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Tourism consumers' perceptions, attitudes and low-carbon tourism behaviors towards "dual carbon" of China

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To support China's "dual carbon" goals, understanding the drivers of low-carbon tourism behavior is crucial. This study investigates these drivers among tourists in Fujian Province, a region with significant ecological and economic diversity. Based on a survey of 1,064 tourists and employing a multiple linear regression model, we analyze how regional differences mediate the influence of cognition and attitudes on sustainable behavior. The research reveals a complex interplay of factors, with key findings indicating that: (i) There is significant regional heterogeneity in tourist perceptions and concerns. For instance, tourists in the economically advanced eastern region display high policy awareness but also attribute primary responsibility to the government and businesses. In contrast, those in the developing western region demonstrate a stronger personal willingness to change their consumption habits, while tourists in the south and north express concerns over potential impacts on travel comfort and costs. (ii) Higher policy awareness does not uniformly translate to positive behavior. Counter-intuitively, in eastern Fujian, greater awareness of "dual carbon" policies was found to negatively impact low-carbon consumption. This suggests that without addressing associated concerns about cost and convenience, mere awareness can create resistance rather than encourage participation. (iii) Pro-environmental attitudes are a more consistent and powerful driver of behavior than cognitive understanding alone. Across the province, a firm belief in the necessity of low-carbon tourism and its importance to the industry's sustainable development were the most significant predictors of sustainable practices. This highlights that fostering a sense of shared value is more effective than simply disseminating policy information. These outcomes provide valuable, region-specific insights for formulating targeted sustainable tourism policies in Fujian and other similarly diverse areas.

KEYWORDS

tourism consumers, "dual carbon", low carbon tourism, Fujian province, multiple linear regression

1 Introduction and theoretical backdrop

With the intensification of global warming, extreme weather events such as heatwaves, heavy rainfall, and droughts are becoming increasingly frequent. For instance, in 2023, temperatures in California's Death Valley exceeded 53.3°C, and in 2021, Zhengzhou in Henan Province, China, experienced a devastating rainstorm that produced nearly three times the region's annual average rainfall within just 3 days. These extreme weather phenomena have resulted in significant loss of life and property, as well as severe ecological damage, posing a grave threat to human society. In response to the challenges posed by climate change, both the *Kyoto Protocol*, which came into effect in 2005, and the *European Green Deal*, proposed by the European Union in 2019, established explicit regulations on carbon emission reduction. In 2020, President Xi Jinping announced at the United Nations General Assembly the objective of achieving peak carbon emissions before 2030 and carbon neutrality before 2060. Consequently, the strategy of peak carbon and carbon neutrality—termed the “dual carbon” strategy—has evolved into a medium-to long-term national development framework. To realize the “dual carbon” goals, China has implemented a range of strategies that include improving energy efficiency, developing clean energy, promoting green building practices, employing carbon capture technologies, enhancing forest carbon sequestration, and advancing low-carbon transportation. The nation also actively advocates for green consumption, including low-carbon tourism.

Tourism was once celebrated as a “smoke-free industry” due to its green development attributes. However, with the intensification of global climate change and the implementation of the “dual carbon” strategy, carbon emissions from the tourism industry have come under increasing scrutiny. According to the International Energy Agency (IEA) report *Global Energy Review: CO₂ Emissions in 2021*, the tertiary sector is progressively becoming a major contributor to the rise in carbon emissions, with a growth rate of 50.43% between 2011 and 2018. This increase is substantially higher than the growth rates of the primary (14.41%) and secondary (12.58%) sectors. Tourism-related CO₂ emissions account for 4%–6% of global emissions, and if no corrective measures are taken, these emissions are projected to increase by 1.5 times by 2035 (Dong and Yang, 2011). As a key component of the tertiary sector, the tourism industry has become one of the primary sources of carbon emissions in China (Ren, 2022). The low-carbon development of China's tourism sector faces numerous challenges, particularly in regions with well-established tourism industries. For instance, in Guizhou Province, total carbon emissions from tourism were 213.7, 254.3, 279.3, 295.1, and 300.3 million tons from 2011 to 2015, respectively, reflecting a rapid growth trend, with a considerable share coming from tourism accommodation and catering services (Su, 2019). China's tourism market is vast, with a large number of tourists generating immense pressure for carbon reduction. According to the Statistical Bulletin of National Economic and Social Development of the People's Republic of China 2024, domestic tourism trips in 2024 reached 5.62 billion, a year-on-year increase of 14.8%, while total domestic tourism expenditure amounted to 5.75 trillion yuan, a 17.1% increase compared to the previous year. The National Immigration Administration reported

that the number of inbound and outbound tourism trips reached 610 million, marking a 43.9% year-on-year increase. In response to this, various government departments in China have prioritized the low-carbon transformation of tourism. They have introduced several standards, including the Green Tourist Attraction (LB/T015-2011) and the Green Tourism Hotel (LB/T007-2015), to guide sustainable practices within the industry.

Low-carbon tourism has attracted significant academic interest in recent years. Existing research has primarily focused on key areas such as carbon sink capacity and carbon emission accounting in tourist destinations (Tao and Huang, 2014; Zha, 2019; Zhang and Zhang, 2020a), factors influencing low-carbon tourism systems (Zhang and Zhang, 2020b; Yang et al., 2021; Zhang H. et al., 2024) strategies for achieving carbon neutrality in tourism (Luo and Zhang, 2011; Lee and January 2019), and the mechanisms through which tourism impacts carbon emissions (Can and Hongbing, 2011; Sun et al., 2021; Raihan, 2024). A review of current studies indicates that over the next 40 years, the carbon sink capacity of China's provincial tourism industry will generally follow a spatial distribution pattern of “high in the north and south, and low in the middle,” with most provinces experiencing continuous growth in tourism-related carbon sinks. In rapidly developing economies like China, tourism expansion is often energy-intensive and contributes substantially to carbon emissions. Notably, a strong positive correlation exists between the increase in tourist numbers and carbon dioxide emissions: a 1% rise in tourist numbers leads to a 0.09% increase in short-term CO₂ emissions and a 0.15% increase in long-term emissions (Zhang W. et al., 2024). Assessments of 10 low-carbon tourism pilot cities in China further reveal a positive relationship between economic development and low-carbon tourism levels (Mao et al., 2022), highlighting the critical role of sustainable tourism in urban development. However, the impact of tourism on carbon emissions varies significantly at the provincial level. While international tourism development has been found to mitigate emissions in economically advanced provinces, it tends to exacerbate emissions in less developed regions. This suggests that governments should implement targeted policies, such as subsidies, to support sustainable tourism in underdeveloped areas (Ahmad et al., 2022). China has explored low-carbon tourism initiatives at multiple scales. At the national level, carbon trading mechanisms have been shown to facilitate both economic growth and emission reduction in pilot regions and their neighboring areas, potentially fostering low-carbon management practices in the hotel industry through carbon emission trading (Wang, 2023). At the city level, empirical studies in Shenzhen emphasize the need for tourism and low-carbon urban development to evolve synergistically. Governments are encouraged to integrate low-carbon policies into tourism planning, implement policy incentives to guide industry transitions, and support businesses in adopting environmentally responsible strategies. Additionally, fostering innovation in low-carbon tourism models and enhancing public education on sustainable tourism can promote broader participation in green practices (Wang et al., 2019). At the scenic site level, evaluations of low-carbon transitions in Dong cultural tourism areas suggest promising outcomes, though further efforts are needed to strengthen environmental awareness, implement systematic socio-economic planning, and promote green tourism initiatives (Hu et al.,

2024). Meanwhile, at the rural level, research based on complex adaptive systems theory suggests that low-carbon tourism development in Yucun, Zhejiang, should involve aggregating diverse stakeholders for collaborative innovation, enhancing public awareness, leveraging pilot projects to drive innovation, and optimizing information and resource flows to improve overall system efficiency (Ye et al., 2024). Despite the urgent need for a transition to low-carbon tourism, scientifically robust and practical emission reduction strategies remain insufficient. Therefore, greater investment in technological research and development is essential, and scholars should continue to explore climate-resilient tourism models to support a more sustainable future for the industry (Gössling et al., 2013).

In summary, significant progress has been made in low-carbon tourism under the “dual carbon” goals. However, existing research has primarily concentrated on carbon emission accounting, mechanisms within the tourism industry, and low-carbon tourism strategies, with relatively little attention given to tourists’ low-carbon behaviors. In fact, raising awareness of low-carbon tourism can encourage more sustainable behaviors among tourists (Lin et al., 2022). Such awareness, attitudes, and behaviors can have a positive impact on the economic development of tourist destinations. Current research on low-carbon tourism consumption behavior primarily focused on analyzing influencing factors to promote sustainable practices (Liu et al., 2023). For instance, Lai et al. (2023) examined determinants affecting tourists’ low-carbon food choices. Parallel studies have employed environmental behavior theories to investigate how individual psychological cognition interacts with external policies and environmental factors in shaping behaviors (He et al., 2024), particularly addressing the intention-behavior gap and its constraints (Wu et al., 2017).

The Theory of Planned Behavior (TPB) posits that human actions result from deliberate planning involving five key components: actual behavior, behavioral intentions, attitudes

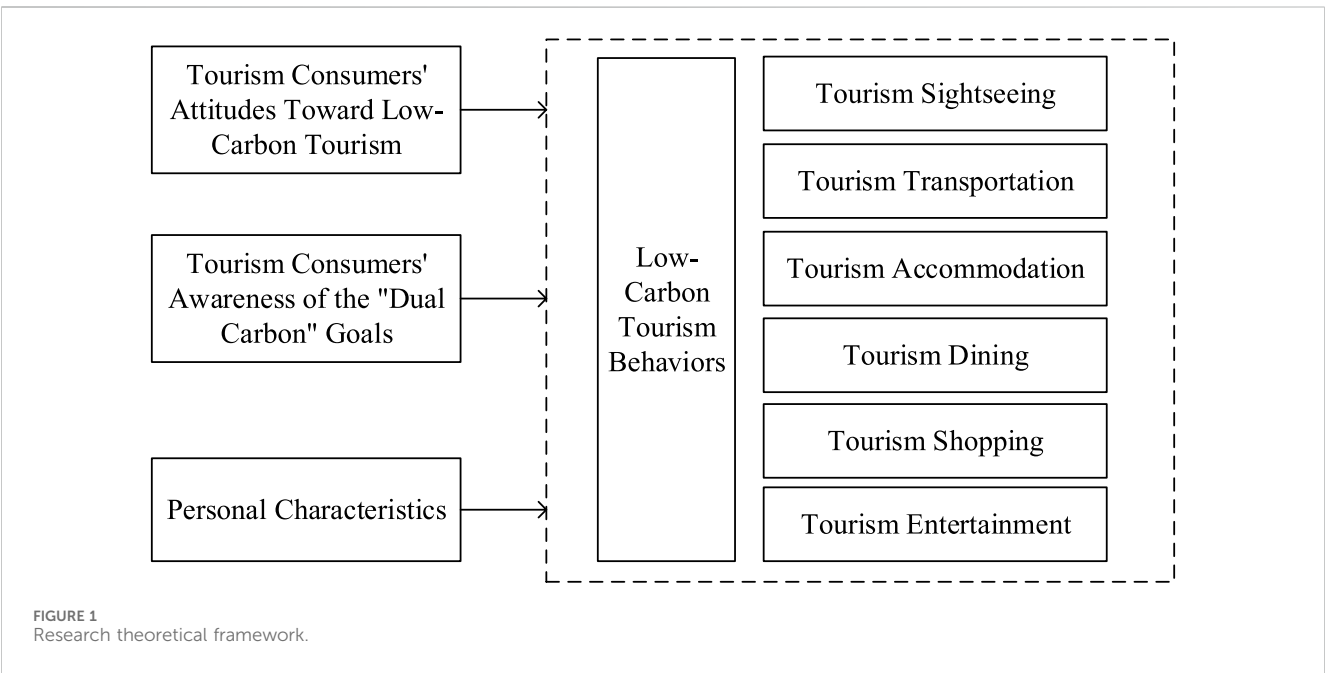
toward the behavior, subjective norms, and perceived behavioral control. While pro-environmental attitudes may significantly drive low-carbon behaviors, this kind of relationship remains debated (Wu et al., 2023). Low-carbon tourism awareness - tourists’ understanding and acceptance of sustainable tourism practices - serves as a crucial psychological driver for behavioral change. This awareness stems from both internal (e.g., education level, income, social status) and external variables (e.g., social, institutional, and regulatory environments) (Wu et al., 2017).

These theoretical foundations highlight the critical need to clarify the relationship between tourists’ cognition, attitudes, and actual low-carbon behaviors. However, existing studies predominantly concentrate on single destinations, lacking comparative regional analyses that could reveal how varying external environments mediate the impact of eco-conscious attitudes and awareness on sustainable tourism behaviors. Addressing this gap, our study examines low-carbon tourism behaviors across four distinct regions in Fujian Province. We systematically analyze regional variations in how cognitive factors and attitudes influence sustainable practices, uncovering the underlying mechanisms. Our findings provide valuable insights for developing targeted climate policies and fostering low-carbon transitions in the tourism sector. The research theoretical framework for this study is presented in Figure 1.

2 Research design and methods

2.1 Overview of the study area

Fujian Province, located on the southeast coast of China and facing Taiwan across the Taiwan Strait, administers nine prefecture-level cities: Fuzhou, Xiamen, Putian, Quanzhou, Zhangzhou, Longyan, Sanming, Nanping, and Ningde, as well as the Pingtan Comprehensive Experimental Zone. In 2023, the province had a



permanent population of 41.83 million, with an urbanization rate of 71.04%. Fujian's annual Gross Domestic Product (GDP) reached 5.43551 trillion yuan, ranking eighth among all Chinese provinces, making it a relatively developed region. Geographically, Fujian is characterized by its “mountains and seas,” with 90% of its land area consisting of mountainous and hilly terrain. This has earned it the description “eight parts mountains, one part water, and one part farmland.” The province boasts an exceptional ecological environment, with a forest coverage rate of 65.95% in 2024, maintaining the highest forest cover in China for 45 consecutive years. As the first National Ecological Civilization Pilot Zone in the country, Fujian provides an excellent foundation for the development of low-carbon eco-tourism. In addition, Fujian is a prominent tourist destination. In 2023, the province attracted 1.7224 million inbound tourists and 570.0358 million domestic tourists.

In recent years, Fujian Province has actively implemented various measures to achieve the “dual carbon” goals. In terms of carbon market development, Fujian is home to China's first provincial-level carbon market integrated service platform. The province leads other pilot regions nationwide in both transaction volume and value of forestry carbon sinks. In the area of green economic development, Fujian is also at the forefront of green financial innovation in China. Through green credit products such as “Minlin Tong,” it supports the development of low-carbon tourism and green agriculture. In the realm of low-carbon tourism, Fujian's *Special Plan for Cultural and Tourism Reform and Development during the 14th Five-Year Plan Period* (2021) introduced the concept of a comprehensive eco-tourism development system, establishing a strong policy foundation for promoting low-carbon tourism. As such, Fujian Province represents an ideal case for investigating tourists' low-carbon behaviors.

Fujian Province's four major regions (Eastern, Western, Southern, and Northern Fujian) exhibit significant variations in economic development, tourism resource endowments and policies. Economically, Southern Fujian serves as the province's economic powerhouse, with its port economy, high-tech industries, and private manufacturing sector providing both financial and technological support for low-carbon tourism initiatives. Eastern Fujian, centered around the provincial capital Fuzhou, demonstrates economic diversity through its port operations, digital economy, and Putian's specialized footwear/apparel manufacturing alongside handicraft industries. The less economically developed Western and Northern regions present distinct profiles: Western Fujian focuses on forestry and green industry transformation, while Northern Fujian's economy revolves around eco-agriculture and renewable energy.

Tourism policy orientations reveal regional specialization: Southern Fujian's *Xiamen Action P. for High-Quality Cultural Tourism Development (2023–2025)* promotes smart tourism and international cooperation. Eastern Fujian emphasizes coastal cultural-technology integration under its “Fresh Fujian” branding. Western Fujian develops revolutionary heritage (“red tourism”) programs, whereas Northern Fujian leverages the Wuyi Mountains' UNESCO dual heritage status to advance tea-tourism synergy and ecological conservation.

Tourism resources showcase unique regional identities: Southern Fujian boasts UNESCO-listed Gulangyu Island and

Quanzhou's Song-Yuan maritime trade relics. Eastern Fujian features the cultural landmarks of Three Lanes and Seven Alleys alongside the ecological attractions of Pingtan International Tourism Island. Western Fujian's Danxia landforms (Taining) and Hakka Tulou (Yongding) highlight geographical diversity, while Northern Fujian's Wuyi Mountain ecosystems and Xiapu mudflats constitute its ecological signature.

2.2 Research design

During the tourism process, tourists generate significant carbon emissions across various activities, including dining, accommodation, transportation, sightseeing, shopping, and entertainment. Transportation is the largest source of carbon emissions in global tourism, with air travel alone contributing 22% of the total, followed by tourism accommodation at 11%, while tourism dining and shopping each contribute 10% (Tang and Ge, 2018). Therefore, tourists' awareness and attitudes toward low-carbon tourism, as well as the extent to which their travel behaviors align with low-carbon principles, will significantly influence tourism-related carbon emissions and, in turn, the implementation of China's “dual carbon” strategy. Based on the six key components of tourism—dining, accommodation, transportation, sightseeing, shopping, and entertainment—this study constructs a measurement system for low-carbon tourism behaviors across these dimensions (Table 1). Relevant indicators were selected by reviewing previous research and considering data availability. The entropy weight TOPSIS method was used to calculate the weights for each dimension in the low-carbon tourism model. Among these, the “transportation” dimension had the highest weight (0.1936), reflecting its dominant role in tourism-related carbon emissions. This approach offers a scientifically robust reflection of tourists' behavioral patterns in low-carbon tourism.

This study treats low-carbon tourism behavior as the dependent variable, while tourists' awareness and attitudes toward low-carbon tourism, along with their personal characteristics, are considered independent variables. A multiple linear regression model is used to explore the influencing factors and underlying mechanisms of tourists' low-carbon tourism behaviors.

In this study, building on previous research (Tang et al., 2018; Gao et al., 2023; Janchai and Suvittawat, 2025), we selected the following indicators to comprehensively measure tourists' low-carbon tourism cognition and attitudes. The cognitive dimensions include: awareness of “Dual Carbon” policies (X6), understanding of “Dual Carbon” concepts (X7), perceived personal relevance of these policies (X8), recognition of their importance for tourism (X9), perception of increased travel costs (X10), awareness that tourism increases carbon emissions (X11), and belief that low-carbon tourism benefits environmental protection (X12). Policy awareness (X6) forms the cognitive foundation, as understanding policies helps tourists recognize low-carbon tourism's significance and its relationship to Dual Carbon goals, thereby influencing behavioral choices. Conceptual understanding (X7) enables tourists to grasp the direct connection between carbon emissions and environmental protection. When tourists perceive policy relevance to their lives (X8), they're more

TABLE 1 Comprehensive measurement of consumers' low-carbon tourism behavior.

Dimension	Weight (%)	Index
Food	0.1872	Prioritize various green, eco-friendly foods and locally sourced, seasonal foods to reduce energy consumption from transportation and packaging. Avoid foods with excessive single-use packaging, such as bottled water and processed meats. When dining, bring your own eco-friendly utensils and avoid using disposable tableware
Accommodation	0.1794	Choose hotels with a “green label” or prioritize small-scale hotels and hostels. Support the hotel’s low-carbon initiatives, such as changing linens only upon request and following low-carbon consumption guidelines. Avoid using disposable items provided by the hotel
Transportation	0.1936	Try to replace driving or flying with walking, cycling, buses, or trains. Upon reaching the travel destination, choose public transportation, walking, cycling, or electric vehicles for sightseeing. Whenever possible, opt for carpooling
Travel	0.1333	Prioritize low-carbon tourism routes. Opt for short-distance destinations instead of long-distance ones, and avoid popular or overdeveloped destinations. When leaving the hotel, remember to turn off lights, TVs, air conditioning, and other electrical appliances to save energy, electricity, and water
Shopping	0.157	When shopping, you bring your own bags to reduce the use of plastic bags. You avoid purchasing overly packaged souvenirs. You try to avoid buying plastic and paper products, and bring your own water bottle and handkerchief
Entertainment	0.1496	When choosing tourist activities, you prioritize low-energy, low-impact leisure activities, such as fish watching, tea tasting, and farm-based activities like fruit picking. You try to participate more in nature-based, low-energy entertainment, such as hot springs and outdoor activities. You also aim to minimize the use of modern, high-energy amusement facilities

likely to adopt low-carbon behaviors. The perceived cost increase (X10) represents a potential barrier, directly affecting acceptance of low-carbon tourism. The environmental benefit belief (X12) measures whether tourists understand low-carbon tourism’s practical impact on mitigating environmental degradation - a core cognitive element directly influencing their support and participation. These indicators collectively assess tourists’ understanding across policy, cost, emissions and environmental dimensions.

The attitudinal dimensions comprise: support for industry promotion of low-carbon tourism (X13), willingness to modify consumption habits to achieve Dual Carbon goals (X14), readiness to compromise comfort for low-carbon tourism (X15), and endorsement of supporting regulations (X16). Industry support (X13) evaluates whether tourists recognize the necessity of proactive low-carbon initiatives, reflecting their fundamental attitude. Consumption modification willingness (X14) assesses tourists’ readiness to change personal behaviors, such as adopting eco-friendly travel options. Comfort compromise willingness (X15) indicates tourists’ adaptability to less convenient sustainable options. Regulatory endorsement (X16) measures support for government measures implementing Dual Carbon policies, revealing tourists’ approval of policy interventions in daily tourism activities. These indicators help uncover tourists’ participatory attitudes and behavioral intentions regarding low-carbon tourism advocacy, policy support and personal behavioral changes. Through these measures, we can thoroughly analyze cognitive and attitudinal factors influencing low-carbon tourism behaviors, providing theoretical foundations for promoting sustainable tourism and policy formulation. All variables are presented in Table 2.

2.3 Data collection

The questionnaire for this study consists of five main sections: demographic characteristics, tourism behavior characteristics, awareness of the “dual carbon” goals, attitudes toward the “dual

carbon” goals, and behaviors related to the “dual carbon” initiative. Some questions were measured using a five-point Likert scale, with response options ranging from 1 (“strongly disagree”) to 5 (“strongly agree”).

The survey targeted tourism consumers in Fujian Province and was conducted online in September 2023. Given that tourism development is influenced by factors such as policies, economic conditions, social awareness, cultural norms, and market demand, consumers from different regions may exhibit varying levels of awareness and behavioral patterns regarding low-carbon tourism. To enable a more accurate comparison of regional differences, Fujian Province was divided into four areas: Eastern Fujian (Fuzhou, Putian), Western Fujian (Longyan, Sanming), Southern Fujian (Xiamen, Zhangzhou, Quanzhou), and Northern Fujian (Nanping, Ningde). A random sampling method was employed to ensure a relatively balanced distribution of responses across these four regions. A total of 1,149 questionnaires were collected, of which 1,064 were valid, yielding an effective response rate of 92.60%. The questionnaire demonstrated strong reliability, with a Cronbach’s alpha of 0.949, and high construct validity, as indicated by a Kaiser-Meyer-Olkin (KMO) value of 0.975, confirming its suitability for factor analysis. The basic attributes of the tourism consumers are presented in Table 3. The sample distribution closely aligns with the overall demographics of Fujian Province, ensuring a certain degree of representativeness.

3 Tourism consumers’ awareness and attitudes toward the “dual carbon” goals

3.1 Analysis of tourism consumers’ awareness of the “dual carbon” goals

The four regions of Fujian Province (Eastern, Western, Southern, and Northern Fujian) demonstrate varying levels of awareness regarding China’s “Dual Carbon” policy, showing significant regional disparities in understanding the policy

TABLE 2 Variables.

Variables	Index	Variable meaning and assignment	Mean value	Standard deviation
Cognition	level of understanding of the ‘dual carbon’ policy (X6)	Very Unfamiliar = 1, Unfamiliar = 2, Neutral = 3, Familiar = 4, Very Familiar = 5	2.590	1.1005
	level of understanding of the ‘dual carbon’ concept (X7)	Very Unfamiliar = 1, Unfamiliar = 2, Neutral = 3, Familiar = 4, Very Familiar = 5	4.039	0.9816
	degree of relevance of the ‘dual carbon’ policy to oneself (X8)	Very Low Relevance = 1, Low Relevance = 2, Neutral = 3, High Relevance = 4, Very High Relevance = 5	4.224	0.8819
	importance of the ‘dual carbon’ goals to tourism (X9)	Very Unimportant = 1, Unimportant = 2, Neutral = 3, Important = 4, Very Important = 5	4.193	0.98770
	the ‘dual carbon’ goals increase tourism costs (X10)	Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5	3.627	1.1779
	tourism increases carbon emissions (X11)	Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5	3.667	1.1320
	low-carbon tourism is beneficial for environmental protection (X12)	Strongly Disagree = 1, Disagree = 2, Neutral = 3, Agree = 4, Strongly Agree = 5	4.305	0.7828
Attitude	the necessity of promoting low-carbon practices in the tourism industry (X13)	Very Unnecessary = 1, Unnecessary = 2, Neutral = 3, Necessary = 4, Very Necessary = 5	4.311	0.7820
	willingness to change tourism consumption patterns to achieve the ‘dual carbon’ goals (X14)	Very Unwilling = 1, Unwilling = 2, Neutral = 3, Willing = 4, Very Willing = 5	4.118	0.8270
	willingness to participate in low-carbon tourism and accept reduced travel comfort (X15)	Very Unwilling = 1, Unwilling = 2, Neutral = 3, Willing = 4, Very Willing = 5	4.024	0.9249
	level of support for regulations aimed at facilitating the ‘dual carbon’ goals (X16)	Strongly Oppose = 1, Oppose = 2, Neutral = 3, Support = 4, Strongly Support = 5	4.271	0.7613
Personal characteristics	gender (X1)	Male = 1, Female = 2	1.76	0.4683
	age (X2)	18 years old and below = 1, 19–35 years old = 2, 36–45 years old = 3, 46–59 years old = 4, 60 years old and above = 5	2.492	0.8009
	residential location (X3)	Urban = 1, Rural = 2	1.338	0.4734
	level of education (X4)	Junior high school or below = 1, High school or vocational school = 2, Associate degree = 3, Bachelor’s degree = 4, Master’s degree or above = 5	3.328	1.0249
	individual monthly income (X5)	0–3,000 yuan = 1, 3,001–5,000 yuan = 2, 5,001–8,000 yuan = 3, Above 8,000 yuan = 4	2.148	1.1487

concepts, recognizing their social impacts, and perceiving personal relevance.

Our findings reveal that Eastern Fujian exhibits the strongest policy awareness among tourists, likely attributable to its comprehensive policy promotion and knowledge dissemination within the tourism sector. In contrast, Western Fujian shows the greatest potential for improvement in low-carbon tourism advocacy. Notably, Northern Fujian leads in understanding the carbon peaking and neutrality concepts (73.6%), followed closely by Eastern Fujian (72.2%). Regarding policy importance, Southern Fujian tourists demonstrate the highest recognition of the strategic significance for tourism (82.1%), with Northern Fujian ranking second (78.1%). The majority of respondents across all regions acknowledge the policy’s contribution to sustainable development, with particularly strong consensus in Eastern (89.3%) and Southern Fujian (89.9%). However, most consumers express concerns about implementation challenges, with Southern

(87.2%) and Northern Fujian (82.6%) showing the highest levels of skepticism about achieving these goals. Eastern Fujian stands out in personal relevance perception, with 83.3% recognizing close connections between the policy and daily life. Southern (79.4%) and Northern Fujian (79.6%) show comparable levels of personal relevance awareness, while Western Fujian lags behind at 72.1%. The specific survey data on tourism consumers’ awareness of the “Dual Carbon” goals and the differences across regions in Fujian Province are shown in [Figure 2](#).

3.2 Tourism consumers’ attitudes toward low-carbon tourism

Regional disparities in tourists’ understanding of the “Dual Carbon” policy are further reflected in their attitudinal differences. Southern Fujian demonstrates the most proactive

TABLE 3 Demographic characteristics of survey respondents.

Parameter	Attribute	Sample capacity(N)	Percentage (%)
Gender	Male	345	32.42
	Female	719	67.58
Age	<18	56	5.26
	19~35	571	53.67
	36~45	305	28.67
	47~59	122	11.47
	>61	10	0.94
Education	Junior high school or below	82	7.71
	High school or vocational school	140	13.16
	Associate degree	244	22.93
	Bachelor's degree	543	51.03
	Master's degree or above	55	5.17
Residence	Urban	704	66.17
	Rural	360	33.83
Monthly income	0~3,000 yuan	440	41.35
	3,001~5,000 yuan	220	20.68
	5,001~8,000 yuan	210	19.74
	Above 8,000 yuan	194	18.23
Annual travel frequency	1~2 times	822	77.26
	3~5 times	191	17.95
	6~8 times	30	2.82
	9~12 times	6	0.56
	Above 13 times	15	1.41
Region	Northern Fujian Region	265	24.91
	Eastern Fujian Region	270	25.38
	Southern Fujian Region	257	24.15
	Western Fujian Region	272	25.56

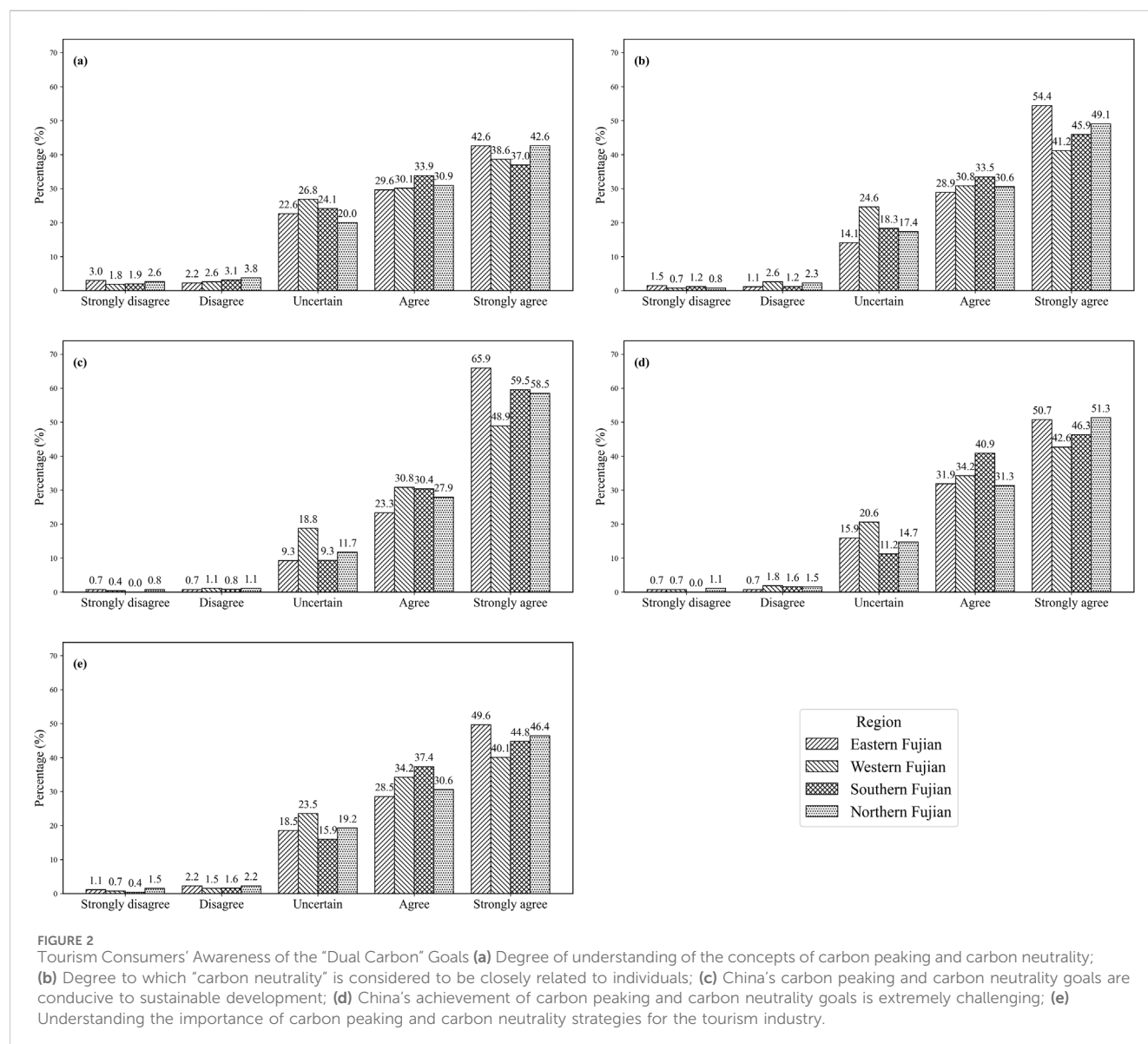
stance, with 92.2% of tourists expressing strong willingness to promote low-carbon tourism knowledge - significantly higher than Western Fujian's 79.8%, indicating a need for enhanced environmental education in the latter region. Regarding stakeholder responsibilities, both Eastern (87.1%) and Southern Fujian (88.7%) show particularly strong expectations for government leadership in policy formulation. Notably, over 80% of respondents across all regions believe enterprises should actively implement low-carbon tourism practices, with Northern Fujian showing the strongest demand (88.2%). These findings reveal consumers' expectations for dominant governmental guidance coupled with corporate accountability. The transition to low-carbon consumption patterns proves crucial for policy implementation. Western (79.1%) and Southern Fujian (79.8%) lead in behavioral willingness, while Western Fujian additionally shows remarkable initiative in seeking related information (79.0%),

demonstrating this group's particularly strong personal commitment to achieving the Dual Carbon objectives. The specific survey data on tourism consumers' attitudes toward low-carbon tourism and the differences across regions in Fujian Province are shown in [Figure 3](#).

4 Low-carbon tourism behaviors of tourism consumers

4.1 Descriptive analysis of low-carbon tourism behaviors

Tourism consumption encompasses six key elements: dining, accommodation, transportation, sightseeing, shopping, and entertainment. Additionally, decisions made by tourism



consumers before embarking on their trips play a crucial role in achieving the "dual carbon" goals. The following analysis examines consumer behaviors related to low-carbon tourism across seven dimensions.

4.1.1 Tourism decision-making

With the implementation of the "dual carbon" policy, environmental considerations are increasingly influencing tourism consumers' decision-making. For instance, in the Southern Fujian region, 77.8% of consumers prioritize selecting low-carbon tourism routes, reflecting a growing public awareness of environmental sustainability. Furthermore, a majority of consumers opt to travel during off-peak seasons and non-peak hours, helping to reduce carbon footprints and alleviate pressure on tourism infrastructure. These trends indicate that Fujian Province has successfully leveraged policy guidance and market incentives to encourage environmentally

conscious travel decisions, thereby accelerating the transition toward low-carbon tourism development.

4.1.2 Tourism transportation

Transportation is one of the largest sources of carbon emissions in tourism, making consumer choices in this sector particularly critical. The data reveals that approximately 75.1% of tourists in Northern Fujian consciously opt for low-carbon transportation alternatives, preferentially choosing walking, cycling, buses, or rail services over private vehicles and air travel when selecting their modes of transportation. These choices not only contribute to reducing carbon emissions but also help ease traffic congestion during peak tourism periods, underscoring the strong support of Northern Fujian consumers for sustainable tourism practices. Encouraging the adoption of low-carbon transportation methods not only mitigates the environmental impact of tourism but also aligns with global

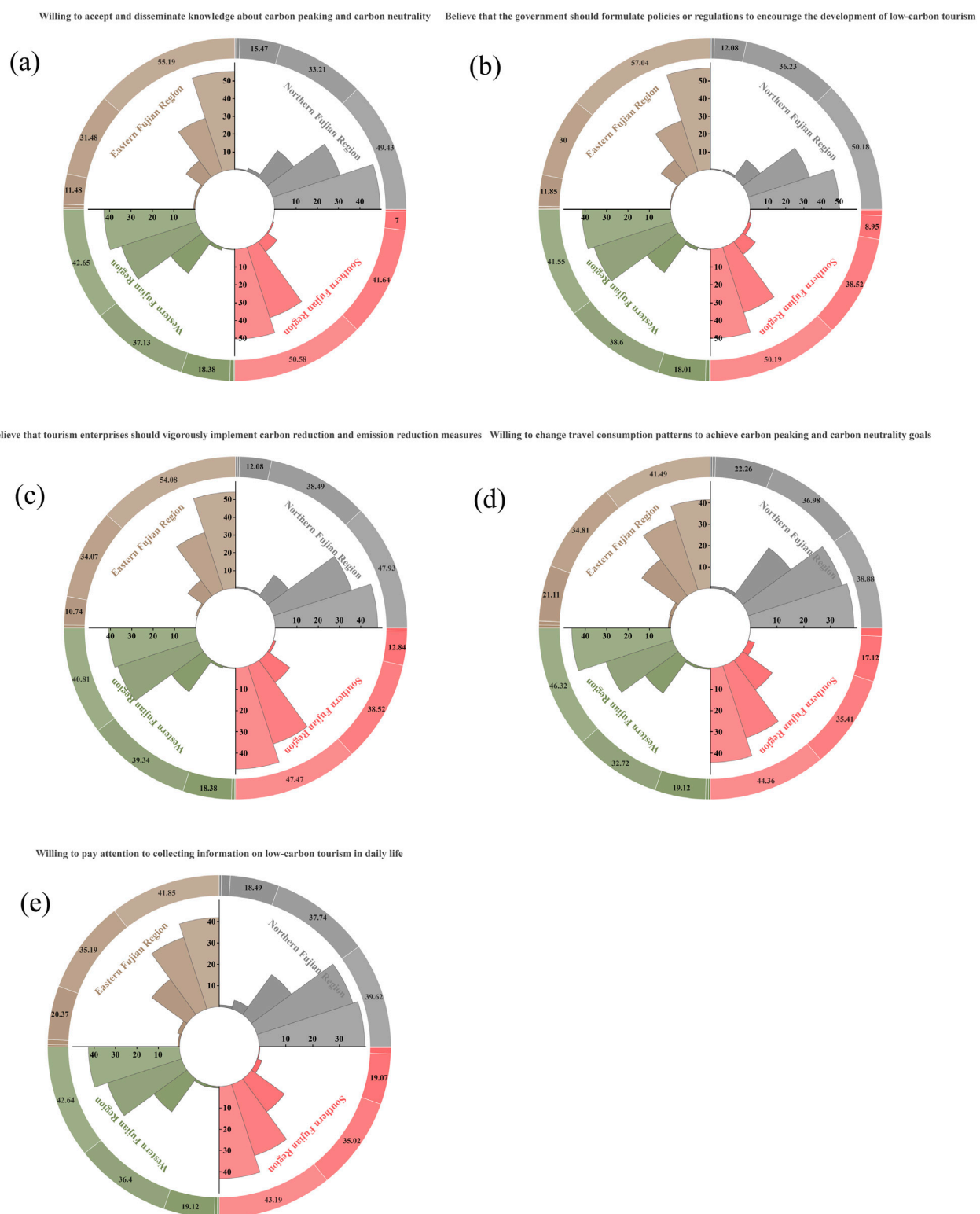


FIGURE 3

Consumers' Attitudes Toward Low-Carbon Tourism (a) Willing to accept and disseminate knowledge about carbon peaking and carbon neutrality; (b) Believe that the government should formulate policies or regulations to encourage the development of low-carbon tourism; (c) Believe that tourism enterprises should vigorously implement carbon reduction and emission reduction measures; (d) Willing to change travel consumption patterns to achieve carbon peaking and carbon neutrality goals; (e) Willing to pay attention to collecting information on low-carbon tourism in daily life.

sustainability goals, highlighting a key direction for the future of tourism mobility.

4.1.3 Tourism accommodation

As a vital component of the tourism industry, sustainable practices in accommodation play a key role in promoting the sector's overall green transformation. In the Eastern Fujian region, 87.2% of tourism consumers actively reduce towel usage and avoid disposable amenities when staying in star-rated hotels, reflecting heightened awareness of energy and resource conservation. Hotels in other regions have also adopted energy-saving measures, such as utilizing energy-efficient equipment and promoting waste recycling. These initiatives not only lower operational costs but also enhance corporate social responsibility, attracting environmentally conscious consumers. Strengthening the development and enforcement of green standards in the accommodation sector will be instrumental in ensuring the industry's sustainable growth.

4.1.4 Tourism dining

In tourism dining, consumer preferences increasingly reflect a commitment to sustainability. In the Southern Fujian region, 41.64% of tourists prioritize green or locally sourced food, reducing carbon emissions associated with long-distance transportation while supporting local agricultural sustainability. Choosing local food also minimizes the need for preservatives and packaging, further decreasing environmental impact. This trend underscores a growing public consciousness toward both health and ecological wellbeing.

4.1.5 Tourism shopping

Eco-friendly consumption practices are gaining traction in tourism shopping, demonstrating a heightened environmental awareness among consumers. In the Western Fujian region, 84.4% of tourists bring reusable shopping bags, reducing plastic waste and mitigating environmental pollution. Similar trends are observed across other regions. To further encourage sustainable shopping behaviors, businesses and tourist destinations can introduce incentives, such as discounts for customers who opt for environmentally responsible products, thereby fostering both sustainability and brand loyalty.

4.1.6 Tourism entertainment

An increasing number of consumers prefer low-energy, low-impact entertainment activities, indicating a growing awareness of environmental sustainability. In the Eastern Fujian region, 89.9% of tourists engage in nature-based, low-energy activities such as outdoor adventures and cultural experiences, reducing reliance on energy-intensive entertainment facilities. These activities not only contribute to environmental conservation but also support local cultural preservation. Direct engagement with nature fosters a deeper appreciation of ecological fragility, serving as an effective tool for environmental education and advocacy.

4.1.7 Tourism sightseeing

Regional differences in sightseeing behaviors reflect varying levels of consumer commitment to eco-friendly tourism, particularly regarding non-motorized transportation and environmental conservation efforts. Northern Fujian leads in

sustainable sightseeing practices, with 84.1% of tourists opting for public transportation, walking, or cycling. These behaviors help reduce carbon emissions and alleviate peak-season congestion. Additionally, tourists in this region actively participate in environmental initiatives, such as litter collection, showcasing a strong sense of environmental responsibility. The Eastern Fujian region also demonstrates notable eco-conscious sightseeing behaviors, with 86.7% of tourists favoring low-carbon transportation. Southern Fujian follows closely at 84.5%, while Western Fujian lags slightly behind at 83.2%. These regional disparities may stem from differences in environmental infrastructure, public awareness, and local policy support.

4.2 Analysis of factors influencing low-carbon tourism behaviors

A multiple linear regression model was employed to analyze the factors influencing low-carbon tourism behavior patterns among tourists in the Northern, Western, Eastern, and Southern regions of Fujian. All variables successfully passed the multicollinearity test. The results (Table 4) indicate that the factors and degree of influence of tourists' awareness (X1–X12) on low-carbon tourism behavior vary across regions, whereas the impact of attitudes toward low-carbon tourism (X13–X16) is more pronounced. Among the awareness-related factors, the perceived importance of the “dual carbon” policy for tourism (X9), the level of understanding of the “dual carbon” policy (X6), and familiarity with the “dual carbon” concept (X7) all exert some influence on low-carbon tourism behavior across different regions. In contrast, attitude-related factors, such as willingness to adjust tourism consumption patterns to align with “dual carbon” goals (X14), willingness to participate in low-carbon tourism despite potential reductions in travel comfort (X15), and support for regulations promoting the “dual carbon” initiative (X16), demonstrate a significant positive impact on low-carbon tourism behavior in all four regions. Conversely, personal characteristics (X1–X5), including gender, age, place of residence, education level, and monthly income, do not exhibit a significant influence on low-carbon tourism behavior in any of the four regions.

The factors influencing low-carbon tourism behavior patterns among tourists exhibit regional variations. In the Northern Fujian region, recognizing the importance of the “dual carbon” goals to tourism (X9) has a significant positive impact on consumers' low-carbon tourism behavior ($\beta = 0.308^{**}$, $t = 5.637$). Awareness of the significance of low-carbon tourism enhances tourists' understanding of sustainable travel, fostering rational consideration of low-carbon practices and encouraging responsible environmental actions. The presence of natural landscape attractions such as Wuyi Mountain, Taimu Mountain, and Sandu Bay—characterized as low-carbon tourism environments—further reinforces this awareness. Prior research by Haybatollahi et al. (2015) suggests that low-carbon tourism environments can enhance tourists' awareness of sustainability, thereby promoting eco-friendly tourism behaviors. The findings of this study further validate this conclusion.

In the Eastern Fujian region, understanding of the “dual carbon” policy (X6) has a significant negative impact on low-carbon tourism behavior ($\beta = -0.126^{**}$, $t = -3.072$). This results may be attributed to

TABLE 4 Regression results.

Independent variable	Northern Fujian		Eastern Fujian		Southern Fujian		Western Fujian	
	β	t	β	t	β	t	β	t
X1	−0.002	−0.056	0.021	0.529	0.056	1.453	0.047	1.488
X2	0.004	0.115	0.044	1.003	−0.065	−1.55	0.027	0.866
X3	−0.001	−0.031	0.024	0.607	0.041	1.078	0.001	0.025
X4	−0.006	−0.152	−0.065	−1.489	−0.039	−0.91	−0.03	−0.89
X5	0.01	0.244	0.043	1.006	0.026	0.621	0.01	0.271
X6	−0.003	−0.079	−0.126**	−3.072	0.026	0.627	0.018	0.583
X7	−0.075	−1.596	−0.097	−1.661	0.108*	2.092	0.019	0.352
X8	0.085	1.677	0.1	1.605	0.065	1.154	−0.026	−0.43
X9	0.308**	5.637	0.091	1.671	0.145**	2.687	0.057	1.131
X10	−0.021	−0.542	0.086	1.78	0.07	1.43	−0.047	−1.09
X11	0.103	2.52	−0.05	−1.002	0.007	0.143	0.009	0.191
X12	0.003	0.05	−0.047	−0.838	−0.006	−0.1	0.051	0.935
X13	0.063	0.982	0.047	0.714	−0.102	−1.52	0.188**	3.102
X14	0.152*	2.378	0.205**	3.366	0.247**	3.969	0.228**	4.164
X15	0.251**	4.396	0.327**	5.903	0.22**	3.837	0.206**	4.426
X16	0.181**	3.223	0.28**	4.518	0.282**	4.268	0.319**	6.063
Adjusted R ²	0.762		0.671		0.68		0.793	
F	F (16,248) = 53.744 p = 0.000		F (16,253) = 35.307 p = 0.000		F (16,240) = 35.057 p = 0.000		F (16,255) = 65.911 p = 0.000	

Among them, *p < 0.05, **p < 0.01; β is the standardized coefficient.

several key factors: a disconnect between policy promotion and practical implementation, convenience-oriented tourism preferences driven by the region's export-oriented economic structure, and insufficient development of low-carbon tourism infrastructure. Similarly, in the Southern Fujian region, understanding of the “dual carbon” concept (X7, β = −0.108*, t = −2.092) and recognizing the importance of the “dual carbon” goals to tourism (X9, β = 0.145**, t = 2.687) strongly influence low-carbon tourism behavior patterns. Public comprehension of the “dual carbon” policy and concept largely depends on education and promotional efforts by the government, tourism authorities, and related institutions. In the Eastern Fujian, however, the connection between “dual carbon” education and low-carbon tourism awareness remains relatively weak. This may be attributed to the diverse nature of tourism resources in the area, which include urban cultural sites such as Three Lanes and Seven Alleys and Yantai Mountain, alongside more remote natural destinations like Meizhou Island and Jiuli Lake, where infrastructure and transportation are less developed. Zhang Lingling et al.'s research on Gulangyu Island in Xiamen found that tourists are more inclined to adopt low-carbon tourism behaviors when they require minimal effort and financial cost, prioritizing factors such as personal economic impact, comfort, and convenience (Zhang et al., 2016). This insight helps explain the disconnect between policy awareness and low-carbon tourism behaviors among tourists in the Eastern Fujian region.

In Western Fujian, the belief in the necessity of promoting low-carbon tourism (X9) has a significant positive impact on consumer behavior patterns (β = 0.188**, t = 3.102). This finding suggests that while tourists in this region acknowledge the importance of low-carbon tourism, their awareness remains largely superficial, with an expectation that the government, tourism enterprises, and scenic areas should take primary responsibility for its development. At the same time, it indicates that tourists in Western Fujian who possess higher awareness of low-carbon tourism exhibit a strong willingness to engage in eco-friendly travel and a heightened sense of responsibility toward sustainability. These findings highlight the need for enhanced promotional efforts to foster deeper engagement with low-carbon tourism practices in the region.

5 Conclusions and discussion

Overall, tourism consumers in Fujian Province exhibit a relatively clear understanding of the “dual carbon” concept and low-carbon tourism, alongside positive attitudes toward adopting sustainable tourism practices. The key findings are as follows: (1) Awareness and perception of the “dual carbon” policy vary across the Eastern, Western, Southern, and Northern regions of Fujian. These differences are reflected in

consumers' understanding of the concept, their evaluation of the policy's impact, and their perception of its relevance to their personal lives. Consumers in the Eastern Fujian region demonstrate a strong awareness of the "dual carbon" policy, whereas efforts to enhance understanding and implementation in the Western Fujian region remain insufficient. (2) Tourism consumers across different regions exhibit diverse attitudes toward China's "dual carbon" policy goals, ranging from basic awareness to specific behavioral intentions. Consumers in the Eastern Fujian region are the most proactive in accepting and disseminating environmental knowledge, while those in the Northern Fujian region strongly acknowledge the policy's importance. Additionally, consumers in the Eastern and Southern Fujian regions emphasize the role of government and businesses in advancing low-carbon tourism. Notably, consumers in the Western Fujian region exhibit the highest willingness to modify their tourism consumption patterns in support of the "dual carbon" goals. (3) The factors influencing consumers' low-carbon tourism behavior patterns vary by region. While attitudes toward low-carbon tourism have a more pronounced impact on behavior, personal characteristics do not significantly affect consumers' engagement in sustainable tourism practices.

The cognitive-behavior gap observed in Eastern Fujian warrants particular attention, with its underlying causes being multifaceted. First, policy promotion emphasizes macro-level goals while lacking specific behavioral guidance. Eastern Fujian's low-carbon policies predominantly focus on technology-enabled solutions like "cultural tourism + technology" integration, with publicity campaigns stressing the overarching significance of Dual Carbon objectives but failing to provide direct incentives for individual low-carbon tourism behaviors. For example, although Fuzhou proposes building a "world-class tourism and leisure city," its policy documents rarely specify reward mechanisms or behavioral norms for tourists' low-carbon actions, resulting in public understanding remaining at a conceptual level rather than translating into concrete practices. Second, there exists a contradiction between consumption preferences driven by the economic structure and low-carbon behaviors. Eastern Fujian's highly export-oriented economy, with well-developed digital and port industries, leads consumers to prioritize convenience and comfort in tourism experiences, such as coastal resorts and smart tourism projects, while perceiving low-carbon behaviors like reducing accommodation energy use or choosing public transportation as "burdens" that compromise experience quality. Finally, insufficient supporting infrastructure for low-carbon tourism limits the translation of policy awareness into actual choices. For instance, while Eastern Fujian promotes ecological tourism projects like the "No.1 Coastal Scenic Route," the coverage of low-carbon transportation options like electric shuttle vehicles and eco-friendly accommodation facilities remains inadequate. Consequently, even when consumers understand the policies, they often cannot implement low-carbon practices due to limited feasible alternatives. A case in point is Pingtan International Tourism Island, which markets itself as an ecotourism destination but still relies heavily on conventional fuel-powered vehicles in actual operations, thereby weakening the consistency between environmental awareness and behavior. In contrast, Western and Northern Fujian have adopted ecologically constrained low-carbon

models through carbon sink trading and electric cruise ships, leading to more profound practical engagement with and understanding of low-carbon tourism that consequently promotes corresponding behaviors. Meanwhile, Southern Fujian incorporates technology-driven approaches like digital intangible cultural heritage and VR experiences into low-carbon consumption scenarios, which helps deepen comprehension of Dual Carbon concepts and their tourism significance while encouraging low-carbon tourism consumption. This differentiated landscape provides both theoretical foundations and practical evidence for Fujian Province to explore diversified low-carbon tourism pathways, offering multidimensional case studies for regional tourism coordination and low-carbon transition.

Zhang et al. (2017) examined the factors influencing tourists' low-carbon tourism behavior in Kunshan, finding that both awareness of low-carbon tourism and willingness to participate had a significant positive impact on tourists' engagement in low-carbon tourism practices. This study further reinforces the notion that cognition and attitude are critical determinants in shaping low-carbon tourism patterns. Similarly, Tang et al. (2011) investigated the awareness, willingness, and behavior of tourists in Zhangjiajie, demonstrating that educational attainment and familiarity with low-carbon tourism were significantly correlated with the level of low-carbon awareness, whereas personal income had no significant effect. The present study extends these findings by revealing that factors such as the perceived relevance of the "dual carbon" policy, the perception of increased tourism costs associated with "dual carbon" initiatives, and the perception of tourism-related carbon emissions—all of which serve as indicators of familiarity with low-carbon tourism—do not significantly influence low-carbon tourism behavior. Additionally, individual attributes such as educational attainment and personal income are also found to have no significant impact, further highlighting the nuanced relationship between awareness, attitudes, and behavioral adoption in the context of low-carbon tourism.

This study has several limitations that should be acknowledged: (1) The survey sample exhibits gender imbalance, with female tourists being overrepresented due to their greater sensitivity to and willingness to participate in low-carbon tourism surveys. However, our analysis reveals that gender does not significantly influence low-carbon consumption behaviors, suggesting this imbalance does not substantially affect the overall conclusions. (2) The research relies solely on 2023 cross-sectional data, whereas understanding the longitudinal dynamics of how attitudes and cognition affect low-carbon tourism behaviors would require panel data from multiple years of tracking surveys for more robust interpretation.

6 Recommendations for the tourism industry

- (1) Given the varying levels of awareness of the "dual carbon" policy across different regions in Fujian Province, it is essential to implement targeted publicity and education initiatives. In the Eastern Fujian, efforts should be directed toward reinforcing and enhancing public perception of the "dual carbon" policy. This can be achieved through environmental education programs and the promotion of

sustainable lifestyles, thereby fostering greater public engagement in low-carbon tourism. Additionally, establishing incentive mechanisms for low-carbon tourism could effectively encourage the adoption of eco-friendly practices among tourists. In contrast, in the Western Fujian region, where awareness of the policy remains relatively low, intensified dissemination efforts are necessary to highlight the significance of low-carbon tourism. Additionally, the introduction of incentive policies can serve as a catalyst, encouraging tourism businesses and consumers to actively participate in sustainable tourism practices.

- (2) Restructuring the tourism industry's internal framework could significantly contribute to energy conservation and emission reduction. Given the growing tourist preference for interactive experiences in travel products, there is a compelling need to develop and promote low-carbon tourism offerings (Tang et al., 2017). Fujian Province boasts rich ecotourism resources and should actively advance the development and promotion of low-carbon tourism products and services, including green hotels, eco-friendly travel routes options. Simultaneously, tourism enterprises should be encouraged to integrate environmentally friendly materials and energy-efficient technologies to mitigate the ecological footprint of tourism activities. In Northern Fujian, efforts should focus on further optimizing ecotourism projects centered around the region's natural landscapes. Meanwhile, in Eastern and Southern Fujian, the establishment and implementation of standardized low-carbon tourism services should be prioritized, with strong support from both governmental policies and corporate social responsibility initiatives.
- (3) Broad stakeholder participation—including local communities, tourists, and tourism industry employees—should be actively encouraged to foster the sustainable development of low-carbon tourism. Local communities should be directly involved in the planning and implementation of low-carbon tourism initiatives to ensure that their interests and needs are fully considered. Additionally, employees within the tourism sector should receive specialized training in low-carbon practices, equipping them to serve as both advocates and practitioners of sustainable tourism. Meanwhile, targeted educational and promotional campaigns should be implemented to enhance tourists' awareness and willingness to adopt low-carbon travel behaviors, such as utilizing public transportation and engaging in eco-friendly activities.
- (4) Environmental innovations in the transportation sector play a pivotal role in mitigating carbon emissions from international tourism, with the development of low-carbon transport technologies being particularly crucial (Erdoğan et al., 2022). To operationalize this, we propose a comprehensive implementation strategy: Firstly, mandate the adoption of new energy shuttle vehicles, coupled with necessary charging infrastructure development. These eco-friendly attractions should receive operational subsidies and policy incentives. Secondly, establish an integrated "high-speed rail + new

energy shuttle" intermodal system, creating dedicated new energy tourism routes at major high-speed rail stations to serve tourist cities. Visitors opting for these low-carbon options should be rewarded with attraction ticket discounts and other benefits. Thirdly, strengthen enforcement of the new energy vehicle credit management system for automobile manufacturers to ensure compliance and accelerate the green transition.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

LZ: Writing – original draft. JY: Writing – review and editing. ML: Writing – review and editing. XQ: Writing – review and 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.

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