binding international agreement to reduce greenhouse gas emissions and promote economic and social adaptation. Concurrently, the concepts of the green economy and low-carbon development have been promoted as essential approaches, focusing on reducing dependence on fossil fuels, managing resources efficiently, and developing and promoting environmentally friendly agricultural technologies.

A case study from the People's Republic of China is particularly noteworthy. The country has a large agricultural sector and plays a crucial role in global food security. The Chinese government has implemented various policies and projects to promote green and low-carbon agriculture, such as using technologies to reduce emissions in rice fields and agricultural areas, developing smart agriculture, and collaborating with the private sector and international organizations to upgrade production systems. Low-carbon agriculture not only

helps mitigate pollution and reduce greenhouse gas emissions but also directly relates to food security, sustainable rural development, and long-term poverty alleviation.

However, challenges remain in several areas, particularly regarding the adoption and application of low-carbon agricultural technologies by farmers. Barriers such as limited access to information, knowledge, and infrastructure in rural areas continue to pose significant obstacles. Attitudinal factors, social norms, perceptions of ease of use, and the recognition of the benefits of the technology all play a crucial role in the intention to adopt low-carbon technologies (Ajzen and Fishbein, 1980; Schwartz, 1973; Venkatesh, 2000; Agarwal and Prasad, 1999). While numerous studies have examined the environmental impacts and strategies for reducing greenhouse gas emissions in agriculture, there remains a gap in understanding the behavioral and social aspects of farmers, particularly in the specific context of Mianyang city, Sichuan Province, a significant agricultural region in China. Therefore, this research is essential for developing a model of farmers' intention to use low-carbon technologies, reflecting behavioral and social factors at a localized level. This will contribute to the development of evidence-based knowledge, leading to effective policies, measures, and strategies for promotion at the local, national, and global levels, ultimately contributing to the achievement of sustainable development goals.

Objectives of the Research

1. To study the level of importance of subjective norms, information and access to information, perceived ease of use, perceived benefits of using technology, and the intention to adopt environmentally friendly technology.

2. To examine the relationships between subjective norms, information and access to information, perceived ease of use, perceived benefits of using technology, and their impact on the intention to adopt environmentally friendly technology.

3. To explore the model of intention to use environmentally friendly technology.

Research Methodology

Step 1: Study of Theoretical Concepts and Literature Review

The researcher reviewed relevant theories, concepts, and previous studies related to technology acceptance behavior, adoption of low-carbon technology, and behavioral models of farmers in the Chinese context.

Step 2: Field Study

The field study was conducted in Mianyang City, Sichuan Province, People's Republic of China, covering five districts: Peicheng, Anzhou, Santai, Yanting, and Pingwu. Data were collected using both quantitative and qualitative methods.

Step 3: Key Informants

Quantitative: The sample consisted of 500 farmers from the five districts. The sample size was determined based on the 10:1 rule proposed by Tabachnick and Fidell (2007).

Qualitative: The key informants were 25 farmers from the same five districts, selected through snowball sampling following the guidelines of Morse and Field (1996) and Creswell (2013), with data collection continuing until saturation.

Step 4: Research Instruments and Methods

Interviews: Semi-structured interviews were conducted, divided into six parts: general information, opinions on subjective norms, access to information, perceived ease of use of technology, perceived benefits of technology, and intention to adopt low-carbon technology.

Focus Group Discussions: Focus group discussions were held with farmers in each district to exchange views on the factors influencing the adoption of low-carbon technology and to validate the findings from individual interviews.

Observation and Follow-up of Implementation/Training: The researcher followed up with farmers who had begun using low-carbon technologies to observe their actual practices, assess behavioral continuity, and identify factors facilitating long-term adoption.

Step 5: Data Collection

Quantitative: Data were collected through an online questionnaire consisting of eight sections: screening questions, opinions on subjective norms, access to information, perceived ease of use, perceived benefits of technology, intention to use technology, intention measurement scale, and open-ended questions. The researcher distributed the questionnaire link to the target farmers and allowed two weeks for responses. Afterward, the data were checked for accuracy and prepared for statistical analysis.

Qualitative: Data were obtained through in-depth interviews, both face-to-face and online, using open-ended questions to allow participants to express their experiences, attitudes, and perspectives freely. The qualitative findings were used to complement and enrich the quantitative results.

Step 6: Data Analysis

Quantitative: Data were analyzed using descriptive statistics such as mean, frequency, range, and standard deviation, followed by inferential statistics, including Pearson’s correlation coefficient at a significance level of 0.05, confirmatory factor analysis (CFA), and structural equation modeling (SEM) to test the model's fit and research hypotheses.

Qualitative: Data were analyzed through content classification and inductive grouping to identify emerging themes and relationships. The results were presented descriptively, supplemented with tables and direct quotations from informants to support the interpretations.

Step 7: Summary and Presentation of Research Findings

The findings from both quantitative and qualitative data were integrated to explain the relationships between subjective norms, perceived usefulness, perceived ease of use, and intention to adopt low-carbon technology among farmers. The results were presented in a comprehensive research report.

Research Results

The research results for Objective 1: To study the level of importance of subjective norms, information and information access, perceived ease of use of technology, perceived benefits of using technology, and the intention to use low-carbon technology among farmers in Mianyang City, Sichuan Province, People's Republic of China.

Table 1 : The Importance Level of Variables Affecting the Intention to Use Low-Carbon Technology

Variable	Mean (M)	Standard Deviation (S.D.)	Level of Importance
Subjective Norms (SN)	4.16	0.656	High
Attitude (Att)	4.16	0.850	High
Reference Group Compliance (Ref)	4.15	0.588	High
Information and Information Access (DDA)	4.22	0.435	Highest
Data and Information Access (DA)	4.23	0.360	Highest
Information Credibility (Cre)	4.20	0.509	Highest
Perceived Ease of Use (PEU)	4.24	0.257	Highest
Internal Factors (PEUI)	4.02	0.454	High
External Factors (PEUE)	4.24	0.795	Highest
Technology Acceptance (PEUac)	4.45	0.352	Highest
Perceived Usefulness (PU)	4.39	0.457	Highest
Valuable Alternatives (PUC)	4.46	0.299	Highest
External Motivation (PUex)	4.33	0.329	Highest
Intention to Use Low-Carbon Technology (ITU)	4.54	0.298	Highest
Expected Efficiency (ITUeff)	4.59	0.397	Highest
Expected Use (ITUU)	4.58	0.409	Highest

Variable	Mean (M)	Standard Deviation (S.D.)	Level of Importance
Social Influence (ITUS)	4.46	0.328	Highest

According to Table 1, the analysis results show that the latent variables with the highest importance on the intention to use low-carbon technology among farmers in Mianyang City are the intention to use low-carbon technology (ITU), followed by perceived usefulness (PU), perceived ease of use (PEU), data and information access (DDA), and subjective norms (SN), in that order. The most significant observed variables are expected efficiency (ITUeff), expected use (ITUU), social influence (ITUS), valuable alternatives (PUC), and technology acceptance (PEUac). The variable with the least importance is internal factors (PEUI).

For Objective 2, which aims to study the relationships between subjective norms, information and information access, perceived ease of use of technology, perceived benefits of using technology, and the intention to use low-carbon technology among farmers in Mianyang City, Sichuan Province, People's Republic of China, the results show that the direct and indirect effects, including direct effect coefficients (DE), indirect effect coefficients (IE), and total effect coefficients (TE), indicate that the most influential variable is subjective norms (TE 6.560), followed by data and information access (TE 2.890), perceived ease of use of technology (TE 0.792), and perceived benefits of use (TE 0.760), respectively. The hypothesis test results show that the components of the factors are significantly aligned with empirical data at a statistical significance level of 0.05.

For Objective 3, which aims to study the model of intention to use low-carbon technology among farmers in Mianyang City, Sichuan Province, People's Republic of China, the results show that the model fits well with the empirical data. This is evident from the goodness-of-fit index (GFI) and the comparative fit index (CFI). Specifically, the overall statistical analysis of the chi-square to degree of freedom ratio ($\chi 2/df$) was 3.253, with a p-value of 0.147. The goodness-of-fit index (GFI) was 0.982, the comparative fit index (CFI) was 0.973, and the root mean square error of approximation (RMSEA) was 0.042, indicating a good fit between the model and the empirical data.

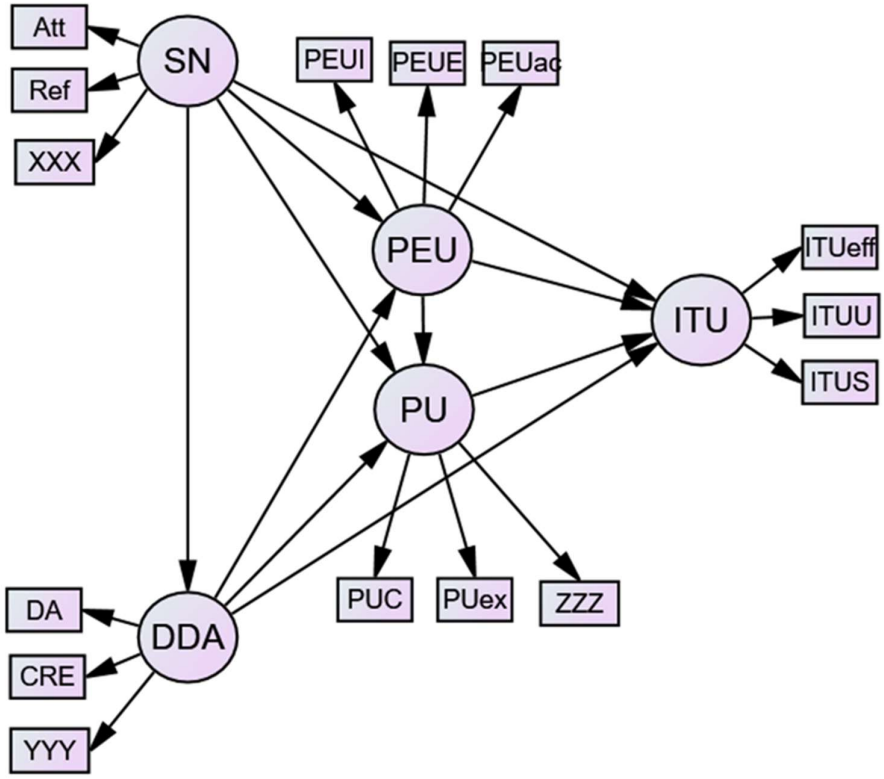


Figure 1: The Model of Intention to Use Low-Carbon Technology Among Farmers in Mianyang City, Sichuan Province, People's Republic of China

The New Body of Knowledge

The research results show that subjective norms, particularly attitudes and pressures from reference groups, have both direct and indirect influences on the intention to use low-carbon technologies. These norms are also linked to information access, perceived ease of use, and perceived benefits. It was found that the quality and credibility of information are more important than mere access to it. Furthermore, perceived ease of use enhances the perception of benefits if farmers find technology convenient, they are more likely to recognize its value. At the same time, external motivation and expectations of efficiency have a prominent effect, particularly for farmers focused on economic returns. The developed structural model aligns with empirical data and can serve as a conceptual framework for formulating effective policies to promote sustainable agriculture.

Discussion of Research Results

The research on “The Development of a Model for Farmers’ Intention to Use Low-Carbon Agricultural Technology in Mianyang City, Sichuan Province, People’s Republic of China” can be discussed as follows:

From the research result of the 1st objective, it was found that the latent variable with the highest importance is the intention to use low-carbon technology, followed by perceived usefulness (PU), perceived ease of use (PEU), data and information access (DDA), and subjective norms (SN). This is because factors such as attitude, reference group compliance, access to information, internal and external factors, as well as perceived benefits and motivation, all play crucial roles in determining the intention to use the technology. Specifically, the positive attitude that farmers have towards new technology reflects their readiness to adopt innovation. At the same time, external support from society, such as government policies or economic environments, continues to be a significant driving force in farmers' decision-making. While access to information remains inconsistent and the credibility of sources is a challenge, the overall model developed appropriately reflects the relationships among variables and is consistent with the concept, theory, and research work of Bhosale and Kadam (2022), which confirmed that farmers' attitudes are related to the ease of access to information. This aligns with Haseeb et al. (2023), who highlighted the role of social networks in reducing perceived risks for farmers, and Kumar et al. (2023), which emphasized the role of ICT tools in increasing awareness and technology adoption.

From the research result of the 2nd objective, it was found that the most influential factor on the model of intention to use low-carbon technology among farmers in Mianyang City is subjective norms, followed by data and information access, perceived ease of use of technology, and perceived benefits of use. This is because subjective norms, data access, and perceived ease of use are key drivers in farmers' decision-making. These findings are consistent with the concept, theory, and research work of Savari et al. (2023), which confirmed that subjective norms are a significant predictor of behavior that supports environmental sustainability, which highlighted the role of internet access and training in increasing the adoption rate of green technology, and Xueying et al. (2024), who emphasized the importance of perceived ease and usefulness of technology in determining intention to use. Additionally, the studies by Nyagango et al. (2023) and Kumar et al. (2023) have shown the importance of ICT tools, particularly mobile phones, in facilitating data access and decision-making in agriculture.

From the research result of the 3rd objective, it was found that the newly developed structural model for the intention to use low-carbon technology among farmers in Mianyang includes 5 components and increased the number of observed variables from 12 to 15 by adding questions based on theoretical guidelines. This is because the model reflects the role of social pressure and the influence of reference groups on the adoption of new technologies, particularly with the credibility of information being an important factor in supporting farmers' decision-making. This is consistent with the concept, theory, and research work of Byrne (2010), Limayem et al. (2004), and Zimbardo and Ebbesen (1970), which emphasized the role of social pressure and reference groups in technology adoption. Data and information access (DDA),

particularly the credibility of information (CRE), remains an important factor in supporting farmers' decision-making. Additionally, the perceived ease of use (PEU) and perceived usefulness (PU) have a direct effect on intention, with PU having the greatest influence, which aligns with the Technology Acceptance Model (TAM) (Davis, 1989). Meanwhile, the variable regarding expected efficiency (ITUeff) shows that farmers are likely to decide to use the technology when they believe it will increase their productivity or income. This is also consistent with the findings of Thanaphon (2024).

Conclusion

The study on the development of a model for farmers' intention to use low-carbon agricultural technology in Mianyang City, Sichuan Province, People's Republic of China, revealed that the integration of technological, informational, and social factors plays a crucial role in shaping farmers' behavioral intentions toward adopting sustainable agricultural innovations. The results demonstrated that among all latent variables examined, the intention to use low-carbon technology ranked as the most significant factor, followed by perceived usefulness, perceived ease of use, access to data and information, and subjective norms. This indicates that farmers' willingness to adopt low-carbon technologies depends not only on their perceptions of the benefits and usability of such technologies but also on their social environment and access to reliable information. The findings further revealed that subjective norms exert both direct and indirect effects on the intention to use low-carbon technologies. Social influence, including community expectations and reference group pressure, plays a significant role in shaping farmers' decisions. Access to credible information and technological literacy were also found to strengthen farmers' confidence in adopting low-carbon practices, as the quality of information and the perceived trustworthiness of sources are more influential than the amount of information available. In addition, perceived ease of use was found to enhance perceived usefulness when farmers find the technology simple and convenient, they are more likely to recognize its value and long-term benefits. The path analysis confirmed that the structural model of farmers' intention to adopt low-carbon technology fits well with the empirical data, indicating consistency between theoretical expectations and actual behaviors. The model highlighted that social norms remain a strong determinant of farmers' behavioral intention, supported by access to information, perceived ease of use, and perceived usefulness of the technology. Furthermore, farmers' expectations regarding productivity and economic return emerged as an important motivational factor, showing that practical benefits continue to drive technology adoption in rural agricultural contexts.

Suggestions

1. The suggestions from the research

1.1 Findings from Objective 1: The study revealed that farmers in Mianyang City, Sichuan Province, possess a moderate level of knowledge, understanding, and awareness regarding low-carbon technologies. Most farmers lack accurate information and accessible learning resources, resulting in limited adoption and use of such technologies.

Therefore, relevant agencies should take the following actions: Government agencies, particularly the Ministry of Agriculture and local authorities, should organize activities and programs to enhance farmers' knowledge, understanding, and awareness of low-carbon technologies. These could include workshops, green agriculture exhibitions, and online information dissemination. Such initiatives would help farmers recognize the benefits and importance of adopting low-carbon technologies in a continuous and sustainable manner.

1.2 Findings from Objective 2: The study found that social factors and subjective norms significantly influence farmers' intentions to adopt low-carbon technology. Farmers who receive recommendations or support from community leaders and model farmers are more likely to adopt such technologies.

Therefore, relevant agencies should take the following actions: Government organizations and agricultural development institutions should promote the role of community leaders, model farmers, and agricultural cooperatives as "knowledge brokers" who share experiences and best practices. These actors can foster positive attitudes, encourage behavioral change, and expand the acceptance of low-carbon technologies at the community level.

1.3 Findings from Objective 3: The study indicated that access to information, government support systems, and policy incentives such as revolving funds, training programs, and carbon footprint certification have a significant impact on farmers' decisions to use low-carbon technologies.

Therefore, relevant agencies should take the following actions: The government should establish community learning centers and a centralized digital platform to disseminate information, provide training, and facilitate access to low-carbon technologies. Additionally, incentive measures should be implemented such as low-interest credit programs, hands-on workshops, and continuous monitoring and evaluation to enhance farmers' readiness and confidence in adopting these technologies in practice.

2. The suggestions for future research

2.1 Conduct comparative studies on low-carbon technology adoption models among farmers in other regions of China or in developing countries to explore social, economic, and cultural factors influencing technology adoption.

2.2 Investigate mechanisms and barriers to promoting low-carbon technology adoption, focusing on policy, financial, and infrastructural factors that affect long-term behavioral change among farmers.

2.3 Undertake longitudinal studies to examine behavioral changes in farmers' adoption of low-carbon technologies and assess environmental, economic, and social impacts, thereby developing a more comprehensive and sustainable adoption model.

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