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The impact of benefit cognition on residents' willingness to participate in low-carbon community construction: an empirical study based on cognitive behavioral theory

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Residents are the core driving force in community construction, and enhancing their willingness to participate is crucial for advancing low-carbon community development. Based on cognitive behavioral theory, this study explores the impact of benefit cognition on residents' willingness to participate in low-carbon community construction. An E-prime experiment was designed with a 2 (Benefit Cognition: high/low) × 2 (Government Subsidy: yes/no) × 2 (Household Income: high/low) framework, selecting five common low-carbon community construction projects as the context, to examine the moderating effects of government subsidies and household income. The results indicate that residents' benefit cognition has a significant positive effect on their willingness to participate in low-carbon community initiatives. Both government subsidies and household income positively moderate the relationship between benefit cognition and residents' willingness to participate; however, the interaction between government subsidies and household income does not significantly moderate the effect of benefit cognition on residents' willingness to participate. This study provides empirical support for policymakers, community managers, and relevant stakeholders, offering practical guidance, particularly in enhancing benefit cognition awareness and designing subsidy policies, to promote residents' involvement in low-carbon community construction.

KEYWORDS

benefit cognition, government subsidy, household income, willingness to participate, low-carbon community

1 Introduction

Low-carbon community construction is an important measure to address climate change and achieve sustainable development. Globally, especially in the context of the Paris Agreement's greenhouse gas reduction goals, countries have taken action to promote the transformation of low-carbon cities and communities (Shang and Lv, 2023). In China, low-carbon city and community construction has become an integral part of achieving the strategic goals of carbon peak and carbon neutrality (Xu et al., 2024). The Chinese government has outlined a series of policy documents, such as the "Action Plan for Carbon Peak Before 2030" (2021), which explicitly identifies "carbon peak in urban and rural

construction" as a key task. The "Implementation Plan for Carbon Peak in Urban and Rural Construction Areas" (2023) further sets the target of "reducing carbon intensity in existing communities by 30% compared to 2020," and promotes reforms in areas such as green buildings and energy-efficient retrofitting, while actively implementing low-carbon community demonstration projects. Low-carbon communities not only contribute to reducing carbon emissions and improving urban energy utilization efficiency but also promote the widespread adoption of green lifestyles among residents. However, despite increasing policy support, the generally low willingness of residents, as the core participants in community construction, to engage in these initiatives has become a significant challenge, hindering the successful development of low-carbon communities (Liu et al., 2021).

A low-carbon community is a sustainable community model that significantly reduces energy consumption and carbon emissions through measures such as spatial optimization, energy-efficient building retrofits, the use of renewable energy, and fostering low-carbon awareness among residents (Jiang et al., 2013). In China, low-carbon community construction is divided into three types: government-led, such as the Green Building Demonstration Area in Guangming New District, Shenzhen, which achieves low-carbon transformation through integrated technologies like photovoltaic rooftops and rainwater collection systems; market-driven, such as the Sun City in Changsha, where developer-led integration of low-carbon technologies effectively reduces operational emissions; and community co-built, such as the Zhangjiang Low-Carbon Community in Shanghai, which promotes waste sorting and energy-efficient retrofitting through a "carbon credit" incentive mechanism. Resident participation is the key to the success of low-carbon community construction. Most studies show that, as the main beneficiaries and implementers of low-carbon activities, residents should actively engage in the renovation of the community to exert their subjective initiative (Liu et al., 2021; Jiang et al., 2013; Heiskanen et al., 2010). Current research primarily focuses on the impact of individual characteristics, such as gender, age, education, participation attitudes, and subjective norms, on residents' willingness to participate (Wang and Hou, 2010; Yu et al., 2019), as well as external factors such as incentives, social capital, and policy support (Wang et al., 2019; Wu et al., 2023). Although existing research has provided valuable perspectives on understanding resident participation, the high cost of projects remains a key factor restricting participation. While national subsidies and other policies have improved residents' attitudes toward participation in the short term, these policies have not fundamentally improved residents' participation decisions from a long-term and sustainable perspective (Jiang et al., 2022).

In studies related to participation willingness, scholars generally agree that individual cognition plays a significant role in promoting participation willingness (Xie, 2024). For instance, research shows that residents' willingness to participate in ecological community construction is jointly influenced by psychological identification, individual characteristics, and community-driven measures (Wu et al., 2024). Farmers' perceived benefits of green agricultural production and their value cognition significantly promote their willingness to participate, while perceived risks have a negative effect (Li et al., 2020). Additionally, for farmers, the degree of understanding of forestry carbon sequestration projects is positively correlated with their willingness to engage in management activities (Ying et al., 2024). However, research on residents' willingness to participate in low-carbon community construction from the perspective of cognitive behavior remains relatively scarce. Cognitive behavioral theory posits that an individual's willingness to participate and behavior is not only directly influenced by external events but also depends on how individuals perceive and interpret these events (Beidel and Turner, 1986). Specifically, in the context of low-carbon community construction, residents' cognition of low-carbon projects directly affects their willingness to participate. Indeed, residents' participation decisions are driven by multiple factors, among which benefit cognition is a core element. When considering whether to participate in low-carbon community construction, residents often base their decision on an evaluation of the costs and benefits of the project, particularly in terms of long-term economic, social, and ecological benefits. Although previous studies have explored the impact of benefit cognition on farmers' willingness to engage in carbon sequestration forestry management, the specific effect of benefit cognition on residents' willingness to participate in low-carbon community construction is yet to be clarified (Ying et al., 2024). Currently, while policies require the disclosure of construction costs, there is a lack of clear guidelines on the publicity of expected project benefits, especially long-term benefits. This limitation in residents' benefit cognition subsequently affects their willingness to participate. Therefore, improving residents' understanding of the benefits of low-carbon community projects and helping them comprehensively recognize the long-term economic, social, and ecological benefits of the projects, thereby stimulating their active participation, is an important research issue that needs to be addressed.

This study, based on cognitive behavioral theory, aims to explore how benefit cognition influences residents' willingness to participate in low-carbon community construction and analyze the role of factors such as government subsidies and household income in this process. Cognitive behavioral theory provides a framework to understand how individuals form behavioral intentions through their cognition of benefits. Through the empirical design of an E-prime behavioral experiment, this study ensures the reliability and validity of the data. By analyzing the impact of benefit cognition on residents' willingness to participate under different levels of government subsidies and household income, the findings will provide a basis for decision-making by policymakers, community managers, and relevant stakeholders.

2 Theoretical foundation and hypotheses

2.1 Cognitive behavioral theory and its application

Cognitive Behavioral Theory (CBT) originates from the integration of cognitive theory and behavioral theory, emphasizing how individuals respond to external events through their cognition and how such cognition triggers emotional and

behavioral reactions. The core idea of CBT is that an individual's emotional and behavioral responses are not directly triggered by external events but are determined by the individual's cognitive interpretation of these events (Beidel and Turner, 1986). Specifically, an individual's cognition of environmental events guides their responses, affecting emotional reactions and behavioral outcomes through selective attention or interpretation of these events. If an individual's understanding of the environment is biased, maladaptive behaviors may emerge, which, in turn, reinforce the erroneous cognition, creating a vicious cycle. The goal of CBT is to identify and correct individual cognitive biases, helping individuals improve emotional and behavioral responses through cognitive restructuring. Its central task is to modify how individuals perceive external events, thus adjusting emotional and behavioral reactions (Foreyt, 2012).

Cognitive Behavioral Theory has been widely applied across various fields, including psychology, sociology, and management. Researchers typically adopt the perspective of cognitive behavioral therapy to adjust emotional and behavioral responses by identifying and altering individual cognitive biases (Sharpe and Tarrier, 1993). For instance, in psychotherapy, CBT is widely used to treat psychological issues such as anxiety and depression. The therapeutic process generally includes identifying cognitive distortions, analyzing their impact on emotions and behaviors, and improving individuals' mental health through cognitive restructuring and behavioral interventions. For example, Barnes et al. (2014) used CBT to correct children's aggressive behavior and demonstrated the effectiveness of cognitive restructuring in modifying individual behavior. Li et al. (2017) analyzed and pointed out that farmers' cognition of the economic benefits of conservation tillage technology is an important factor influencing their adoption behavior, indicating the key role of benefit cognition in agricultural behavior change. Additionally, Ying et al. (2024) studied the application of cognitive behavioral theory in forestry carbon sequestration projects, examining the cognition and behavior of farmers and discovering differences in the impact of benefit cognition and perceived benefit cognition on farmers' willingness to engage in carbon sequestration forestry management (Ying et al., 2024). These studies show that CBT is not only limited to treating psychological issues but also serves as an effective tool for analyzing behavioral changes.

In the context of current low-carbon community construction, cognitive behavioral theory offers a new perspective for understanding the psychological mechanisms of residents' willingness to participate. Residents' willingness to participate in low-carbon community construction is influenced not only by external incentive factors (such as government subsidies, policy support, etc.) but also by residents' cognition of the project's benefits, expectations of long-term changes, and their understanding of external support (Tan et al., 2025). This study, combining cognitive behavioral theory, explores how benefit cognition affects residents' willingness to participate in low-carbon community construction. Specifically, residents' cognition of the economic, social, and ecological benefits of low-carbon projects may influence their willingness to participate. By integrating cognitive behavioral theory, this study aims to explore its application in low-carbon community construction and provide new theoretical perspectives and empirical support for the advancement of low-carbon community initiatives.

2.2 Benefit cognition and residents' willingness to participate

The "rational economic agent" theory is a foundational assumption in Western economics, which posits that individuals engage in economic activities with the goal of maximizing their own benefits. In this theory, residents are viewed as independent decision-makers who, when faced with issues related to their own interests, typically adopt strategies to maximize their utility by seeking benefits and avoiding harm (Wilson and Dowlatabadi, 2007). In the context of low-carbon community construction, insufficient information disclosure from the government and developers results in a lack of awareness among residents regarding the benefits of low-carbon communities. In order to protect their own interests, residents often adopt defensive measures to safeguard their rights. Benefit cognition, which refers to residents' understanding and evaluation of the economic, social, and ecological benefits that low-carbon community construction can bring, is a key factor influencing their willingness to participate. Through recognizing these benefits, residents are able to comprehensively assess the feasibility of the project and make more informed decisions (Bülbül et al., 2023). From an economic perspective, residents can evaluate the long-term financial impact of low-carbon community construction on their financial situation; from a social perspective, residents can recognize the improvements in life quality, social interaction, and sense of belonging brought about by low-carbon community construction; from an ecological perspective, residents can realize the actual effects of low-carbon communities in reducing energy consumption and pollutant emissions, thus understanding the project's long-term sustainability and the value of their participation. Therefore, benefit cognition may influence residents' participation motivation and behavioral decisions, but its specific mechanisms still need further validation.

To date, academic research from an individual cognition perspective on low-carbon participation has achieved certain results. For example, Zhang et al. (2022) found that perceived economic benefits, policy subsidies, and government publicity are key factors influencing farmers' participation in land conservation. Huang and Yao (2021) found that the higher the farmers' ecological cognition, the stronger their willingness to participate in the improvement of their living environment. Tan et al. (2025) studied that perceived personal benefits, moral perception, and policy perception significantly influence urban residents' support for low-carbon city construction and their willingness to pay for photovoltaic rooftop retrofitting costs. These studies highlight the crucial role of benefit cognition in promoting residents' participation in environmental protection activities.

Similarly, low-carbon community construction integrates economic, social, and ecological value. Residents' cognition of the various benefits that can be gained from participating in

low-carbon communities may influence their willingness and behavior to participate. A lack of awareness regarding the long-term benefits of low-carbon community projects may lead residents to overlook the potential benefits, thus reducing their willingness to participate. On the other hand, a thorough understanding of the benefits can elevate residents' cognitive awareness, alter their expectations of the project, and thus stimulate their participation motivation. This process, under the framework of cognitive behavioral theory, can be understood as a significant increase in residents' willingness to participate through cognitive restructuring and emotional adjustment. This study, combining cognitive behavioral theory, aims to explore how benefit cognition affects residents' willingness to participate in low-carbon community construction. By analyzing residents' cognition of low-carbon community construction projects, including economic, ecological, and social benefits, the research will reveal how these cognitions influence residents' participation decisions and provide relevant theoretical and empirical support. Based on this, the following hypothesis is proposed:

H1: Benefit cognition has a significant positive impact on residents' willingness to participate in low-carbon community construction.

2.3 Moderating effects of government subsidies and household income

Research has shown that government subsidies and household income significantly affect residents' participation enthusiasm (Daniel and Hunt, 2014; He and Chen, 2021). As an economic incentive, government subsidies help significantly increase residents' willingness to participate in low-carbon community construction by reducing their financial burdens or increasing the actual benefits of participation. At the same time, household income may affect residents' acceptance and understanding of the information regarding the benefits of low-carbon community construction, which influences their level of benefit cognition. Higher-income households typically have more resources and time to obtain relevant information and understand related policies, while lower-income households may focus more on short-term economic benefits, which in turn affects their cognition of long-term benefits and willingness to participate.

The impact of government subsidies on residents' participation is part of the individual's socialization process. The government promotes residents' participation demands through subsidy policies, stimulates participation willingness, and enhances the implementation effectiveness and social recognition of the policies (Huang and Yao, 2021). Scholars have deeply explored the moderating role of government subsidies in residents' willingness to participate. For instance, Heclo (2002) argued that the government should guide and regulate residents' participation behavior through the formulation and implementation of appropriate policies to maximize public interest. Ding et al. (2018) analyzed the impact of different demographic characteristics of residents (such as income, education level, and employment field) on their expectations for government subsidies for solar photovoltaic power generation, and found significant differences in residents' subsidy expectations. Additionally, Luo and Yang (2021) demonstrated the moderating effect of government subsidies on residents' participation in Public-Private Partnership (PPP) construction projects. Therefore, under the condition of certain benefit cognition, different government subsidy strategies may influence residents' willingness to participate. Based on this, the following hypothesis is proposed:

H2: Government subsidies have a positive moderating effect on the relationship between benefit cognition and residents' willingness to participate.

Residents with higher household income have greater financial capacity and risk tolerance. Previous studies have shown a positive relationship between household income and residents' willingness to participate. For example, Guo (2023) proposed that the moderating effect of economic income levels enhances the impact on residents' participation. Generally, higher-income households, due to less financial pressure, tend to have a higher willingness to participate, while lower-income households face greater cost burdens, leading to lower participation willingness. Ellen and Martin (2022) explored the moderating role of household income between environmental motivation and behavior, finding that higher-income households have a more significant relationship between energy-saving behaviors and environmental motivation, while lower-income households show stronger motivation to reduce consumption behaviors. Deng et al. (2013) found that as farmers' environmental awareness increased, higher-income farmers were more likely to voluntarily engage in ecological protection behaviors under government guidance. Similarly, in low-carbon community construction, residents with higher household income are more economically capable of supporting low-carbon behaviors. As their ecological cognition improves, their willingness to participate may also increase. In contrast, lower-income residents focus more on short-term economic benefits, with cost control being a major consideration. While they may recognize the environmental pollution and resource waste caused by their current lifestyles and acknowledge that low-carbon community construction can generate long-term economic, social, and ecological benefits, the high participation costs and the inconvenience of changing their existing lifestyles often limit their willingness to participate. When benefit cognition influences higher-income residents, it is more likely to be converted into positive participation willingness; however, for lower-income residents, short-term cost pressures suppress their cognition of long-term benefits, reducing their willingness to participate. Based on this, the following research hypothesis is proposed:

H3: Household income has a positive moderating effect on the relationship between benefit cognition and residents' willingness to participate.

Furthermore, some studies have confirmed that this is not always the case. Low-income households may be willing to participate in low-carbon community construction to gain economic benefits and government subsidies, as their energy expenditures account for a larger proportion of their income

(Si and Stephens, 2021). There exists an interaction between government subsidies and household income. As an incentive policy, government subsidies may strengthen the positive moderating effect of household income on the relationship between benefit cognition and willingness to participate. Therefore, the following hypothesis is proposed:

H4: Government subsidies enhance the positive moderating effect of household income on the relationship between benefit cognition and willingness to participate. Specifically, the positive moderating effect of household income is stronger when government subsidies are present compared to when they are absent.

The research model is shown in Figure 1.

3 Research methodology

This study adopts a 2 (Benefit Cognition) × 2 (Household Income) × 2 (Government Subsidy) between-subjects experimental design, with residents' willingness to participate as the dependent variable. The research will be conducted in a controlled laboratory or indoor environment, where all stimulus materials and questionnaire items will be presented using computers and E-prime 2.0 software, and data will be analyzed using SPSS software.

3.1 Sample

An a priori power analysis was conducted using G*Power 3.1 software. Since the study involves three between-subjects factors, sample sizes were calculated for each main effect, two-factor interaction effect, and three-factor interaction effect. A medium effect size (0.5) was chosen as the estimated effect size. According to the software's calculations, a sample size of 64 participants per group, totaling 512 participants, is needed to achieve a statistical power of 0.8 (significance level $\alpha = 0.05$).

Considering that residents from different socio-economic and cultural backgrounds may exhibit differences in environmental awareness and low-carbon behaviors, for example, residents in economically developed regions (such as Tianjin and Shenzhen) are generally more focused on environmental protection, whereas residents in less economically developed regions (such as Liaoning, Shanxi, and Guangxi) tend to have lower participation in low-carbon behaviors. Additionally, cultural differences also influence residents' environmental attitudes and behavioral habits. For instance, Liaoning and Shanxi have long relied on resource development, leading to weaker environmental awareness; Tianjin and Shenzhen, as first-tier commercial cities, are more likely to accept emerging environmental technologies; while Guangxi retains traditional ecological wisdom, fostering stronger environmental awareness but lower acceptance of new environmental measures. The research team recruited 530 community residents from Liaoning, Tianjin, Shanxi, Shenzhen, and Guangxi as participants. All participants volunteered and signed an informed consent form before the experiment began. Upon completion of the experiment, participants received a 10 RMB (∼1.40 USD) cash reward.

After excluding samples from participants who did not complete the experiment, a total of 518 valid sample data were obtained, with 208 males and 310 females, and ages ranging from 22 to 60 years. In terms of household income, 33% of participants earn <10,000 RMB (∼1,400 USD) per month, 52% earn between 10,000 and 20,000 RMB (∼1,400 to 2,800 USD), and 15% earn more than 20,000 RMB (∼2,800 USD and above). In terms of education level, 22% have a high school diploma or lower, 46% have a college diploma, and 32% have a bachelor's degree or higher. This study strictly follows the principle of representative sampling to ensure that the sample includes residents from different socio-economic backgrounds, fully reflecting the heterogeneity in key socio-demographic characteristics across regions. However, due to sample size limitations, the research sample may not fully represent the overall characteristics of all low-carbon community residents. Therefore, we have controlled for sample characteristics in the analysis to ensure the validity and reliability of the research results.

3.2 Materials preparation

The pre-experiment materials were designed by comparing a specific project in a low-carbon community with the same project in a regular community. A total of five sets of comparative photographs were used, including comparison images of the green environment, rooftops, trash bins, streetlights, and carports. Figure 2 shows one set of images, comparing the rooftop of a regular community with the rooftop of a low-carbon community featuring solar photovoltaic panels.

The formal experimental materials were designed based on five low-carbon construction projects from five communities, which included ground source heat pumps, rooftop photovoltaic power generation, solar thermal water systems for engineering, photovoltaic charging piles, and rainwater collection pools. Each project was designed with four images based on different displayed information: (A) cost information only, (B) cost and benefit information, (C) cost and government subsidy information, and (D) cost, government subsidy, and benefit information. The figures can be found in Appendix. Each project's materials included the four types of images, totaling 20 images.

The residents' benefit cognition questionnaire was adapted from the evaluation index system established by Li et al. (2015), including economic benefit cognition, social benefit cognition, and ecological benefit cognition (Li et al., 2015). The residents' participation willingness questionnaire was adapted from the mature scale proposed by Cui et al. (2019), with revisions based on expert suggestions and the characteristics of low-carbon community construction. The variable measurement items and methods are detailed in Table 1. To ensure the reliability and validity of the measurements, all items were revised by experts and pre-tested with 50 randomly selected passers-by from the school and surrounding areas. The results showed that the Cronbach's α coefficients for the two scales were 0.87 and 0.89, respectively, both higher than 0.7 (Nunnally and Bernstein, 1994); the average

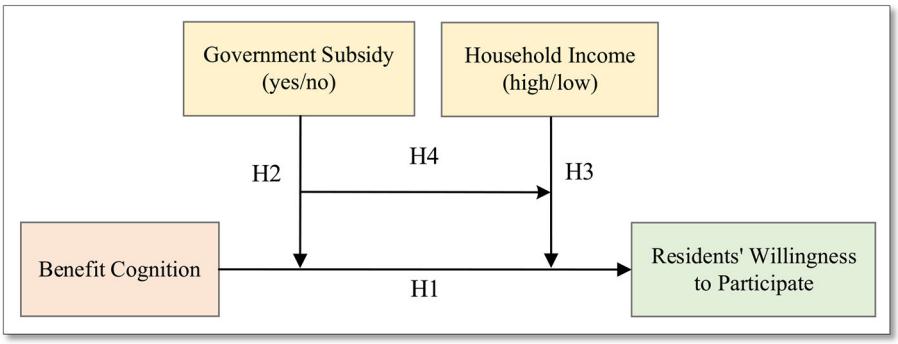

FIGURE 1
Research model.

FIGURE 2
Comparison of rooftops between a regular community and a low-carbon community.

variance extracted (AVE) values were 0.62 and 0.68, both exceeding 0.5 (Fornell and Larcker, 1981); the composite reliability (CR) values were 0.91 and 0.93, both higher than 0.7 (Hair et al., 2010), indicating good internal consistency and validity of the scales.

3.3 Procedure

Before the experiment, a demographic questionnaire was collected, including age, gender, education level, household income, and residence location. Additionally, participants were required to sign an informed consent form and were provided with introductory instructions, including an introduction to the research background and experimental procedures. Before the experiment, participants were briefly explained the definition of low-carbon communities and their potential economic, social, and ecological benefits, ensuring that participants could respond based on their actual situations and life experiences.

The experiment is divided into four groups (A, B, C, D), with image materials presented according to the different information provided to each group. Specifically, participants in Group A observe only the cost information for each project; participants in Group B observe both the cost and benefit information for each project; participants in Group C observe both the cost and government subsidy information for each project; and participants in Group D observe the cost information, government subsidy information, and benefit information for each project. The image materials for each project are comparable to those shown in Figures A, B, C, and D in Appendix.

TABLE 1 Measurement items and methods of variables.

Measurement variables		Measurement items	Scoring method
Benefit cognition	Economic benefit cognition	How do you think the revenue increase effect of low-carbon community operations is?	Likert 7-point scoring, with the average value assigned to the corresponding benefit cognition. The higher the value, the higher the residents' benefit cognition level.
		Do you think energy-efficient building renovations in low-carbon communities can effectively reduce household energy consumption?	
		Do you think the construction of low-carbon communities can effectively enhance the market value of real estate?	
		How do you think the government's green subsidy policy impacts the reduction of low-carbon community construction costs?	
	Social benefit cognition	How much do you think the construction of low-carbon communities improves residents' quality of life?	
		Do you think the construction of low-carbon communities effectively raises the environmental awareness of community residents?	
		Do you think the construction of low-carbon communities can significantly improve public facilities in the community?	
		How do you think the construction of low-carbon communities impacts the creation of new employment and entrepreneurial opportunities?	
	Ecological benefit cognition	How do you think the construction of low-carbon communities affects the reduction of energy consumption and pollutant emissions?	
		How do you think the construction of low-carbon communities contributes to improving ecological environmental protection?	
Residents' willingness to participate	/	I will thoroughly learn more about low-carbon community construction projects.	Likert 7-point scoring, with the average value assigned. The higher the value, the higher the willingness to participate.
		I will spread positive information about low-carbon community construction to others.	
		I plan to participate in low-carbon community construction activities.	
		I will recommend others to participate in low-carbon community construction activities.	

The experiment is divided into two parts: the pre-test and the formal experiment. During the pre-test phase, participants can choose to repeat the practice trials to familiarize themselves with the experimental content and procedures. Before the experiment begins, participants are required to read the instructions and learn the computer keyboard controls (the uppercase "F" key and the numbers "1–7" keys). The instructions emphasize that participants need to carefully review all the images and text presented on the computer screen and thoroughly think through and understand them. Participants will enter their subject number and group in the "Subject Number" dialog box, confirm the information, and click "YES" to start the formal experiment. In the formal experiment, participants will sequentially observe the image materials for each project and score the benefit cognition and participation willingness items on the questionnaire based on their true thoughts, with scores ranging from 1 to 7. To ensure the effective presentation of materials and the scientific integrity of the experiment, the order of the image materials is randomized. Considering the differences in the content of each image and the participants' reading and comprehension abilities, there is no time limit for the presentation of the images. After reviewing each image, participants press the "F" key to switch to the next project image. Once all the image materials have been presented, the system automatically pops up the questionnaire, asking participants to score based on their true thoughts, where 1 means "strongly disagree" and 7 means "strongly agree." The E-Prime experimental procedure design is shown in Figure 3.

4 Research results

First, the reliability of the scales was tested. The Cronbach's α coefficients for the benefit cognition and participation willingness scales were 0.96 and 0.92, respectively, both >0.9, indicating excellent reliability of the scales.

(1) Testing the Effect of Benefit Cognition on Residents' Willingness to Participate. A one-way ANOVA revealed that the main effect of benefit cognition on residents' willingness to participate was significant in the benefit information group compared to the no-benefit-information group, $F_{(1,515)} = 19.261$, $p < 0.001$. For residents, obtaining benefit information resulted in higher benefit cognition levels and stronger participation willingness compared to only receiving cost information, $M_{with\_benefits} = 5.12$, $M_{without\_benefits} = 4.12$, $p = 0.019 < 0.05$, thus validating H1.

(2) Testing the Moderating Effect of Government Subsidies. Whether for residents with benefit information (high benefit cognition) or residents who only received cost information (low

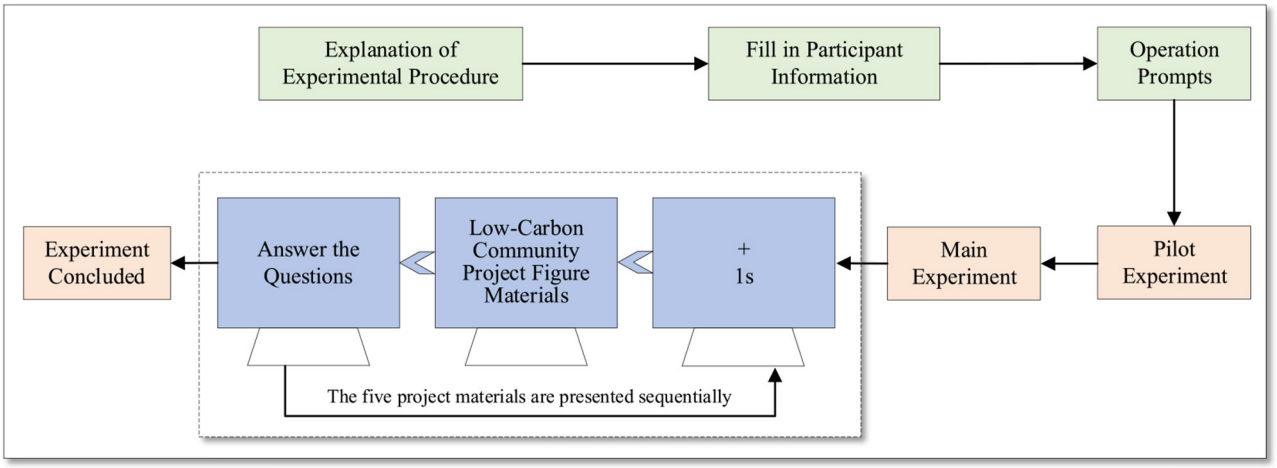

FIGURE 3
E-prime experimental procedure diagram.

benefit cognition), the presence of government subsidies had a significantly stronger positive impact on residents' participation willingness than the absence of subsidies. Statistical results showed a significant two-stage interaction effect between benefit cognition and government subsidies on participation willingness, $F_{(1,515)} = 6.772$, $p < 0.001$. For residents who received benefit information, those with government subsidies had stronger participation willingness than those without subsidies, $M_{with\_subsidy} = 6.11$, $M_{without\_subsidy} = 4.58$, $p = 0.011 < 0.05$. Similarly, for residents who only received cost information, those with government subsidies had stronger participation willingness than those without subsidies, $M_{with\_subsidy} = 5.12$, $M_{without\_subsidy} = 4.12$, $p = 0.028 < 0.05$. Therefore, H2 was validated.

(3) Testing the Moderating Effect of Household Income. Whether for residents with benefit information (high benefit cognition) or residents who only received cost information (low benefit cognition), those with higher household income exhibited a significantly stronger positive effect on their participation willingness than those with lower household income. Statistical results showed a significant two-stage interaction effect between benefit cognition and household income on participation willingness, $F_{(1,515)} = 7.058$, $p < 0.001$. For residents who received benefit information, those with higher household income had stronger participation willingness than those with lower household income, $M_{high\_income} = 5.58$, $M_{low\_income} = 4.11$, $p = 0.015 < 0.05$. For residents who only received cost information, the difference in participation willingness between high-income and low-income households was not significant, $M_{high\_income} = 4.50$, $M_{low\_income} = 4.21$, $p = 0.322 > 0.05$. Therefore, H3 was partially validated.

(4) Testing the Moderating Effect of Government Subsidies on Household Income. The results indicated that the three-way interaction effect of benefit cognition, government subsidies, and household income on participation willingness was not significant, $F_{(1,515)} = 2.639$, $p = 0.107 > 0.05$. Therefore, H4 was not supported.

5 Conclusion and discussion

This study primarily explores the impact of benefit cognition on residents' willingness to participate in low-carbon community construction. Using a situational experimental design, we manipulated the variables of benefit cognition and government subsidies and examined the moderating effects of government subsidies and household income. Data were analyzed using SPSS, and the conclusions are as follows: (1) Benefit cognition positively predicts residents' willingness to participate in low-carbon community construction. Based on cognitive behavioral theory, residents' acquisition and cognition of benefit information guide their participation responses. This conclusion is consistent with the findings of Ying et al. (2024) in the field of carbon sequestration forestry management. (2) Under different levels of benefit cognition, the impact of government subsidies on residents' participation willingness significantly varies. As a direct economic incentive, government subsidies can significantly enhance residents' enthusiasm for participating in low-carbon community construction. This conclusion is also consistent with the findings of Pan et al. (2021) and Li et al. (2021), which suggest that government subsidies not only reduce the economic burden of residents' participation but also, to some extent, reinforce their cognition of the benefits of low-carbon community construction projects, thus increasing their willingness to participate. (3) Under different levels of benefit cognition, the impact of household income on residents' participation willingness significantly varies. Residents with higher household income, due to their more abundant financial resources and greater risk tolerance, are more willing to understand and evaluate the long-term benefits (benefit cognition) of low-carbon community construction projects, making them more likely to support projects with long-term economic, social, and ecological returns. Additionally, this result may also be influenced by residents' education levels and prior knowledge of the benefits

of low-carbon projects. Members of high-income households are usually better educated and able to better understand the long-term benefits of low-carbon projects, making them more inclined to support such projects. (4) The interaction between government subsidies and household income did not significantly moderate the positive predictive effect of benefit cognition on participation willingness. That is, the presence of government subsidies did not significantly enhance the effect of benefit cognition on participation willingness for either high-income or low-income households. Possible reasons include: First, the disparities in the responses of different income groups to government subsidies. High-income households, being financially more secure, may exhibit less reliance on subsidies, while low-income households, though more dependent on subsidies, might experience diminished effectiveness due to financial constraints and obstacles in accessing information. Second, variations in information access and benefit cognition abilities. High-income households often possess better educational backgrounds and greater access to information channels, enabling them to better comprehend the long-term benefits of low-carbon projects. In contrast, low-income households may fail to fully grasp the potential value of subsidies due to information asymmetry. Third, differences in socio-economic status. High-income households typically have stronger social participation motivations and are more inclined to support low-carbon projects, whereas low-income households may have lower trust in the long-term benefits, with subsidies failing to substantially alter their participation attitudes. Finally, limitations in sample size and analytical methods may affect the detection of the interaction effect. Although no significant interaction effect was observed, this does not imply its complete absence. Future research could investigate the participation patterns of different income groups in low-carbon community construction and the impact of subsidy policies by expanding the sample size and optimizing the analytical techniques.

The conclusions of this study have practical implications for enhancing residents' willingness to participate in low-carbon community construction: (1) The government should formulate and implement benefit cognition strategies when promoting low-carbon community construction. Specifically, community education and publicity should be strengthened to ensure that residents fully understand the economic, social, and ecological benefits of the project, thereby stimulating participation enthusiasm. (2) The government should accelerate the improvement of subsidy measures, select applicable subsidy standards for different regions and differentiated demonstration projects, and make these standards public. The government should encourage social capital to support low-carbon community projects in various forms, providing financial support for projects with high expected benefits. (3) Low-carbon community construction should focus on increasing publicity efforts for low-income households, including promoting government subsidy policies and the economic, social, and ecological benefits of these projects. Differentiated subsidy policies should be developed based on household income levels and specific family circumstances to enhance support for low-income households.

This study has some limitations: (1) Although this study considered the differences among residents from different socio-economic and cultural backgrounds in sample selection and enhanced the generalizability of the research conclusions, the limited scope of the sample prevented an in-depth analysis of economic levels and cultural differences. Therefore, future research should expand the sample range, consider cross-regional and cross-cultural comparative experiments or data analyses, and more accurately assess differences in low-carbon behavior and community participation willingness among different regional groups to enhance the external validity of the research results. (2) This study primarily focuses on the impact of benefit cognition, government subsidies, and household income on residents' willingness to participate in low-carbon community construction. However, residents' participation willingness is influenced by various factors, such as environmental awareness, risk perception, and individual characteristics, which may not have been fully considered. Future research could explore these potential factors in greater depth and employ multi-factor interaction analysis methods (such as qualitative comparative analysis, complex mediation models, etc.) for comprehensive research, further revealing the motivations and influencing mechanisms behind residents' participation in low-carbon community construction. (3) This study relies on self-report data, which may introduce potential biases. Specifically, participants may be inclined to provide responses that conform to social expectations, such as inflating their environmental awareness or willingness to engage, thereby introducing social desirability bias. Furthermore, variations in participants' interpretations of survey questions could lead to comprehension bias. Although we have minimized these biases through expert revision of the questionnaire, pre-testing, and providing detailed research background and instructions, we cannot completely eliminate these issues. Therefore, future research could incorporate behavioral data or use multiple data collection methods (e.g., interviews, observations) to further validate the findings and reduce the potential biases introduced by self-reports.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of Tianjin University of Technology. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

CS: Conceptualization, Funding acquisition, Project administration, Resources, Supervision, Writing – review & editing. ZZ: Conceptualization, Data curation, Formal analysis,

Methodology, Software, Validation, Writing – original draft. TL: Investigation, Methodology, Software, Validation, Writing – original draft. HJ: Funding acquisition, Project administration, Resources, Supervision, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2025.1633291/full#supplementary-material

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