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Research Article

# Developing a Model for Sustainable Tourism: Promoting Low-Carbon Tourist Behaviors at Qingdao as a Destination

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**Abstract:** The environmental damage caused by tourism activities is increasingly severe. We are trying various lowcarbon tourism activities to reduce carbon emissions and carbon footprint. This research aims to investigate the path of subjective norms, comfort preferences, local attachment, and perceptual-behavioral control in affecting low-carbon tourism behaviours, and to examine the mediating roles of low-carbon tourism attitudes and low-carbon tourism intentions.
The research used an online survey to collect 757 tourists from five significant provinces in China—Beijing, Henan, Hebei, Jiangsu, and Anhui—who had visited Qingdao city, China. A purposive sampling method was employed to target participants with a relevant background in low-carbon tourism and environmental awareness. Then, structural equation modelling (SEM) was used to process the data. The findings reveal that subjective norms, comfort preferences, and local attachment positively influence tourists' attitudes and intentions toward low-carbon tourism, while perceptual-behavioural control is a significant predictor of actual low-carbon tourism behaviours. Furthermore, the study demonstrates that both attitudes and intentions act as mediators between these factors and behaviour, particularly emphasizing the critical role of comfort preference in shaping tourism behaviours. The results offer practical insights for stakeholders in the tourism sector, highlighting the need for targeted interventions to enhance tourists' emotional connections to destinations, increase awareness of eco-friendly practices, and promote comfort in low-carbon tourism options.

**Keywords:** ocean biology management, low-carbon tourism, marine protection, sustainable tourism, Qingdao, marine ecology

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## 1. Introduction

As global awareness of climate change intensifies, the tourism industry faces increasing pressure to adopt sustainable practices that balance economic growth with environmental preservation (Idroes et al., 2024). Low-carbon tourism, as a significant subset of sustainable tourism, focuses on reducing the carbon footprint associated with tourism activities (Li et al., 2023). It promotes environmentally friendly travel practices such as the use of energy-efficient transportation, renewable energy sources, and eco-friendly accommodations. Low-carbon tourism offers a way to achieve this balance by encouraging both tourists and businesses to minimize their environmental impact (Hsiao et al., 2021). This shift is significant in popular tourist destinations where

large numbers of visitors contribute significantly to carbon emissions.

Qingdao, a prominent coastal city in China, has emerged as a critical destination for exploring the application of lowcarbon tourism (Sun et al., 2024). Known for its scenic beaches, cultural landmarks, and rich natural resources, Qingdao attracts millions of tourists annually, contributing significantly to the local economy. In 2023, from January to August, the city welcomed 89.56 million domestic tourists, an increase of 57.98% compared to the previous year and a 16.15% increase compared to 2019 (Dazhong Daily, 2024). This surge in tourism generated China's domestic tourism revenue of 117.63 billion yuan, up by 38.63%. For the entire year, Qingdao is projected to receive 117 million visitors, with tourism revenue expected to reach 170.65 billion yuan, reflecting a robust recovery post-pandemic and emphasizing the industry's critical role in driving economic growth (Dazhong Daily, 2024).

However, the environmental pressure from such rapid tourism growth is evident, particularly in terms of carbon emissions and resource overuse (Ali et al., 2021). Qingdao has actively responded to national carbon peak and neutrality goals by implementing a series of emission reduction measures. According to the 2023 Qingdao Ecological Environment Report, the city has significantly reduced vital pollutants, including 20,623 tons of chemical oxygen demand and 7,387 tons of nitrogen oxides (Qingdao Government Network, 2024). Additionally, efforts to promote low-carbon tourism include upgrading sewage treatment facilities and industrial waste management while encouraging green practices across tourist attractions (Lin et al., 2022). Qingdao's focus on green, low-carbon operations in major scenic areas is a critical component of its sustainable tourism strategy (Sun et al., 2024). Nevertheless, challenges remain, particularly in managing the environmental impacts of peak tourist seasons, overdevelopment, and maintaining the ecological balance in highly visited areas (Zhang & Li, 2021). Thus, while tourism continues to drive economic benefits, Qingdao's efforts to integrate sustainability are crucial for the long-term protection of its natural environment (Li et al., 2021).

The low-carbon tourism economy in Qingdao has gained momentum through various initiatives aimed at promoting environmentally conscious travel. The city has invested in green infrastructure, such as extensive public transportation networks and cycling paths around popular destinations like Laoshan (Chen et al., 2022). Many hotels and resorts have adopted green practices, incorporating energy-saving technologies, waste-reduction measures, and the use of renewable energy sources (Luo et al., 2021). These efforts not only reduce the environmental impact of tourism but also align with broader sustainability goals, attracting eco-conscious travellers.

However, Qingdao's tourism growth has also led to environmental challenges. Tourism-related activities have contributed to marine pollution, as seen in areas like Jiaozhou Bay, where water quality has deteriorated due to pollutants such as inorganic nitrogen. Additionally, overdevelopment in tourist areas, like the illegal expansion of Taipingling Cemetery in Laoshan, has caused deforestation and ecological damage (Wang, 2020). Peak tourist seasons bring further stress, exemplified by frequent green algae blooms along the coast, which harm both the marine environment and tourism (Häder et al., 2020). Furthermore, the rapid growth of tourism has outpaced the city's capacity to manage resources like water and waste, highlighting the need for more robust environmental governance and public participation to ensure sustainable development.

In recent years, Qingdao has seen a steady increase in the adoption of low-carbon tourism activities, such as cycling events and beach cleaning campaigns. They indicated a growing emphasis on sustainability within the region (Li et al., 2024). However, the adoption of low-carbon behaviours is not uniform, and significant challenges remain in promoting eco-friendly practices across all tourist segments (Hong et al., 2024). While some tourists actively seek out sustainable options, others continue to engage in carbon-intensive activities, suggesting the need for further education and incentives to encourage broader participation in low-carbon tourism.

As the global tourism industry continues to evolve, the importance of low-carbon tourism cannot be overstated. In Qingdao, the integration of low-carbon principles into the tourism sector presents both challenges and opportunities.

While significant progress has been made in understanding these dynamics, existing literature often generalizes findings across various destinations, lacking focus on the unique context of cities like Qingdao. This study fills this gap by applying TPB and SCT within the specific environment of Qingdao, exploring how these theories can inform targeted strategies for promoting low-carbon tourism. Doing so contributes to a more nuanced understanding of sustainable tourism practices, offering actionable recommendations for fostering eco-friendly behaviours that align with Qingdao's unique ecological and cultural landscape. This study aims to explore the key factors influencing low-carbon tourism behaviour in Qingdao, focusing on how subjective norms, comfort preferences, local attachment, and perceived behavioural control affect tourists' attitudes and intentions toward low-carbon tourism. Additionally, the research investigates the mediating roles of low-carbon tourism attitudes and intentions in the relationships between these psychological and social factors and actual low-carbon behaviours.

Following this, the second section provides a literature review, introducing the theoretical framework, variables, and relevant hypotheses. The third section discusses the research methodology. The fourth section presents the research findings. The fifth section offers a discussion of the results, including comparisons with previous studies and practical implications. Finally, the conclusion summarizes the study and explains its limitations, as well as directions for future research.

## 2. Literature Review

Low-carbon tourism behaviour has garnered significant attention in recent years, particularly in light of global concerns surrounding climate change and sustainability

(Gössling & Higham, 2020). Low-carbon tourism refers to the activities undertaken by tourists to minimize their carbon footprint, such as using public transportation, staying in ecofriendly accommodations, and reducing waste (Fakfare & Wattanacharoensil, 2023). This concept aligns with the broader goal of sustainable tourism, which aims to balance economic, environmental, and social considerations to promote environmental protection and social welfare.

Theory of Planned Behavior (TPB) is a crucial framework for understanding low-carbon tourism behaviour, suggest that individuals' behavioural intentions are influenced by their attitudes, subjective norms, and perceived behavioural control, which together determine whether they will engage in a particular behaviour. Recently, TPB has been widely applied in the context of environmental protection and sustainable development, significantly to predict tourists' behavioural intentions regarding eco-friendly and low-carbon tourism practices (Panwanitdumrong & Chen, 2021).

Subjective norms are a core component of TPB, referring to the perceived social pressure from others to engage in a particular behaviour (Husain et al., 2021). In the context of low-carbon tourism, subjective norms often reflect the social support that tourists feel or the expectations others have for them to engage in eco-friendly behaviours. These expectations may come from friends, family, or the broader social community. When individuals perceive solid social support, they are more likely to form positive attitudes and further develop intentions to participate in low-carbon tourism (Cheng et al., 2024). Subjective norms play a critical role in promoting environmentally friendly behaviours by shaping both attitudes and intentions. Therefore, this study proposes the following hypotheses:

• H1: Subjective norms positively affect low-carbon tourism attitudes.

• H2: Subjective norms positively affect low-carbon tourism intention.

Comfort preference is another critical psychological factor, especially in tourism decision-making. Comfort preference refers to the extent to which individuals prioritize convenience and comfort when making travel choices (Fitch et al., 2022). In the context of low-carbon tourism, tourists may be reluctant to adopt low-carbon behaviours if they perceive these actions as inconvenient or uncomfortable. For instance, public transportation may be less comfortable than private cars, and eco-friendly accommodations may lack specific amenities (Mouratidis et al., 2021). Therefore, the following hypotheses are proposed:

• H3: Comfort preference positively affects low-carbon tourism attitudes.

• H4: Comfort preference positively affects low-carbon tourism intention.

Local attachment refers to the emotional bond that individuals feel toward a specific place or destination, which significantly influences their attitudes and behaviours regarding the conservation of the local environment (Daryanto & Song, 2021). In the context of low-carbon tourism, local attachment is reflected in tourists' emotional investment in a destination. Tourists who feel a strong connection to a destination are more likely to engage in eco-friendly behaviours to help preserve the natural environment of the area they cherish (Tu & Ma, 2021). Thus, local attachment not only affects tourists' attitudes toward low-carbon tourism but also enhances their intention to participate in sustainable tourism.

Therefore, the following hypotheses are proposed:

• H5: Local attachment positively affects low-carbon tourism attitudes.

• H6: Local attachment positively affects low-carbon tourism intention.

Perceived behavioural control is another crucial construct within TPB, referring to individuals' beliefs regarding their ability to perform a particular behaviour, including their assessment of available resources, knowledge, and the perceived difficulty of the behaviour (Fischer & Karl, 2021). In the context of low-carbon tourism, perceived behavioural control indicates tourists' beliefs about their ability to engage in low-carbon behaviours, such as using eco-friendly transportation or reducing carbon emissions during travel. When tourists believe they have sufficient resources and capabilities, they are more likely to form positive attitudes and engage in low-carbon tourism behaviours. Therefore, the following hypotheses are proposed:

• H7: Perceived behavioural control positively affects low-carbon tourism attitudes.

• H8: Perceived behavioural control positively affects low-carbon tourism intention.

• H9: Perceived behavioural control positively affects low-carbon tourism behaviour.

Within TPB, attitudes and intentions act as mediators, connecting psychological factors (such as subjective norms, comfort preference, and local attachment) to actual behaviour. A positive attitude toward low-carbon tourism is a precursor to solid behavioural intention, which in turn increases the likelihood of engaging in low-carbon behaviours (Dolnicar & Demeter, 2024). For instance, research indicates that tourists with a positive attitude toward low-carbon tourism are more likely to choose eco-friendly accommodations and transportation options (Zhang et al., 2023). Based on this understanding, the following hypotheses are proposed:

• H10: Low-carbon tourism attitudes positively affect low-carbon tourism intention.

• H11: Low-carbon tourism attitudes positively affect low-carbon tourism behaviour.

• H12: Low-carbon tourism intention positively affects low-carbon tourism behaviour.

In the Theory of Planned Behavior, subjective norms not only directly affect low-carbon tourism attitudes and intentions but also influence actual behaviour through indirect pathways (Lin & Wang, 2021). Specifically, subjective norms may foster positive low-carbon tourism attitudes, which can then translate into actual behaviour. This indirect mechanism highlights the more profound impact of subjective norms, whereby individuals alter their behaviour based on perceived social expectations (Zong et al., 2024). Additionally, subjective norms can influence behaviour via intention

as a mediating variable, creating a more enduring and stable effect. Therefore, the following hypotheses are proposed:

• H13: Low-carbon tourism attitudes mediate the relationship between subjective norms and low-carbon tourism behaviour.

• H14: Low-carbon tourism intention mediates the relationship between subjective norms and low-carbon tourism behaviour.

Comfort preference occupies a unique position in low-carbon tourism behaviour (Suryawan & Lee, 2023). Although comfort preference is often seen as a barrier to environmental behaviour, it can be transformed into eco-friendly behaviour through positive attitudes with appropriate guidance (Tran et al., 2022). This transformation involves the direct influence of comfort preference on attitudes, which subsequently affects behaviour. Specifically, fulfilling tourists' comfort preferences fosters positive attitudes toward low-carbon tourism, which further encourages low-carbon tourism behaviors. Additionally, comfort preference may be indirectly linked to behavior through intention as a mediator; that is, tourists who balance comfort with strong environmental intentions are more likely to engage in low-carbon tourism behaviors. Thus, the following hypotheses are proposed:

• H15: Low-carbon tourism attitudes mediate the relationship between comfort preference and low-carbon tourism behaviour.

• H16: Low-carbon tourism intention mediates the relationship between comfort preference and low-carbon tourism behaviour.

Local attachment is a significant factor in eco-tourism settings. Local attachment not only strengthens tourists' emotional ties to a destination but also fosters a sense of responsibility and commitment to protecting the local environment (Yu et al., 2022). Tourists with strong local attachments tend to engage in eco-friendly behaviours to protect the natural resources and ecological balance. The influence of local attachment on low-carbon tourism behaviour can be transmitted through attitudes, meaning that emotional ties to a destination can translate into positive attitudes toward lowcarbon tourism, which subsequently lead to eco-friendly behaviours (He et al., 2024). Additionally, intention plays a crucial mediating role in this process (Masuda et al., 2022). The responsibility and sense of belonging that come with local attachment reinforce tourists' intentions to protect the environment, increasing the likelihood of engaging in low-carbon tourism behaviours. Therefore, the following hypotheses are proposed:

• H17: Low-carbon tourism attitudes mediate the relationship between local attachment and low-carbon tourism behaviour.

• H18: Low-carbon tourism intention mediates the relationship between local attachment and low-carbon tourism behaviour.

• Perceived behavioural control not only directly affects individuals' low-carbon tourism attitudes and intentions but also indirectly influences behaviour (Nuwan Gunarathne et al., 2020). Perceived behavioural control refers to an individual's belief in their ability to engage in certain behaviours (Aitken et al., 2020). When tourists believe they have sufficient resources and capabilities to engage in low-carbon tourism behaviours, they are more likely to form positive attitudes and intentions. This confidence enhances the likelihood of adopting low-carbon tourism behaviours. The indirect influence of perceived behavioural control can be transmitted through attitudes and intentions, particularly when tourists perceive eco-friendly behaviours as feasible; their positive attitudes and intentions further translate into low-carbon tourism behaviors. Therefore, the following hypotheses are proposed:

H19: Low-carbon tourism attitudes mediate the relationship between perceived behavioural control and low-carbon tourism behaviour.

H20: Low-carbon tourism intention mediates the relationship between perceived behavioural control and lowcarbon tourism behaviour.

Finally, low-carbon tourism attitudes not only directly influence low-carbon tourism behaviour but also play a mediating role through behavioural intention (Zhan et al., 2024). A positive attitude toward low-carbon tourism is a

prerequisite for forming behavioural intentions, and intention acts as a bridge, translating attitudes into actual behaviour. Tourists with positive attitudes toward low-carbon tourism and a clear environmental intention are more likely to adopt low-carbon behaviours during their travels (Zhang & Zhang, 2020). Therefore, the following hypothesis is proposed:

H21: Low-carbon tourism intention mediates the relationship between low-carbon tourism attitudes and low-carbon tourism behaviour.

**Combined with the above content, figure 1 embodies the empirical mode l.**

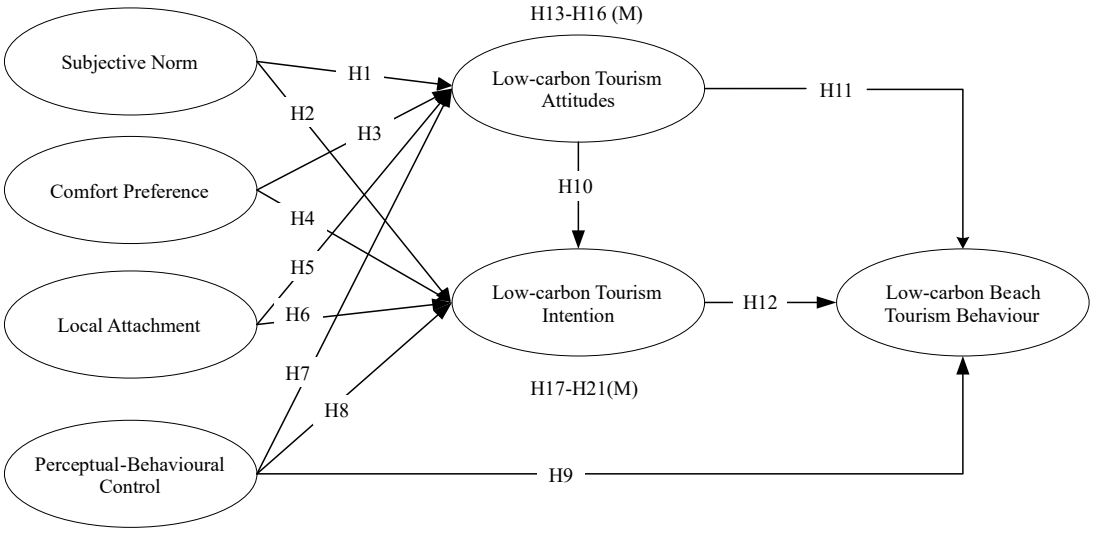


**Figure 1 The Empirical Framework of the Study**

## 3. Research Method

This study began with data collection through a structured online questionnaire targeting tourists from five significant provinces in China: Beijing, Henan, Hebei, Jiangsu, and Anhui. These provinces were selected due to their high number of travellers to Qingdao and their diverse socio-economic backgrounds, making them ideal for examining factors influencing low-carbon tourism practices. A purposive sampling technique was used to ensure that participants had a relevant background in low-carbon tourism, particularly those who had joined the Environmental Volunteer Association, thus ensuring a heightened awareness of environmental issues.

Table 1 introduces a total of 757 valid responses were collected, all from tourists who had visited Qingdao within the past year. In terms of sample demographics, the distribution was reasonably balanced across genders, with 53.4% male and 46.6% female respondents. The age distribution was also diverse, with 25% of respondents aged 26-35, 19.1% aged 18-25, and 19.2% aged 56 and above. Geographically, the respondents were well-represented, with Beijing (23.8%) and Jiangsu (21.1%) contributing the most enormous proportions. Education levels were notably high, with 75% of respondents holding a bachelor's degree or higher, suggesting that the sample might have a heightened awareness of environmental and sustainable tourism practices. Regarding behaviours related to low-carbon tourism, 59.2% of respondents had visited the Laoshan Scenic Area, indicating its popularity as a low-carbon tourist attraction. Other popular sites included Qingdao Forest Park and the Badaguan Scenic Area. The survey also identified non-low-carbon behaviours, with 53% reporting littering and 52.1% noting the use of high-emission motor vehicles. However, positive behaviours such as participation in educational programs on sustainability (53.9%) and staying in eco-friendly accommodations (50.6%) were also reported, indicating significant engagement in sustainable practices.

This diverse sample, both geographically and socio-economically, provides a comprehensive understanding of lowcarbon tourism behaviours, allowing for the generalizability of the findings across broader tourist populations

**Table 1 Essential Information**

| Information | Parameter | | Frequency | Per cent |
|---|---|---|---|---|
| Age | | 18-25 | 105 | 19.1 |
| | | 26-35 | 138 | 25.0 |
| | | 36-45 | 104 | 18.9 |
| | | 46-55 | 98 | 17.8 |
| | | 56 and above | 106 | 19.2 |
| Gender | | Male | 294 | 53.4 |
| | | Female | 257 | 46.6 |
| Province | | Beijing | 131 | 23.8 |
| | | Henan | 92 | 16.7 |
| | | Hebei | 103 | 18.7 |

| | | | | |
|---|---|---|---|---|
| | | Jiangsu | 116 | 21.1 |
| | | Anhui | 109 | 19.8 |
| | | High school diploma and below | 135 | 24.5 |
| Education Level | | Bachelor's degree | 130 | 23.6 |
| | | Master's degree | 145 | 26.3 |
| | | Doctorate | 141 | 25.6 |
| | Laoshan Scenic Area | YES | 326 | 59.2 |
| | | NO | 225 | 40.8 |
| | Qingdao Forest Park | YES | 251 | 45.6 |
| | | NO | 300 | 54.4 |
| Attractions related to low-carbon tourism in Qingdao | Qingdao Botanical Garden | YES | 193 | 35.0 |
| | | NO | 358 | 65.0 |
| | Children Bathing Beach | YES | 277 | 50.3 |
| | | NO | 274 | 49.7 |
| | Badaguan Scenic Area | YES | 289 | 52.5 |
| | | NO | 262 | 47.5 |
| | Other | YES | 291 | 52.8 |
| | | NO | 260 | 47.2 |
| | Littering | YES | 292 | 53 |
| | | NO | 259 | 47 |
| | Use of plastic bottles | YES | 190 | 34.5 |
| | | NO | 361 | 65.5 |
| | Uncontrolled bonfires | YES | 197 | 35.8 |
| Non-low-carbon behavior | | NO | 354 | 64.2 |
| | Use of non-recyclable materials | YES | 256 | 46.5 |
| | | NO | 295 | 53.5 |
| | Excessive use of high-emission motor vehicles (motorboats, banana boats) | YES | 287 | 52.1 |
| | | NO | 264 | 47.9 |
| | Cycling along the coastal road | YES | 262 | 47.5 |
| | | NO | 289 | 52.5 |
| | Walking tours in eco-friendly areas | YES | 283 | 51.4 |
| | | NO | 268 | 48.6 |
| | Eco-friendly water sports | YES | 232 | 42.1 |
| | | NO | 319 | 57.9 |
| low-carbon activities on the Qingdao tour | Participation in beach clean-up activities | YES | 218 | 39.6 |
| | | NO | 333 | 60.4 |
| | Educational programs on sustainability | YES | 297 | 53.9 |
| | | NO | 254 | 46.1 |
| | Staying in eco-friendly accommodations | YES | 279 | 50.6 |
| | | NO | 272 | 49.4 |
| | Use of public transportation | YES | 235 | 42.6 |
| | | NO | 316 | 57.4 |

**3.2 Instrument**

The research instrument for this study was a structured questionnaire designed to examine the factors influencing low-carbon tourism behaviour in Qingdao. The questionnaire was divided into several sections to measure critical constructs such as subjective norms, comfort preferences, local attachment, perceptual-behavioural control, low-carbon tourism attitudes, low-carbon tourism intentions, and low-carbon tourism behaviours. Each construct was assessed using a 5-point Likert scale, where respondents rated each item from 1 (strongly disagree) to 5 (strongly agree). This structure enabled a detailed assessment of both psychological and behavioural aspects of low-carbon tourism. Appendix shows the detail of the scale measurement.

The first section gathered basic demographic information, including age, gender, education level, and travel history, to provide an overview of the respondent characteristics. This ensured that the sample profile was well understood and relevant to low-carbon tourism.

The second section assessed subjective norms, defined as the perceived social pressure to engage in low-carbon tourism. This section included five items, adapted from the work of Zhang et al. (2020), which evaluated how respondents were influenced by social groups such as friends, family, and media. Comfort preferences, which assessed how the availability of comfortable and convenient sustainable options influenced tourists' participation in low-carbon tourism. This section included four items adapted from the study by Asghar et al. (2023). Local attachment, capturing the emotional connection tourists feel toward the destination. This section included four items, adapted from Asghar et al. (2023).

Perceived behavioural control, focusing on how easy or difficult tourists felt it was to engage in low-carbon tourism. This section included four items adapted from Zhang et al. (2020). Low-carbon tourism attitudes, which included two items adapted from Qiu et al. (2019). Low-carbon tourism intentions, using five items adapted from Zhang et al. (2020). This section evaluated respondents' future intentions related to low-carbon tourism. Low-carbon tourism behaviour with three items adapted from Rujiu et al. (2024). These items measured tourists' actual behaviours.

**3.3 Data Analysis Tool**

Based on the survey data, we use descriptive statistical analysis and reliability analysis, validity test. Additionally, confirmatory factor analysis (CFA) and path analysis were conducted using Structural Equation Modeling (SEM) to examine the relationships between variables and to test the validity of the hypotheses.

**4. Results**

Table 2 reports the Cronbach's alpha coefficients for each construct. The constructs—subjective norm, comfort preference, local attachment, perceptual-behavioural control, low-carbon tourism attitudes, low-carbon tourism intention, and low-carbon tourism behaviour—each demonstrates acceptable to high levels of internal consistency, with all values exceeding the accepted threshold of 0.7, indicating the reliable measurement of the constructs.

Specifically, the subjective norm=0.874, suggesting strong reliability in capturing the influence of social expectations on low-carbon tourism behaviour. Comfort preference and local attachment both had identical Cronbach's alpha values of 0.820, demonstrating consistent and reliable responses regarding the importance of comfort and emotional connection in shaping tourists' behaviours. Perceptual-Behavioral Control also exhibited a robust Cronbach's alpha of 0.832, indicating a high level of reliability in measuring the respondents' perceived control over engaging in low-carbon tourism practices.

The constructs measuring low-carbon tourism attitudes, intention, and behaviour showed good reliability as well, with Cronbach's alpha values of 0.749, 0.866, and 0.774, respectively. These results suggest that the questionnaire items effectively capture the critical psychological and behavioural factors influencing low-carbon tourism in Qingdao.

**Table 2 Reliability Test**

| Variables | Number of questions | Cronbach's α |
|---|---|---|
| Subjective Norm | 5 | 0.874 |
| Comfort Preference | 4 | 0.820 |
| Local Attachment | 4 | 0.820 |
| Perceptual-Behavioral Control | 4 | 0.832 |
| Low-Carbon Tourism Attitudes | 2 | 0.749 |
| Low-Carbon Tourism Intention | 5 | 0.866 |
| Low-Carbon Tourism Behavior | 3 | 0.774 |

In this study, the validity of the instrument was rigorously assessed using the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. A KMO value closer to 1 indicates that factor analysis is likely to be suitable. In this research, the KMO=0.920 (>0.9) suggests that the variables in the dataset share a significant amount of common variance, thus validating the applicability of factor analysis. Additionally, Bartlett's Test of Sphericity was employed to determine whether the correlation matrix of the data is an identity matrix, which would suggest that factor analysis is inappropriate. The test produced a Chi-Square value of 6769.952 with 351 degrees of freedom and a significance level of 0.000, decisively rejecting the null hypothesis. This result indicates that the variables in the dataset are sufficiently correlated and are likely to uncover underlying factors through factor analysis.

**Table 3. KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.920 |
| Approx. Chi-Square | | 6769.952 |
| Bartlett's Test of Sphericity | df | 351 |
| Sig. | | 0.000 |

Figure 2 presents a confirmatory factor analysis diagram. Each observed variable is connected to its corresponding latent variable through arrows, which represent the factor loadings. Overall, this measurement model serves as a foundational tool for understanding the intricate relationships among the key constructs influencing low-carbon tourism behaviours in the context of this study. It provides a visual and statistical basis for analyzing the impact of these variables on tourists' behaviours in promoting sustainable tourism practices.

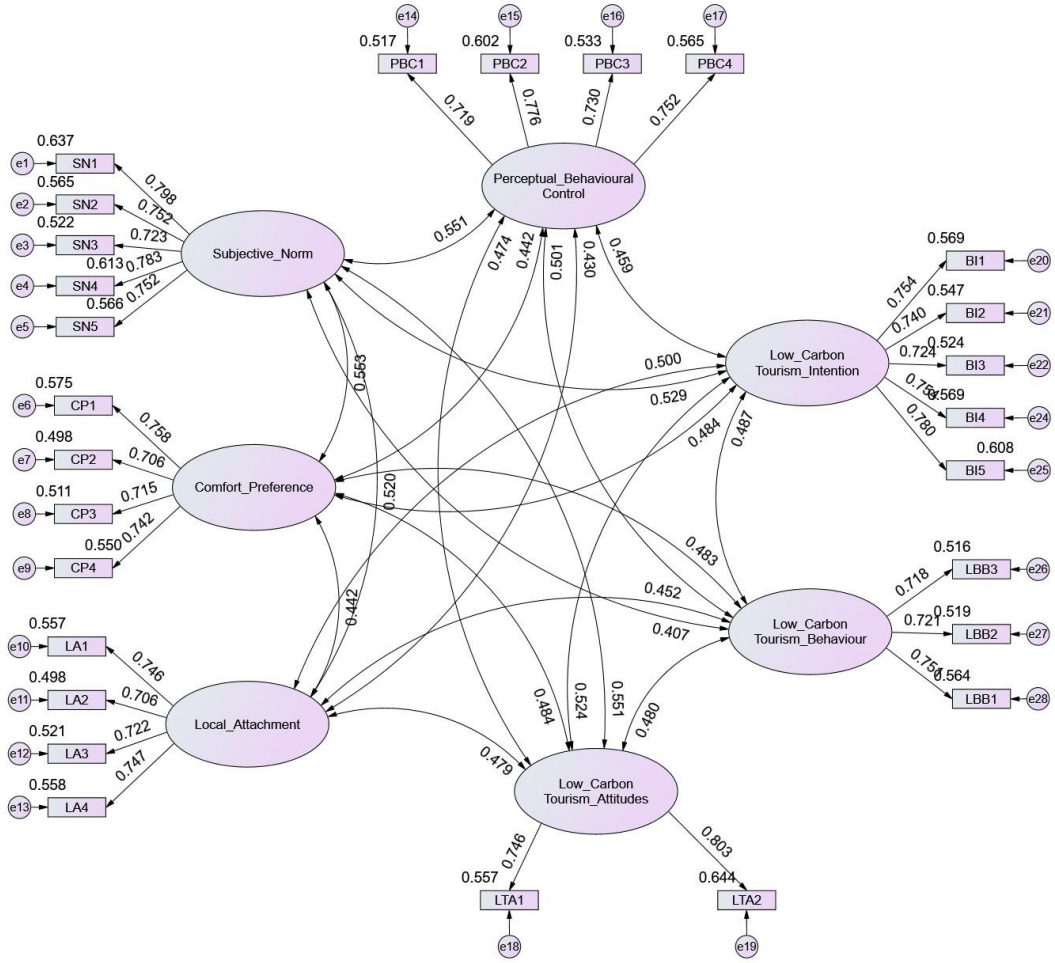


**Figure 2 Measurement Model**

Table 4 presents a range of fit indices that were employed to assess the adequacy of the measurement model used in evaluating the latent constructs related to tourists' low-carbon behaviours in Qingdao. These indices ensure a robust and comprehensive evaluation of the model's alignment with the observed data. The $\chi^2/df$ =1.543 (<3), demonstrating that the model is not overly complex yet fits the data well. The Root Mean Square Error of Approximation (RMSEA) assesses how well the model, with unknown but optimally chosen parameter estimates, would fit the population's covariance matrix.

A value below 0.08 is considered a close fit; the obtained RMSEA value of 0.031 suggests a strong alignment between the model and the population data.

Moreover, the Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) provide additional insight into how much variance in the observed data is explained by the model. Values above 0.9 for both indices are typically regarded as excellent, and this model achieved GFI and AGFI values of 0.942 and 0.928, respectively, affirming a significant proportion of explained variance. Incremental fit indices, such as the Normative Fit Index (NFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI), were also considered. These indices measure the improvement of the model fit over a baseline model. In this study, values of 0.932 (NFI), 0.971 (TLI), and 0.975 (CFI) were obtained, further substantiating the model's robustness and accuracy compared to the null model. These high-fit indices validate the theoretical

framework and its applicability to understanding the factors that influence low-carbon tourism behaviours in Qingdao.

This evaluation of the model's fit ensures that the constructs in the study are reliable and that the model provides a solid empirical foundation for further analyses into tourists' low-carbon behaviours.

**Table** Error! No text of specified style in document. **Measure Model Fit Metrics**

| Fit index | χ2/df | RMSEA | GFI | AGFI | NFI | TLI | CFI |
|---|---|---|---|---|---|---|---|
| Reference standards | <3 | <0.08 | >0.9 | >0.9 | >0.9 | >0.9 | >0.9 |
| Result | 1.543 | 0.031 | 0.942 | 0.928 | 0.932 | 0.971 | 0.975 |

Table 5 provides a thorough evaluation of the convergent validity of the measurement model implemented in this study. Convergent validity confirms that multiple indicators of the same construct are in agreement, thereby establishing that they are measuring the same theoretical concept. The assessment comprises factor loadings, composite reliability (CR), and average variance extracted (AVE) for each latent variable, which include Subjective Norm, Comfort Preference, Local Attachment, Perceptual-Behavioral Control, Low-Carbon Tourism Attitudes, Low-Carbon Tourism Intention, and Low-Carbon Tourism Behavior. Factor loadings exceeding 0.7 indicate that the observed variables have a strong and significant relationship with their respective constructs. This model's factor loadings uniformly surpass this benchmark, ensuring that the constructs are robustly measured.

Composite Reliability (CR) values exceeding 0.7 reflect high internal consistency across all indicators. For instance, CR values like 0.874 for Subjective Norm and 0.866 for Low-Carbon Tourism Intention indicate excellent reliability of the constructs. Additionally, AVE values, which must exceed 0.5 to confirm that the constructs account for the majority of the variance in the indicators, meet the standard across all variables. For example, AVE values such as 0.601 for LowCarbon Tourism Attitudes and 0.564 for Low-Carbon Tourism Intention confirm the constructs' substantial reliability in representing the latent variables. These measures collectively confirm that the model has convergent solid validity, supporting the claim that the constructs are appropriately measured and represented within the study.

**Table 5 Convergence Validity**

| Latent variables | Observation indicators | Factor loading | CR | AVE |
|---|---|---|---|---|
| Subjective Norm | SN1 | 0.798 | 0.874 | 0.581 |
| | SN2 | 0.752 | | |
| | SN3 | 0.723 | | |
| | SN4 | 0.783 | | |
| | SN5 | 0.752 | | |
| Comfort Preference | CP1 | 0.758 | 0.821 | 0.534 |
| | CP2 | 0.706 | | |
| | CP3 | 0.715 | | |
| | CP4 | 0.742 | | |
| Local Attachment | LA1 | 0.746 | 0.821 | 0.534 |
| | LA2 | 0.706 | | |
| | LA3 | 0.722 | | |
| | LA4 | 0.747 | | |
| Perceptual-Behavioral Control | PBC1 | 0.719 | 0.833 | 0.555 |
| | PBC2 | 0.776 | | |
| | PBC3 | 0.730 | | |
| | PBC4 | 0.752 | | |
| Low-Carbon Tourism Attitudes | LTA1 | 0.746 | 0.750 | 0.601 |
| | LTA2 | 0.803 | | |
| Low-Carbon Tourism Intention | BI1 | 0.754 | 0.866 | 0.564 |
| | BI2 | 0.740 | | |
| | BI3 | 0.724 | | |
| | BI4 | 0.754 | | |
| | BI5 | 0.780 | | |
| Low-Carbon Tourism Behavior | LBB1 | 0.751 | 0.774 | 0.533 |
| | LBB2 | 0.721 | | |
| | LBB3 | 0.718 | | |

Table 6 assesses the discriminant validity of the latent constructs used to analyze factors influencing tourists' lowcarbon behaviour. Discriminant validity ensures that each construct is empirically distinct from others in the model by comparing the square root of the Average Variance Extracted (AVE) of each latent variable to the inter-construct correlations. The square root of the AVE is presented diagonally in the table, with off-diagonal

elements representing correlations between different constructs. According to the Fornell-Larcker criterion, discriminant validity is confirmed when the square root of the AVE for each construct exceeds the correlations with other constructs in the model.

The diagonal values in this table, such as 0.762 for Subjective Norm, 0.731 for Comfort Preference, and 0.775 for Low-Carbon Tourism Attitudes, are consistently higher than the corresponding inter-construct correlations in the offdiagonal cells. For example, the square root of the AVE for Subjective Norm (0.762) is more significant than its correlations with Comfort Preference (0.553) and Local Attachment (0.520), demonstrating that the constructs are sufficiently distinct. This pattern holds across all latent variables, confirming the model's discriminant validity. Such distinctiveness is critical for ensuring that each construct captures unique aspects of tourists' low-carbon behaviour, thereby supporting the theoretical framework of the study.

**Table 6 Discriminant Validity Test**

| Latent variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Subjective Norm | **0.762** *** | | | | | | |
| Comfort Preference | 0.553 | **0.731** *** | | | | | |
| Local Attachment | 0.520 | 0.442 | **0.731** *** | | | | |
| Perceptual-Behavioral Control | 0.551 | 0.442 | 0.430 | **0.745** *** | | | |
| Low-Carbon Tourism Attitudes | 0.551 | 0.484 | 0.479 | 0.474 | **0.775** *** | | |
| Low-Carbon Tourism Intention | 0.529 | 0.484 | 0.500 | 0.459 | 0.524 | **0.751** *** | |
| Low-Carbon Tourism Behavior | 0.407 | 0.483 | 0.452 | 0.501 | 0.480 | 0.487 | **0.730** *** |

Note: The diagonal is the square root of the corresponding dimension AVE
***: $p<0.001$

Table 7 outlines the model fit indices for the structural equation model (SEM) employed in the study to explore lowcarbon tourism behaviour dynamics. The $\chi 2/df$ ratio, a critical metric for assessing model complexity and fit, is reported at 1.585 (<3). The Root Mean Square Error of Approximation (RMSEA) further corroborates this conclusion, with a value of 0.033 (<0.08), indicating that the model closely approximates the population data. Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) are also noteworthy, standing at 0.940 and 0.926, respectively. These values not only exceed the generally accepted cutoff of 0.9 but also reflect the model's ability to explain the variance and covariance in the observed data. The Normative Fit Index (NFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI) further demonstrate the model's robustness, with values of 0.930, 0.969, and 0.973, respectively—well above the recommended threshold of 0.9. These indices collectively affirm that the structural model provides an optimal representation of the data, capturing the intricate relationships between low-carbon tourism attitudes, intentions, and behaviours. The comprehensive evaluation underscores the strength of the model in accurately reflecting the relationships among the latent variables and providing a solid foundation for further analysis of low-carbon tourism behaviour.

**Table 7 Model Fit Metrics**

| Fit index | $\chi 2/df$ | RMSEA | GFI | AGFI | NFI | TLI | CFI |
|---|---|---|---|---|---|---|---|
| Reference standards | <3 | <0.08 | >0.9 | >0.9 | >0.9 | >0.9 | >0.9 |
| Result | 1.585 | 0.033 | 0.940 | 0.926 | 0.930 | 0.969 | 0.973 |

Table 8 presents the results of the path analysis for direct effects within the structural equation model, examining the relationships between constructs that influence low-carbon tourism behaviours. This analysis provides critical insights into how vital antecedent variables such as Subjective Norm, Comfort Preference, Local Attachment, and PerceptualBehavioral Control directly impact Low-Carbon Tourism Attitudes, Intention, and Behavior.

The table includes metrics commonly used in structural equation modelling (SEM), including the Non-Standardized Estimate (NS.EST.), Standardized Estimate (β), Standard Error (S.E.), Critical Ratio (C.R.), and p-value (P). Each metric plays a role in determining the strength and significance of the hypothesized paths. A C.R. >1.96 typically signifies statistical significance at a 95% confidence level, while p-values below 0.05 suggest strong support for the hypothesized relationships.

For instance, H1 proposes that Subjective Norms positively affect Low-Carbon Tourism Attitudes, which is supported by a β value of 0.251 and a significant p-value, affirming that social pressures contribute meaningfully to tourists' lowcarbon attitudes. Similarly, the positive and significant effects observed across other hypotheses—such as Comfort Preference on both Low-Carbon Tourism Attitudes (β = 0.197, p = 0.002) and Intention (β = 0.159, p = 0.005)—highlight the relevance of these constructs in shaping sustainable behaviours.

Moreover, the model reveals the direct and robust effects of Perceptual-Behavioral Control on Low-Carbon Tourism Behavior (β = 0.284, p < 0.001), demonstrating that tourists' perceived ability to engage in eco-friendly practices directly influences their participation in such activities. The paths examined in this analysis validate the theoretical framework and underline the importance of various psychological and situational factors in influencing low-carbon tourism behaviour.

**Table 8 Direct Path Effects**

| Hs | Path | NS.EST. | β | S.E. | C.R. | P | Results |
|---|---|---|---|---|---|---|---|
| **H1** | LTA<---SN | 0.249 | 0.251 | 0.067 | 3.700 | *** | Supported |
| **H2** | BI<---SN | 0.164 | 0.160 | 0.064 | 2.578 | 0.010 | Supported |
| **H3** | LTA<---CP | 0.193 | 0.197 | 0.061 | 3.175 | 0.002 | Supported |
| **H4** | BI<--- | 0.160 | 0.159 | 0.057 | 2.796 | 0.005 | Supported |
| **H5** | LTA<---LA | 0.188 | 0.201 | 0.056 | 3.333 | *** | Supported |
| **H6** | BI<---LA | 0.194 | 0.201 | 0.054 | 3.606 | *** | Supported |
| **H7** | LTA<---PBC | 0.168 | 0.160 | 0.064 | 2.620 | 0.009 | Supported |
| **H8** | BI<---PBC | 0.124 | 0.115 | 0.060 | 2.074 | 0.038 | Supported |
| **H9** | LBB<---PBC | 0.303 | 0.284 | 0.063 | 4.785 | *** | Supported |
| **H10** | BI<---LTA | 0.210 | 0.204 | 0.065 | 3.245 | 0.001 | Supported |
| **H11** | LBB<---LTA | 0.239 | 0.236 | 0.067 | 3.590 | *** | Supported |
| **H12** | LBB<---BI | 0.237 | 0.241 | 0.059 | 3.994 | *** | Supported |

***: p<0.001

Note: SN: Subjective Norm; CP: Comfort Preference; LA: Local Attachment; PBC: Perceptual-Behavioral Control; LTA: Low-Carbon Tourism Attitudes; BI: Low-Carbon Tourism Intention; LBB: Low-Carbon Tourism Behavior.

Table 9 evaluates the indirect effects between crucial constructs in the low-carbon tourism behaviour model. This approach is essential for understanding how variables like subjective norms (SN), comfort preference (CP), local attachment (LA), and perceptual-behavioural control (PBC) influence low-carbon tourism behaviour (LBB) indirectly through the mediating variables low-carbon tourism attitudes (LTA) and low-carbon tourism intention (BI). Each mediation path is measured with an estimate (EST.), reflecting the strength of the indirect effect, and a standard error (S.E.), indicating the uncertainty around this estimate.

The results further provide a bias-corrected 95% confidence interval (CI) for each mediation effect, which ensures a more accurate representation of the effect by adjusting for potential biases in the bootstrap method. For a mediation effect to be deemed significant, its 95% CI must not include zero. This criterion allows the model to assess the statistical significance of each hypothesized indirect relationship.

For example, the mediation path from subjective norms through low-carbon tourism attitudes to low-carbon tourism behaviour (H13) shows an estimate of 0.060 with a standard error of 0.034. The bias-corrected 95% confidence interval, ranging from 0.002 to 0.134, confirms the significance of the mediation effect, leading to the acceptance of the hypothesis. Similarly, other hypothesized mediation paths are primarily supported, affirming the model's capacity to explain how these constructs contribute to shaping low-carbon tourism behaviour. However, hypotheses H16 and H20, which examine the indirect effects of perceptual-behavioural control through low-carbon tourism attitudes and intention, are rejected, as their

95% CIs include zero, signalling that these specific paths do not significantly influence low-carbon tourism behaviour.

**Table 9 Mediation Effect Bootstrap Test**

**Table 9 Mediation Effect Bootstrap Test**

| Hs | Mediation path | EST. | S.E. | Bias-Corrected 95%CI | | Results |
|---|---|---|---|---|---|---|
| **H13** | SN--->LTA--->LBB | 0.060 | 0.034 | 0.002 | 0.134 | Supported |
| **H14** | CP--->LTA--->LBB | 0.046 | 0.033 | 0.001 | 0.127 | Supported |
| **H15** | LA--->LTA--->LBB | 0.045 | 0.029 | 0.002 | 0.122 | Supported |
| **H16** | PBC--->LTA--->LBB | 0.040 | 0.030 | -0.001 | 0.115 | Rejected |
| **H17** | SN--->BI--->LBB | 0.039 | 0.027 | 0.002 | 0.107 | Supported |
| **H18** | CP--->BI--->LBB | 0.038 | 0.027 | 0.002 | 0.122 | Supported |
| **H19** | LA--->BI--->LBB | 0.046 | 0.027 | 0.006 | 0.113 | Supported |
| **H20** | PBC--->BI--->LBB | 0.029 | 0.021 | -0.003 | 0.080 | Rejected |
| **H21** | LTA--->BI--->LBB | 0.050 | 0.028 | 0.008 | 0.115 | Supported |

Note: SN: Subjective Norm; CP: Comfort Preference; LA: Local Attachment; PBC: Perceptual-Behavioral Control; LTA: Low-Carbon Tourism Attitudes; BI: Low-Carbon Tourism Intention; LBB: Low-Carbon Tourism Behavior.

Figure 3 illustrates the relationships among the vital latent constructs: subjective norm (SN), comfort preference (CP), local attachment (LA), perceptual behavioural control (PBC), low-carbon tourism attitudes (LTA), low-carbon tourism intention (BI), and low-carbon tourism behaviour (LBB). The latent constructs are represented by ellipses, with singleheaded arrows indicating directional relationships between them. Path coefficients associated with these arrows represent the strength and direction of the connections, while double-headed arrows represent correlations between the constructs.

Additionally, the model includes detailed factor loadings for each latent construct with its corresponding observed variables, along with error terms and R-squared values ($R^2$), which indicate the proportion of variance explained by the constructs in the model. Notable significant paths include those extending from the subjective norm (SN), comfort preference (CP), local attachment (LA), perceptual, behavioural control (PBC), low-carbon tourism attitudes (LTA), lowcarbon tourism intention (BI), and low-carbon tourism behaviour (LBB).

The model also highlights essential relationships, such as the influence of subjective norm (SN), comfort preference (CP), local attachment (LA), perceptual, behavioural control (PBC), low-carbon tourism attitudes (LTA), low-carbon tourism intention (BI), and low-carbon tourism behaviour (LBB). This figure visually captures the complex interactions driving low-carbon tourism behaviour, demonstrating how attitudes and intentions mediate the effects of other variables within the model.

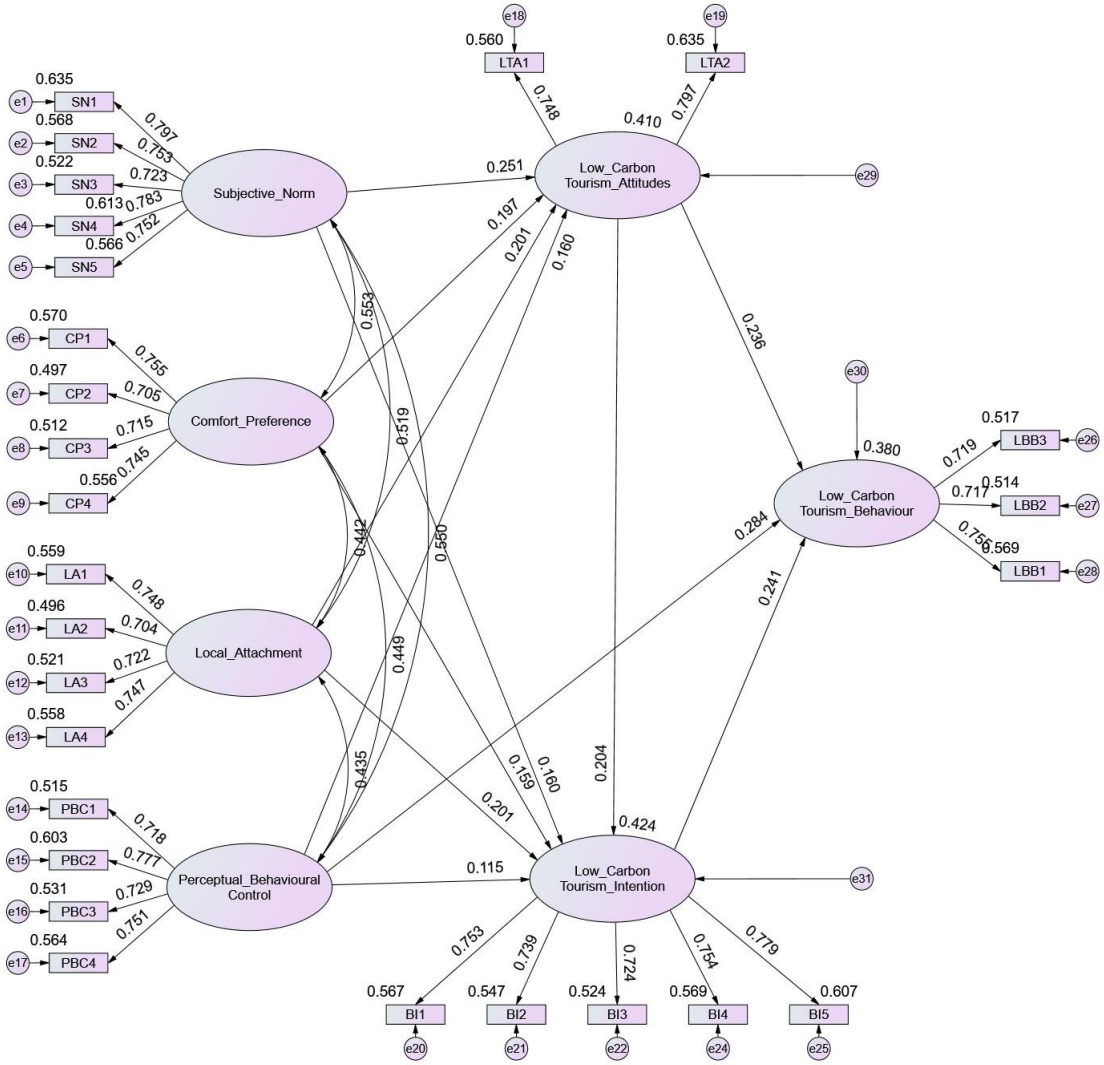


**Figure 3 Structural equation Model**

Table 10 presents the total effects within the structural model, capturing both direct and mediated influences of key predictors on low-carbon tourism behaviours. The total effect of a variable represents the overall influence it exerts on another variable through all possible pathways, including both direct and indirect effects. Each effect is quantified by its effect size, which indicates the magnitude and direction of the relationship between the constructs.

The 'SE' (Standard Error) column provides a measure of the variability around the effect size, which reflects the precision of the estimation. More minor standard errors indicate a more precise estimate. The 'Bias-Corrected 95%CI' (Bias-Corrected 95% Confidence Interval) offers an adjusted range for the effect size, which

accounts for potential biases in the sampling process, ensuring a more reliable confidence interval. If the 95% confidence interval does not include zero, the effect is considered statistically significant.

For instance, the total effect of Subjective Norm on Low-Carbon Tourism Attitudes is estimated at 0.249, with a standard error of 0.097 and a confidence interval ranging from 0.010 to 0.417, indicating a positive and statistically significant influence. Similarly, local attachment exerts a substantial influence on low-carbon tourism behaviour, with an effect size of 0.381 and a confidence interval from 0.236 to 0.550, which signifies a substantial and significant effect within the model.

**Table 10 Total Effects**

| Effect path | Effect size | SE | Bias-Corrected 95%CI | |
|---|---|---|---|---|
| LTA<---SN | 0.249 | 0.097 | 0.010 | 0.417 |
| LTA<---CP | 0.193 | 0.084 | 0.018 | 0.358 |
| LTA<---LA | 0.168 | 0.094 | -0.019 | 0.348 |
| LTA<---PBC | 0.188 | 0.074 | 0.060 | 0.382 |
| BI<---SN | 0.216 | 0.089 | 0.030 | 0.389 |
| BI<---CP | 0.201 | 0.081 | 0.041 | 0.364 |
| BI<---LA | 0.160 | 0.081 | 0.004 | 0.323 |
| BI<---PBC | 0.233 | 0.072 | 0.091 | 0.354 |
| BI<---LTA | 0.210 | 0.096 | -0.010 | 0.390 |
| LBB<---SN | 0.111 | 0.039 | 0.035 | 0.195 |
| LBB<---CP | 0.094 | 0.038 | 0.032 | 0.181 |
| LBB<---LA | 0.381 | 0.078 | 0.236 | 0.550 |
| LBB<---PBC | 0.100 | 0.034 | 0.039 | 0.170 |
| LBB<---LTA | 0.289 | 0.086 | 0.089 | 0.425 |
| LBB<---BI | 0.237 | 0.087 | 0.065 | 0.420 |

Note: SN: Subjective Norm; CP: Comfort Preference; LA: Local Attachment; PBC: Perceptual-Behavioral Control; LTA: Low-Carbon Tourism Attitudes; BI: Low-Carbon Tourism Intention; LBB: Low-Carbon Tourism Behavior.

## 5. Discussion

### 5.1 Theoretical Implications

This study demonstrates that subjective norms, comfort preferences, local attachment, and perceptual-behavioural control all positively influence low-carbon tourism attitudes and intentions. Furthermore, low-carbon tourism attitudes and intentions have a significant positive impact on low-carbon tourism behaviour. Specifically, low-carbon tourism attitudes partially mediate the relationships between subjective norms, comfort preferences, and local attachment to lowcarbon tourism behaviour. Similarly, low-carbon tourism intentions mediate the relationships between subjective norms, comfort preferences, and low-carbon tourism behaviour.

While most hypotheses were supported, H16 and H20 were rejected. H16 posited that low-carbon tourism intentions would mediate the relationship between comfort preferences and low-carbon tourism behaviour, while H20 suggested a similar mediating role of intentions between perceived behavioural control and behaviour. However, the analysis showed that the indirect effects of these hypotheses were not statistically significant within the 95% confidence interval, suggesting that comfort preferences and perceptual-behavioural control influence low-carbon tourism behaviour primarily through direct effects rather than through the mediating role of intentions.

In contrast, other supported hypotheses demonstrated robust mediation effects. For instance, subjective norms significantly influenced low-carbon tourism behaviour through both attitudes and intentions, illustrating the strong impact of social pressures and environmental expectations on behaviour. Additionally, comfort preferences and local attachment had positive indirect effects on low-carbon tourism behaviour via attitudes and intentions, indicating that tourists' desire for comfort and emotional ties to destinations are crucial factors in shaping their eco-friendly behaviours.

These findings suggest that enhancing tourists' comfort and fostering emotional connections to destinations can significantly strengthen their pro-environmental behaviours. Moreover, the study highlights the critical role of low-carbon tourism attitudes and intentions as mediating factors that bridge psychological influences and actual behaviours, thereby enriching the theoretical framework for understanding the environmental impact of tourism behaviours.

Our research addresses gaps in the literature and provides new insights into the role of perceptual-behavioral control. Unlike earlier models emphasizing the mediation of cognitive factors, both comfort preferences and perceptualbehavioural control exert their influence more directly on behaviour without the need for mediation through attitudes or intentions. The result contrasts with traditional models and suggests that for certain psychological constructs, a direct relationship with behaviour may be more pronounced.

In comparison, other supported hypotheses align with findings from previous studies. For example, Wang et al. (2021) highlighted the role of subjective norms and attitudes in shaping environmental behaviours, while

our research extends this by incorporating the additional influences of comfort preferences and local attachment. Similarly, Zhang et al. (2020) explored local attachment in promoting sustainable tourism but did not account for the mediating role of attitudes and intentions. Our study advances their work by showing how local attachment not only directly influences behaviour but also has significant indirect effects via attitudes and intentions.

Further comparisons can be made with recent studies such as Liu et al. (2020), who found that subjective norms had a weaker influence on young people's low-carbon travel intentions, while perceptual-behavioural control and environmental concern played a more prominent role, aligns with our finding that perceptual-behavioural control exerts a strong direct influence on low-carbon tourism behaviour, reinforcing its central role in eco-friendly decision-making.

Moreover, (Wang et al., 2023) examined the influence of subjective norms and attitudes on low-carbon travel behaviour and found strong mediating effects of behavioural intention. Similarly, our study supports this by demonstrating the indirect influence of subjective norms through both attitudes and intentions. However, our research adds to this by exploring the roles of comfort preferences and local attachment, showing how these factors also influence low-carbon behaviour via similar mediating mechanisms.

Finally, the rejection of H16 and H20 brings new perspectives to the role of perceptual-behavioural control in tourism behaviour. Previous studies, such as (Wu et al., 2020), emphasized the moderating role of situational factors between perceived behavioural control and behaviour, but our study suggests a more direct effect in the tourism context.

In conclusion, the rejection of H16 and H20 suggests that not all psychological factors influence low-carbon tourism behaviours in the same way. Direct effects may play a more critical role than previously recognized. Our findings contribute to existing theories by expanding the understanding of how perceptual-behavioural control, subjective norms, comfort preferences, and local attachment interact to shape low-carbon tourism behaviours. These insights provide a richer theoretical framework for future research and offer practical guidance for designing interventions that promote low-carbon tourism.

**5.2 Practical implications**

The findings of this study offer valuable insights for improving low-carbon tourism experiences in Qingdao, providing actionable strategies for policymakers, tourism marketers, and service providers. Based on empirical results, several strategies are recommended to strengthen tourists' engagement in low-carbon tourism behaviours.

A notable insight from the study is the role of subjective norms in influencing tourists' low-carbon attitudes and behaviours (H1, H2, H13, H17). Policymakers can leverage social influence to foster responsible tourism practices. By partnering with local influencers, environmental groups, and community leaders, the tourism sector can promote lowcarbon tourism as both desirable and socially endorsed. Social media campaigns that highlight the environmental benefits of low-carbon tourism or feature eco-friendly experiences shared by famous figures can instil a sense of community responsibility among tourists.

Addressing comfort preferences is also crucial in promoting low-carbon tourism behaviours (H3, H4, H15, H18). Service providers need to ensure that eco-friendly options maintain the comfort and convenience tourists seek. For example, energy-efficient accommodations that do not compromise quality or transport services offering comfortable, scenic electric vehicle routes align with the study's findings on comfort's significant impact on low-carbon tourism decisions. Tourists are more inclined toward eco-friendly options if these options also meet their comfort needs.

The study also underscores the importance of local attachment in fostering sustainable behaviours among tourists (H5, H6, H17, H18). To cultivate this, marketers should enhance tourists' emotional connections to Qingdao's natural and cultural heritage. Promoting immersive experiences that allow tourists to engage with local traditions and environments— such as eco-tours or conservation projects—strengthens visitors' attachment to the destination. This more profound attachment can motivate tourists to adopt more responsible behaviours during their stay, reinforcing their commitment to preserving the local environment.

The role of perceived behavioural control in promoting low-carbon tourism intentions and behaviours (H7, H8, H9, H19, H20) is another crucial insight. Tourists are more likely to engage in sustainable activities if they feel confident and capable of doing so. Service providers can support this by making eco-friendly options easy to access and well-publicized. For instance, hotels can offer clear instructions on recycling programs or user-friendly apps guiding tourists through ecofriendly activities, enhances tourists' sense of control, making sustainable choices more appealing and feasible.

In addition, low-carbon tourism attitudes and intentions serve as essential mediating factors that bridge subjective norms, comfort preferences, local attachment, and perceived behavioural control with actual behaviours (H10, H11, H12, H21). Strengthening tourists' intentions through positive experiences and clear behavioural cues can more effectively drive sustainable behaviours. Policymakers and marketers should emphasize the cognitive and emotional rewards of low-carbon tourism in their messaging.

For policymakers, creating an enabling environment for sustainable tourism is vital. Government initiatives can include incentives for businesses adopting eco-friendly practices, such as tax breaks for low-carbon accommodations or subsidies for electric transportation options. Investment in sustainable public transportation infrastructure, such as electric buses or bike-sharing systems, can further promote low-carbon travel. Establishing environmental standards for tourism operators ensures that the tourism industry aligns with broader sustainability goals.

Finally, marketing strategies should highlight the unique, comfortable, and enriching experiences that

low-carbon tourism in Qingdao offers, positioning the city as a leader in sustainable travel. Compelling narratives that showcase the personal and environmental rewards of sustainable travel can inspire tourists to choose eco-friendly options and foster a strong emotional connection with the destination.

In conclusion, the practical implications of this study suggest that a multifaceted approach—encompassing subjective norms, comfort, local attachment, perceived control, and mediating attitudes and intentions—is essential for promoting low-carbon tourism in Qingdao. By implementing targeted actions that align with tourists' needs and sustainability goals, stakeholders can enhance the low-carbon tourism experience while supporting Qingdao's long-term environmental and economic sustainability as a premier tourism destination.

## 6. Conclusion

This study has systematically explored the relationship between subjective norms, comfort preferences, local attachment, and perceptual and behavioural control and their effects on low-carbon tourism behaviours in Qingdao. By integrating the Theory of Planned Behavior (TPB) with specific low-carbon tourism behaviour models, the research has unveiled how these factors collectively shape low-carbon tourism attitudes, intentions, and behaviours. The empirical findings highlight the mediating role of low-carbon tourism attitudes and intentions, confirming that these factors transform social norms, comfort, and emotional attachments into concrete low-carbon tourism actions. This theoretical integration demonstrates both the individual and combined significance of these constructs in explaining tourist behaviour in the context of low-carbon tourism.

The practical implications of this research are significant for tourism policymakers and service providers in Qingdao. Based on the findings, stakeholders can adopt targeted strategies to promote low-carbon tourism. For example, improving tourists' comfort while engaging in eco-friendly activities, leveraging social norms to encourage responsible tourism behaviour, and enhancing local attachment through immersive, sustainable experiences can significantly influence tourists' behaviours. These strategies are essential for promoting Qingdao as a leading low-carbon tourism destination and should be integrated into marketing campaigns that emphasize both comfort and environmental responsibility.

This study also contributes to the theoretical literature by expanding the TPB framework to include constructs specific to low-carbon tourism. This approach has enriched our understanding of how psychological and social factors, such as subjective norms and perceived control, work together to shape tourists' sustainable behaviours. Future research could further extend this framework by exploring how other demographic factors, such as age or nationality, influence lowcarbon tourism behaviours.

Despite its contributions, this study has certain limitations. The sample is limited to a specific demographic group, which may restrict the generalizability of the findings. Future research could expand the sample to include a broader range of tourists, both domestic and international, to understand better the factors influencing low-carbon tourism behaviour in different contexts. Additionally, the cross-sectional design of this study only provides a snapshot of tourists' attitudes and behaviours at one point in time. Longitudinal research could offer more insights into how these factors evolve.

Furthermore, while this study focuses on psychological and behavioural aspects, it does not fully explore economic and policy-related factors that may also impact low-carbon tourism behaviours. Incorporating these elements into future studies could offer a more comprehensive understanding of how to promote sustainable tourism practices. Lastly, qualitative methods such as interviews or focus groups could complement the quantitative findings, providing deeper insights into tourists' motivations and experiences. Future research should also consider comparative studies across different regions to identify both unique and standard drivers of low-carbon tourism behaviour, thereby enhancing the applicability of the findings.

**Appendix Measurement**

| Construct | Revised Items | Source |
|---|---|---|
| Subjective Norm | SN1: Mass media (e.g., TV, news websites) can help me learn how to choose environmentally friendly tourism options. | Zhang et al. (2020) |
| | SN2: Content shared by friends on social media about low-carbon tourism in Qingdao encourages me to focus on how to reduce carbon emissions during travel. | |
| | SN3: Public environmental campaigns or promotional programs, such as free trial days or discounts, can motivate me to participate in low-carbon tourism activities in Qingdao. | |
| | SN4: The green travel practices of my relatives and friends in Qingdao influence my low-carbon tourism decisions. | |
| | SN5: When my family wants to participate in sustainable tourism activities in Qingdao, I find it meaningful to join and support them in low-carbon travel experiences. | |
| Comfort Preference | CP1: Choosing environmentally certified accommodation can provide me with a comfortable and convenient low-carbon tourism experience. | Asghar et al. (2023) |
| | CP2: Low-carbon transportation options such as electric buses or shared bicycles can provide sufficient comfort for my travels in Qingdao. | |
| | CP3: The green scenic spots and clean energy facilities in Qingdao enhance my overall travel experience. | |
| | CP4: Green tourism services, such as eco-friendly hotels and paperless ticket systems, make my tourism experience in Qingdao more convenient and comfortable. | |
| Local Attachment | LA1: I feel a deep emotional connection to Qingdao's local community, and I am willing to participate in and support local low-carbon tourism projects. | Asghar et al. (2023) |
| | LA2: The residents of Qingdao share values similar to mine regarding environmental protection and low-carbon behaviours, which strengthens my willingness to engage in low-carbon activities during my trip. | |
| | LA3: The abundant low-carbon activities and environmental promotion in Qingdao resonate with my values, inspiring me to participate in these activities. | |
| | LA4: I feel a strong alignment with low-carbon practices in the Qingdao community, such as beach clean-ups and eco-friendly hiking, which increases my support for Qingdao's environmental efforts. | |
| Perceptual-Behavioural Control | PBC1: I have enough resources to get information on low-carbon accommodation and green travel routes in Qingdao to help me make better low-carbon travel decisions. | Zhang et al. (2020) |
| | PBC2: I possess the necessary environmental knowledge to understand and practice low-carbon tourism in Qingdao, and I take sustainable actions while travelling. | |
| | PBC3: I can quickly obtain information about low-carbon tourism sites and activities in Qingdao through mobile apps, tourism websites, or environmental organizations. | |
| | PBC4: I can conveniently use eco-friendly transportation, such as shared bicycles or electric vehicles, to reach tourist destinations and reduce carbon emissions. | |
| Low-carbon Tourism Attitudes | LTA1: Participating in low-carbon tourism activities in Qingdao, such as visiting eco-friendly scenic spots and engaging in green tourism projects, is a pleasant experience for me. | Qiu et al. (2019) |

| | | |
|---|---|---|
| | LTA2: Visiting environmental museums and experiencing sustainable ecological parks in Qingdao is exciting and attractive, sparking my interest in further low-carbon tourism. | |
| Low-carbon Tourism Intention | BI1: Before visiting Qingdao, I prefer to learn about its low-carbon tourism guides and eco-friendly travel suggestions online. | Zhang et al. (2020) |
| | BI2: I am willing to visit Qingdao's eco-themed parks and green tourism trails to participate in low-carbon tourism activities. | |
| | BI3: I am inclined to travel to Qingdao specifically to experience low-carbon tourism projects, such as eco-friendly accommodations and car-free ecological tour routes. | |
| | BI4: While travelling in Qingdao, I am willing to pay higher fees for eco-friendly accommodations or to support locally-produced eco-friendly products. | |
| | BI5: I am happy to recommend Qingdao's low-carbon tourism activities and eco-friendly attractions to others, encouraging them to participate in green tourism. | |
| Low-carbon Tourism Behaviour | LBB1: During my travels in Qingdao, I actively choose low-carbon transportation methods, such as cycling or walking, to minimize carbon emissions. | Rujiu et al. (2024) |
| | LBB2: I prioritize choosing eco-certified accommodations and services to reduce my negative impact on the local environment. | |
| | LBB3: I actively participate in low-carbon tourism practices, such as reducing plastic use, joining beach clean-ups, choosing low-carbon guided tours, and promoting eco-friendly behaviours to other tourists. | |

**Reference**


1. Aitken, R., Watkins, L., Williams, J., & Kean, A. (2020). The positive role of labelling on consumers' perceived
2. behavioural control and intention to purchase organic food. *Journal of Cleaner Production*, *255*, 120334. https://doi.org/10.1016/j.jclepro.2020.120334
3. Ali, Q., Yaseen, M. R., Anwar, S., Makhdum, M. S. A., & Khan, M. T. I. (2021). The impact of tourism, renewable energy,
4. and economic growth on ecological footprint and natural resources: A panel data analysis. *Resources Policy*, *74*, 102365. https://doi.org/10.1016/j.resourpol.2021.102365
5. Asghar, A., Asif, R., Akhtar, N. J. J. o. H., & Insights, T. (2023). Servicescapes and social servicescapes: impact on
6. perceived usefulness, choice satisfaction and behavior at fast-food restaurants. https://doi.org/10.1108/JHTI-032023-0125
7. Chen, H., Sui, Y., Shang, W.-l., Sun, R., Chen, Z., Wang, C., Han, C., Zhang, Y., & Zhang, H. (2022). Towards renewable
8. public transport: Mining the performance of electric buses using solar-radiation as an auxiliary power source. *Applied Energy*, *325*, 119863. https://doi.org/10.1016/j.apenergy.2022.119863
9. Cheng, X., Wu, F., Li, W., Yang, J., & Long, R. (2024). What maintains low-carbon consumption behaviors: Evidence from China. *Renewable and Sustainable Energy Reviews*, *189*, 114050. https://doi.org/10.1016/j.rser.2023.114050
10. Dazhong Daily. (2024). 5G enables thousands of industries and all industries: Shandong to accelerate the development
11. level of digital economy. https://baijihao.baidu.com/s?id=1781960745999037408
12. Daryanto, A., & Song, Z. (2021). A meta-analysis of the relationship between place attachment and pro-environmental
13. behaviour. *Journal of Business Research*, *123*, 208-219. https://doi.org/10.1016/j.jbusres.2020.09.045
14. Dolnicar, S., & Demeter, C. (2024). Why targeting attitudes often fails to elicit sustainable tourist behaviour. *International*
15. *Journal of Contemporary Hospitality Management*, *36*(3), 730-742. https://doi.org/10.1108/IJCHM-07-20220828
16. Fakfare, P., & Wattanacharoensil, W. (2023). Low-carbon tourism: determining domestic tourist perception from Thailand: Tourism Agenda 2030. *Tourism Review*, *78*(2), 496-516. https://doi.org/10.1108/TR-12-2021-0537
17. Fischer, R., & Karl, J. A. (2021). Predicting Behavioral Intentions to Prevent or Mitigate COVID-19: A Cross-Cultural

18. Meta-Analysis of Attitudes, Norms, and Perceived Behavioral Control Effects. *Social Psychological and Personality Science*, *13*(1), 264-276. https://doi.org/10.1177/19485506211019844
19. Fitch, D. T., Carlen, J., & Handy, S. L. (2022). What makes bicyclists comfortable? Insights from a visual preference
20. survey of casual and prospective bicyclists. *Transportation Research Part A: Policy and Practice*, *155*, 434-449.
21. https://doi.org/10.1016/j.tra.2021.11.008
22. Gössling, S., & Higham, J. (2020). The Low-Carbon Imperative: Destination Management under Urgent Climate Change. *Journal of Travel Research*, *60*(6), 1167-1179. https://doi.org/10.1177/0047287520933679
23. Häder, D.-P., Banaszak, A. T., Villafañe, V. E., Narvarte, M. A., González, R. A., & Helbling, E. W. (2020). Anthropogenic
24. pollution of aquatic ecosystems: Emerging problems with global implications. *Science of The Total Environment*, *713*, 136586. https://doi.org/10.1016/j.scitotenv.2020.136586
25. He, X., Ye, C., Huang, S., & Su, L. (2024). The "Green Persuasion Effect" of Negative Messages: How and When Message Framing Influences Tourists' Environmentally Responsible Behavior. *Journal of Travel Research*, 00472875241289571. https://doi.org/10.1177/00472875241289571
26. Hong, Y., Al Mamun, A., Masukujjaman, M., & Yang, Q. (2024). Sustainable consumption practices among Chinese youth. *Humanities and Social Sciences Communications*, *11*(1), 1058. https://doi.org/10.1057/s41599-024-03582-5
27. Hsiao, T.-Y., Sung, P.-L., Tsai, H.-Y., Wang, T.-S., & Liang, A. R.-D. (2021). Establishing a model of low-carbon tour
28. promotion for use by travel agencies from the perspective of shared value theory. *Tourism Management Perspectives*, *37*, 100787. https://doi.org/10.1016/j.tmp.2020.100787
29. Husain, F., Shahnawaz, M. G., Khan, N. H., Parveen, H., & Savani, K. (2021). Intention to get COVID-19 vaccines: Exploring the role of attitudes, subjective norms, perceived behavioral control, belief in COVID-19 misinformation, and vaccine confidence in Northern India. *Human Vaccines & Immunotherapeutics*, *17*(11), 3941-3953. https://doi.org/10.1080/21645515.2021.1967039
30. Idroes, G. M., Rahman, H., Uddin, I., Hardi, I., & Falcone, P. M. (2024). Towards sustainable environment in North African countries: The role of military expenditure, renewable energy, tourism, manufacture, and globalization on environmental degradation. *Journal of Environmental Management*, *368*, 122077. https://doi.org/10.1016/j.jenvman.2024.122077
31. Li, C., Agyeiwaah, E., & Zhao, Y. (2024). Understanding tourists' eco-paralysis, environmental concern, and pro-
32. environmental behavior: an explanatory sequential mixed methods study. *Journal of Sustainable Tourism*, *32*(10), 2060-2079. https://doi.org/10.1080/09669582.2023.2266778
33. Li, M., Fu, H., & Jiang, S. (2023). What is Sustainable Tourism in Social Media? Evidence From Tweets. *Management*, *21*(1), 204-218. https://doi.org/10.21511/ppm.21(1).2023.18
34. Li, S., Ding, J., Zheng, X., & Sui, Y. (2021). Beach tourists behavior and beach management strategy under the ongoing prevention and control of the COVID-19 pandemic: A case study of Qingdao, China. *Ocean & Coastal Management*, *215*, 105974. https://doi.org/10.1016/j.ocecoaman.2021.105974
35. Lin, B., & Wang, X. (2021). Does low-carbon travel intention really lead to actual low-carbon travel? Evidence from
36. urban residents in China. *Economic Analysis and Policy*, *72*, 743-756. https://doi.org/10.1016/j.eap.2021.10.010
37. Lin, H.-H., Ling, Y., Chen, I.-S., Wu, P.-Y., Hsu, I.-C., Hsu, C.-H., & Zhang, S.-F. (2022). Can low-carbon tourism
38. awareness promote rural and ecological development, create safe leisure spaces, and increase public happiness?
39. A discussion from the perspective of different stakeholders. *Water*, *14*(21), 3557. https://doi.org/10.3390/w14213557
40. Luo, J. M., Chau, K. Y., Fan, Y., & Chen, H. (2021). Barriers to the Implementation of Green Practices in the Integrated Resort Sector. *Sage Open*, *11*(3), 21582440211030277. https://doi.org/10.1177/21582440211030277
41. Masuda, H., Han, S. H., & Lee, J. (2022). Impacts of influencer attributes on purchase intentions in social media influencer
42. marketing: Mediating roles of characterizations. *Technological Forecasting and Social Change*, *174*, 121246.
43. https://doi.org/10.1016/j.techfore.2021.121246
44. Mouratidis, K., Peters, S., & van Wee, B. (2021). Transportation technologies, sharing economy, and teleactivities:
45. Implications for built environment and travel. *Transportation Research Part D: Transport and Environment*, *92*, 102716. https://doi.org/10.1016/j.trd.2021.102716
46. Nuwan Gunarathne, A. D., Hitigala Kaluarachchilage, P. K., & Rajasooriya, S. M. (2020). Low-carbon consumer
47. behaviour in climate-vulnerable developing countries: A case study of Sri Lanka. *Resources, Conservation and Recycling*, *154*, 104592. https://doi.org/10.1016/j.resconrec.2019.104592
48. Panwanitdumrong, K., & Chen, C.-L. (2021). Investigating factors influencing tourists' environmentally responsible
49. behavior with extended theory of planned behavior for coastal tourism in Thailand. *Marine Pollution Bulletin*, *169*, 112507. https://doi.org/10.1016/j.marpolbul.2021.112507

50. Qingdao Government Network. (2024). 2023 Qingdao Ecological Environment Status Bulletin.
51. https://www.qingdao.gov.cn/
52. Qiu, Q., Zheng, T., Xiang, Z., & Zhang, M. J. S. (2019). Visiting intangible cultural heritage tourism sites: From value
53. cognition to attitude and intention. *12*(1), 132. https://doi.org/10.3390/su12010132
54. Rujiu, G., Koh, D., Wang, L. J. J. o. P. E., & Sport. (2024). Mechanism of low-carbon sports tourism behavior based on
55. an extended theory of planned behavior. *24*(4), 905-914. https://doi.org/10.7752/jpes.2024.04103
56. Sun, L., Luo, L., Dong, C., Hua, H., & Shi, R. (2024). Effects of China's pilot low-carbon city policy on carbon emission
57. reduction in the hotel industry: A quasi-natural experiment in tourism cities. *Energy Reports*, *11*, 3037-3049. https://doi.org/10.1016/j.egyr.2024.02.059
58. Suryawan, I. W. K., & Lee, C.-H. (2023). Community preferences in carbon reduction: Unveiling the importance of adaptive capacity for solid waste management. *Ecological Indicators*, *157*, 111226. https://doi.org/10.1016/j.ecolind.2023.111226
59. Tran, K., Nguyen, T., Tran, Y., Nguyen, A., Luu, K., & Nguyen, Y. (2022). Eco-friendly fashion among generation Z:
60. Mixed-methods study on price value image, customer fulfillment, and pro-environmental behavior. *PLOS ONE*, *17*(8), e0272789. https://doi.org/10.1371/journal.pone.0272789
61. Tu, H., & Ma, J. (2021). Does Positive Contact Between Residents and Tourists Stimulate Tourists' Environmentally Responsible Behavior? The Role of Gratitude and Boundary Conditions. *Journal of Travel Research*, *61*(8), 1774-1790. https://doi.org/10.1177/00472875211048938
62. Wang . (2020). Marine ecological disasters and prevention countermeasures in Jiaozhou Bay. *Nature Science* , *8(1)*, 37-
63. 42. https://doi.org/10.12677/OJNSj.2020.81006
64. Wang, Q.-C., Ren, Y.-T., Liu, X., Chang, R.-D., & Zuo, J. (2023). Exploring the heterogeneity in drivers of energy-saving
65. behaviours among hotel guests: Insights from the theory of planned behaviour and personality profiles.
66. *Environmental Impact Assessment Review*, *99*, 107012. https://doi.org/10.1016/j.eiar.2022.107012
67. Wang, S., Lehto, X., Cai, L., Behnke, C., & Kirillova, K. (2021). Travelers' Psychological Comfort with Local Food Experiences and Place Attachment. Journal of Hospitality & Tourism Research, 47(8), 1453-1477. https://doi.org/10.1177/10963480211058474
68. Wu, J., Font, X., & Liu, J. (2020). Tourists' Pro-environmental Behaviors: Moral Obligation or Disengagement? *Journal*
69. *of Travel Research*, *60*(4), 735-748. https://doi.org/10.1177/0047287520910787
70. Yu, J., Xu, W., Zou, Y., Yang, H., & Ding, Z. (2022). Studying what influences the effects of environmental education on
71. visitors of Fuzhou National Park in China—The mediating role of place attachment. *Forests*, *13*(10), 1735. https://doi.org/10.3390/f13101735
72. Zhan, P., Shen, L., & He, H. (2024). Low-carbon behavior between urban and rural residents in China: An online survey
73. study. *Sustainable Production and Consumption*, *46*, 690-702. https://doi.org/10.1016/j.spc.2024.03.022
74. Zhang, A., Xi, W., Xu, F. Z., & Wu, R. (2023). Deconstructing consumers' low-carbon tourism promotion preference and
75. its consequences: A heuristic-systematic model. *Journal of Hospitality and Tourism Management*, *57*, 48-60. https://doi.org/10.1016/j.jhtm.2023.08.020
76. Zhang, G., Chen, X., Law, R., & Zhang, M. (2020). Sustainability of heritage tourism: A structural perspective from
77. cultural identity and consumption intention. *Sustainability*, *12*(21), 9199. https://doi.org/10.3390/su12219199
78. Zhang, J., & Zhang, Y. (2020). Assessing the low-carbon tourism in the tourism-based urban destinations. *Journal of Cleaner Production*, *276*, 124303. https://doi.org/10.1016/j.jclepro.2020.124303
79. Zhang, T., & Li, L. (2021). Research on temporal and spatial variations in the degree of coupling coordination of tourism–
80. urbanization–ecological environment: a case study of Heilongjiang, China. *Environment, Development and*
81. *Sustainability*, *23*(6), 8474-8491. https://doi.org/10.1007/s10668-020-00976-8
82. Zong, W., Din, A. U., Rahman, I. U., Han, H., Wang, J., Ma, Z., & Alhrahsheh, R. R. (2024). Perceived seriousness ofenvironmental issues and the influence of willingness to pay for hybrid vehicles: An anthropological extension of the theory of planned behavior. *International Journal of Sustainable Transportation*, *18*(9), 727-743.
83. https://doi.org/10.1080/15568318.2024.2399166