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Exploring Barriers to Low Carbon Tourism Development in Thailand: A Supply-Side Perspective

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Abstract

The research aims to achieve the following objectives: (1) To explore the barriers hindering the development of low carbon tourism in Thailand and (2) To conduct Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) on the identified barriers of low carbon tourism development in Thailand. The study adopts a mixed methods approach, combining qualitative and quantitative techniques. Data collection involved conducting in-depth interviews with 17 key informants involved in the supply-side of tourism. The data was analyzed using Nvivo 20 software, and the findings were utilized to develop a questionnaire. The questionnaire was then administered to 224 individuals engaged in the supply-side of tourism to assess their opinions. The collected data underwent EFA and CFA for further analysis. The research findings revealed three dimensions of barriers to low carbon tourism development in Thailand: Structure Constraints, Intrapersonal Constraints, and Interpersonal Constraints. These results provide insights into the specific barriers inhibiting the development of low carbon tourism in Thailand and can guide policymakers, industry stakeholders, and researchers in formulating strategies to overcome these obstacles.

Keywords*: low carbon tourism; barriers of low carbon tourism; low carbon tourism development; barrier of low carbon tourism development; low carbon tourism in Thailand; supply-side of low carbon tourism*

1. Introduction

Based on research conducted by scientists worldwide, it has been established that the future climate is expected to undergo distinct changes compared to the past and present climate. Consequently, we will inevitably confront the repercussions of climate change. It is widely acknowledged that resolving the issue of climate change in the near future (within the next 30-50 years) is unlikely. The United Nations Intergovernmental Panel on Climate Change emphasizes that the primary cause of global warming is the release of carbon dioxide (CO_2), with human activities accounting for over 90% of these emissions. Thailand, in particular, is exposed to climate change risks that could have diverse impacts on both the nation's tourism industry and its overall well-being. Given this context, it is imperative to earnestly evaluate the situation and devise strategies to mitigate these impacts. As stated by Cabrini Luigi, Murray Simpson, and Daniel Scott (2009), approximately 5% of carbon dioxide emissions stem from the tourism industry, with transportation alone contributing to roughly 75% of these emissions. Moreover, the extensive energy consumption in the accommodation sector has also played a significant role in exacerbating climate change (United Nations, 2017).

According to the extensive literature review, it becomes evident that climate change has emerged as a pressing concern globally. Moreover, the tourism sector, being an energy-intensive industry with significant carbon emissions, is deeply entangled with environmental challenges. Notably, the behavioral patterns of tourists have witnessed a noticeable shift since 2021, following the outbreak of the COVID-19 virus. Tourists have increasingly demonstrated a heightened awareness and conscientiousness towards environmental matters. Hence, the imperative arises for tourism to embrace an ethos of environmental sustainability while also ensuring social and economic viability. Consequently, nations across the globe must seek pathways to

foster sustainable tourism practices that align with these principles. One proposed approach to curbing carbon dioxide emissions within the tourism domain is the concept of "Low-carbon tourism". Low-carbon tourism, also known as low-carbon travel or green tourism, is a sustainable form of tourism that aims to minimize carbon dioxide (CO_2) emissions and overall environmental impact throughout the entire tourism lifecycle (UNWTO, 2018). This alternative form of tourism has garnered substantial interest from numerous countries, including Thailand. Nevertheless, a significant number of destinations remain oblivious to the importance of cultivating low-carbon tourism. Furthermore, in many developing nations, the concept of low-carbon tourism has not been adequately translated, impeding its widespread implementation, and introducing potential obstacles. Notably, economic, social, and physical barriers pose substantial challenges to the realization of low-carbon tourism. Hence, a comprehensive examination of these barriers is crucial in formulating strategies to mitigate or eliminate them, thereby facilitating the transition of the tourism industry towards low-carbon practices. Previous research studies have focused on the various obstacles and challenges related to low-carbon initiatives in different contexts. For instance, Liu (2014) explored the barriers to the adoption of low carbon production: A multiple-case study of Chinese industrial firms. Changbo and Jingjing (2011) examined construction of low-carbon tourist attractions based on low-carbon economy. Luo, Lam, and Ye (2019) identified barriers for the sustainable development of entertainment tourism in Macau. Additionally, several research studies have focused on low-carbon tourism management approaches. For example, Hsiao, Sung, Tsai, Wang, and Rong-Da Liang (2021) developed Establishing a model of low-carbon tour promotion for use by travel agencies from the perspective of shared value theory. Nicomsom, and Thirasak (2017) conducted a case study on low-carbon tourism management in Koh Mak, Trat Province. Songkran (2015) examined environmentally friendly and low-carbon tourism management in Thailand. Pimlapas (2017) studied carbon footprints from consumption in the tourism industry in Koh Samui, Surat Thani Province. However, despite these research efforts, successful implementation of low-carbon tourism practices in Thailand has not been achieved. There is hardly any research on the barriers to developing low-carbon tourism in Thailand. While Thailand has policies promoting low-carbon tourism, there are other factors that hinder the successful implementation of low-carbon tourism management.

Drawing from the preceding discourse, the researcher endeavors to investigate the subject matter entitled "Exploring Barriers to Low-Carbon Tourism Development in Thailand: A Supply-Side Perspective." The aim is to explore, analyze, and evaluate the impediments encountered in the advancement of low-carbon tourism within the Thai context, specifically from the standpoint of the supply side. The comprehensive comprehension of the factors impeding or restricting the progress of low-carbon tourism development in Thailand on the supply side holds the potential to facilitate the successful cultivation of low-carbon tourism within the country's tourism industry. This, in turn, will contribute to the establishment of sustainable tourism practices, thereby yielding multifaceted benefits encompassing economic, social, and environmental aspects for Thailand in the future.

2. Objectives

(1) To explore barriers hindering the development of low carbon tourism in Thailand

(2) To conduct exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) on the identified barriers.

3. Materials and Methods

This study adopts a mixed-methods approach, encompassing both qualitative and quantitative research methodologies. Its primary objective is to explore barriers to the development of low-carbon tourism in Thailand from the perspective of the tourism supply side. This includes stakeholders from the government and private sectors associated with tourism, tourism-related service businesses, as well as experts in tourism and environmental studies. By identifying and comprehending the obstacles hindering the progress of low-carbon tourism in Thailand, this research aims to enhance awareness and understanding of the challenges in this domain. The study employs a comprehensive literature review to gain insights into the barriers and limitations associated with low-carbon tourism. In-depth interviews and questionnaires are utilized as data collection tools, enabling the acquisition of more comprehensive and practicable data. The research process followed in this study is depicted in Figure 1, illustrating the sequential steps undertaken throughout the research endeavor.

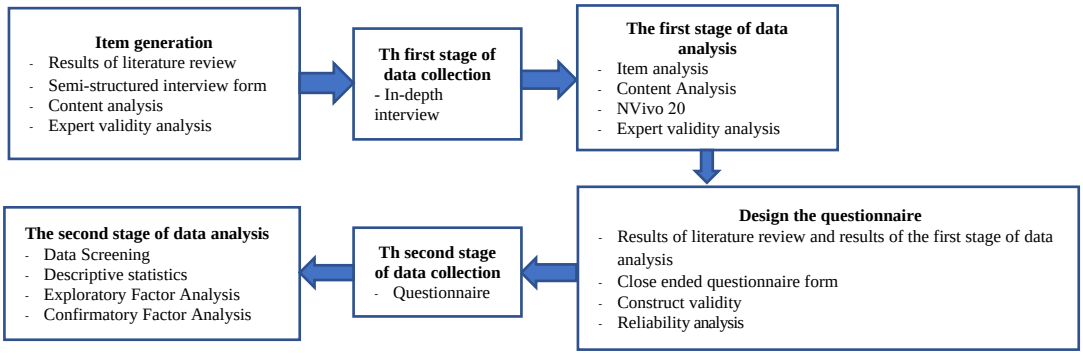

Figure 1 the sequential steps of research

3.1 The first phase of the study (qualitative research method)

3.1.1 Participants

The initial phase of this study employed a qualitative research methodology, focusing on key informants involved in tourism policy planning and management, tourism and environmental academics, and tourism business operators in Thailand. The selection of participants was based on their expertise and involvement in the field of tourism. Following Boddy (2016) recommendation, the sample size for in-depth interviews was determined to be 12 or more key informants, or until data saturation was achieved. In this study, a total of 17 key informants were included, providing valuable insights and perspectives. Further details regarding the participants can be found in Table 1, which is presented below.

Table 1 Information of key informants

No.	Organization name	Type of organization	Position
1	Tourism Authority of Thailand	Government sector	Governor
2	Ministry of Tourism and Sports	Government sector	Director of Tourism Development Division
3	Designated Areas for Sustainable Tourism Administration (Public Organization)	Government sector	Head of Knowledge Management Office of Sustainable Tourism
4	Thai Responsible Tourism Association	Private sector	Vice President
5	Thai Ecotourism And Adventure Travel Association	Private sector	Vice President
6	Lampang Rajabhat University	Academia sector	Lecturer in Tourism Program (Ph.D.) Academic Representative of northern region
7	Rangsit University	Academia sector	Lecturer in Tourism and Hospitality Management (Ph.D., Assistant Professor) Academic Representative of central region
8	Kasetsart University Chalermphrakiat Sakon Nakhon Province Campus	Academia sector	Deputy Dean for Student Affairs Development and Special Affairs and a lecturer at the Department of Service Industry (Ph.D.) Academic Representative of northeastern region
9	Prince of Songkla University	Academia sector	Director of Ecotourism Innovation Management Center (Ph.D.) Academic Representative of southern region
10	Centara Hotel and Resort (5 Green Hotel Award: Central World, Had Yai, Samui, Krabi, and Pattaya)	Service Business: 5 stars hotel	Senior Director of Affairs and Legal Relations

No.	Organization name	Type of organization	Position
11	Baan Taley Dao Resort (certified International Standards in terms of sustainable tourism management services from Travel life and certification measures for environmentally friendly domestic services from Green Hotel, Greenleaf, and Hotel Standards.)	Service Business: 3 stars hotel	Managing Director and Business Owner
12	Baan Nam Kieng Din Restaurant Green restaurant -Gold level 2021-2024)	Service Business: Restaurant	Managing Director and Business Owner
13	Kao Mai Pla Man Restaurant (Green restaurant-Silver level 2021-2024)	Service Business: Restaurant	Managing Director and Business Owner
14	Trekking Thai Co., Ltd.	Service Business: Travel	Managing Director
15	Malai Siam Co., Ltd.	Service Business: Travel	Managing Director
16	Rafts tour Phraek Nam Daeng Community Canal (Low Carbon Tourism, Samut Songkhram Province)	Service Business: Travel	Business Owner
17	Suksamran Electric Boat Transport	Service Business: Transportation	Business Owner

3.1.2 Data collection

The study was conducted in three distinct phases, as follows:

Phase 1: Preparation of Semi-Structured Interview Form. In this phase, a semi-structured interview form was developed based on the research conceptual framework. The interview questions were carefully crafted to address each specific aspect of the framework. Additionally, interview guidelines were designed to ensure consistency and facilitate the data collection process.

Phase 2: Familiarization with "Low Carbon Tourism". Before each interview session, the concept of "Low Carbon Tourism" was explained and clarified to the key informants. This step aimed to ensure that the participants were well-informed and adequately prepared to address the interview topics, thereby maximizing the study's outcomes and alignment with the research objectives.

Phase 3: Data Collection through In-Depth Interviews. Data collection involved conducting in-depth interviews with 17 key informants who possessed expertise and experience in the tourism industry. Each interview session lasted approximately 60-90 minutes and was audio-recorded with the consent of the participants. These interviews served as a valuable source of primary data, allowing for comprehensive exploration and analysis of the research topic.

By following these three sequential phases, the study successfully gathered rich and detailed insights from the key informants, contributing to a thorough understanding of the subject matter.

3.1.3 Data analysis

The data analysis process undertaken by the researcher is outlined as follows:

Step 1: Transcription and Data Organization. The audio files obtained from the in-depth interviews with key informants were transcribed into written format, specifically Word files. The subsequent step involved organizing and structuring the data. In line with qualitative data analysis principles (Miles, & Huberman, 1994), member review and expert review were employed to enhance the reliability and credibility of the qualitative analysis process (Mhyre, 2010).

Step 2: Content Analysis. Content analysis was employed as the research method to interpret the textual information gathered from the interviews. This method involved a systematic classification process, whereby issues and patterns were encoded and identified within the data (Hsieh, & Shannon, 2005).

Step 3: Utilization of NVivo 20. To facilitate the management and analysis of the qualitative data, the researcher utilized the computer software NVivo 20. This software aided in organizing, examining relationships within the data, encoding, classifying, and interpreting the data, providing valuable support for the qualitative data analysis process.

By following these steps, the researcher effectively analyzed the collected data, ensuring a rigorous and systematic approach to derive meaningful insights and conclusions from the research.

3.1.4 Expert Validation

The researcher followed a rigorous validation process for the written transcribed interviews to ensure accuracy and reliability:

1. Key Information Confirmation: The written transcriptions were returned to the key informants for assessment and confirmation. This step aimed to verify that the interpretations accurately reflected the intended meaning conveyed by the key informants during the interviews.

2. Expert Reviews: To enhance the analytical rigor, two travel experts were invited to review the entire data set. Their role was to identify any overlooked analytical units and provide their expert opinions on the data analysis process, thereby contributing to greater accuracy and robustness. This step aligns with the recommendation by Chang, Shen, and Li. (2019) to address any inconsistencies or potential discrepancies within the data.

3. Validation by Low-Carbon Tourism Experts: After categorizing the data using the NVivo 20 software, three experts with expertise in low-carbon tourism were engaged to validate the classification results. Their valuable insights and knowledge helped to ensure the accuracy and reliability of the data analysis process, reinforcing the credibility of the study.

By incorporating these validation measures, the researcher demonstrated a commitment to rigor and quality in the analysis of the data, contributing to the overall validity and trustworthiness of the research findings.

3.2 The second phase of the study (quantitative research method)

3.2.1 Participants

The second phase of this study utilized quantitative research methodology. The participants in this phase were selected from a diverse range of stakeholders in the tourism industry, including public and private tourism-related agencies, tourism service operators, and scholars specializing in tourism and environmental studies. The determination of the sample size for the closed-ended questionnaires followed the guideline proposed by Kline (2010). According to this guideline, the sample size should be 10 times the number of indicators or observed variables. As the qualitative study identified 20 indicators, the optimal sample size for this phase of the study was calculated to be 200 (20x10) participants. In total, 224 online questionnaires were collected to gather the necessary data for analysis. This sample size exceeded the calculated optimal size, providing a robust dataset for the quantitative analysis.

3.2.2 Data collection

This study was conducted in three distinct phases, as outlined below:

Phase 1: Data Analysis and Questionnaire Preparation. In this initial step, the researcher utilized the data analysis results obtained from the in-depth interviews, which were categorized using the NVivo 20 software. Based on these findings, a closed-ended questionnaire was prepared, consisting of two parts.

Part 1 of the questionnaire focused on gathering general information from the respondents. It included four items: the type of agency or organization they represent, gender, age, and level of education. These items aimed to establish a demographic profile of the participants.

Part 2 of the questionnaire comprised a 20-item opinion section, specifically designed to assess the perceived obstacles to the development of low-carbon tourism in Thailand. Respondents were asked to rate their opinions using a 5-level Likert scale, as recommended by Mirahmadizadeh, Delam, Seif, and Bahrami (2018).

Phase 2: Data Collection. In this step, data collection was carried out through an online platform. A total of 224 individuals participated by accessing the questionnaire via a provided link or by scanning a QR code. This online data collection method ensured convenience and accessibility for the respondents.

By following these sequential phases, the study effectively combined qualitative and quantitative approaches to gain comprehensive insights into the barriers of low-carbon tourism development in Thailand.

3.2.3 Data analysis

The data analysis process for this study is outlined as follows:

Step 1: Data Screening and Review. Before proceeding with the analysis, the researcher carefully reviewed and screened the data. Several criteria were considered, including the skewness, kurtosis, Variance Inflation Factor (VIF), and Tolerance of all observed variables. Skewness and kurtosis were examined to ensure the normal distribution of the data, with values within ±1.96 indicating normality. The VIF and Tolerance values were assessed to check for multicollinearity issues. The researcher followed established guidelines, considering a VIF value below 10 and a Tolerance value not less than 0.10 for further analysis. (Hair, Anderson, Tatham, & Black, 1995; Kennedy, 1992; Neter et al., 1989; Tabachnick, Fidell, & Osterlind, 2001; Rose, 2015; Kanlaya, 2018)

Step 2: Statistical Analysis. The research data was analyzed using appropriate statistical methods with the aid of a computer program. The following statistical techniques were employed:

1. Descriptive Statistics: Mean scores ($\overline{\mathbf{X}}$) and percentages were used to analyze the baseline data of the study sample.

2. Exploratory Factor Analysis (EFA) was conducted to identify common factors that could explain the relationships between observed variables. The Kaiser-Meyer-Olkin (KMO) statistic was used to assess the suitability of the analysis, with a KMO value close to 1 indicating appropriateness. Bartlett's test of sphericity was used to test the hypothesis of whether the correlation matrix was an identity matrix or not. Principal Component Analysis (PCA) was employed, considering factor loading variables with weights greater than 0.5 and at least three observed variables per factor. The Eigenvalue greater than 1 criterion was used, and the Varimax Rotation method was applied for orthogonal rotation to determine the observed variables that loaded on each component (Jöreskog, & Sörbom, 1996).

3. Confirmatory Factor Analysis (CFA) was performed to confirm the structure of the components obtained from the EFA. Criteria for evaluating the model's goodness of fit included the Chi-Square Statistics ($\chi 2/df$), with $\chi 2/df$ values less than or equal to 3.00 considered acceptable. For complex models, $\chi 2/df$ values should not exceed 5.00. The Root Mean Square Error of Approximation (RMSEA) should be less than 0.08 to indicate model consistency. Other indices, such as Adjusted Goodness-of-Fit Index (AGFI), Comparative Fit Index (CFI), and Standardized Root Mean Squared Residual (SRMR), were also considered. Threshold values for these indices were determined based on established guidelines (Kline, 1998; Schumacker, & Lomax, 2010; Steiger, 1990; Byrne, 2013; Hu, & Bentler, 1999; Byrne, 1998; Diamantopoulos, Siguaw, & Cadogan, 2000).

By following this systematic data analysis process, the researcher ensured the accuracy and reliability of the findings, enabling a robust evaluation of the research objectives.

3.2.4 Expert Validation

To ensure the validity and reliability of the data, the researcher employed expert validation techniques as follows:

1. Verification of Data Validity: To assess the validity of the data, the researcher utilized the Index of Item Objective Congruence (IOC), a measure of congruence between the questionnaire items and the research objectives. The questionnaires and research objectives were presented to three experts in the field, who evaluated the alignment between the questionnaire items and the main content. The criteria for question selection involved an IOC consistency index of ≥ 0.5, indicating acceptable congruence. The analysis revealed that the consistency index of the questions ranged from 0.67 to 1.00. The experts' suggestions were then incorporated to enhance the completeness of the questionnaire.

2. Verification of Reliability: To assess the reliability of the questionnaire, the researcher made improvements based on the experts' suggestions and conducted a pilot test with a sample of 30 individuals.

The data obtained from the pilot test were analyzed using Cronbach's alpha coefficient (α) (Cronbach, 1990). A minimum reliability value of 0.70 was considered acceptable (Hair, Anderson, & Tatham, 1987; Hair, Black, Babin, & Anderson, 2013). The calculated Cronbach's alpha coefficient was 0.931, which surpassed the specified criteria.

By employing these expert validation techniques, the researcher ensured the validity and reliability of the data collection instrument, thereby enhancing the credibility of the research findings.

4. Results

4.1 In-depth interview results

The in-depth interviews conducted in this study involved a total of 17 key informants from the tourism supply sector. The key informants were selected based on their expertise and involvement in tourism-related activities in Thailand. The composition of the key informants was as follows: 5 executives from public and private agencies involved in tourism (29.41%), 4 academicians specializing in tourism and environment (23.53%), and 8 service business operators associated with the tourism industry (47.06%).). Detailed information regarding the distribution of key informants is presented in Table 2.

Table 2 Number and percentage of key informants classified by type of organization

Type of organization	Number (people)	Number (%)
Government and private sectors involved in tourism in Thailand	5	29.41
Academic Sector: Higher Education Institutions in Tourism and Environment	4	23.53
Service business related to the tourism industry	8	47.06
Total	17	100

The data analysis conducted using the NVivo 20 program resulted in a total of 175 data units. These units were further classified into 4 main categories and 15 subcategories, which are closely related to the barriers encountered in the development of low-carbon tourism in Thailand. To ensure the credibility of the analysis, the data units were reviewed by experts. The first expert achieved a credibility score of 0.91 (160/175), the second expert obtained a score of 0.94 (165/175), and the third expert achieved a score of 0.96 (168/175). The resulting coding hierarchy, developed based on the data analysis approach, is presented in the form of a coding hierarchy chart, as depicted in Figure 2. This chart provides a visual representation of the hierarchical structure of the coding system used to organize and analyze the data.

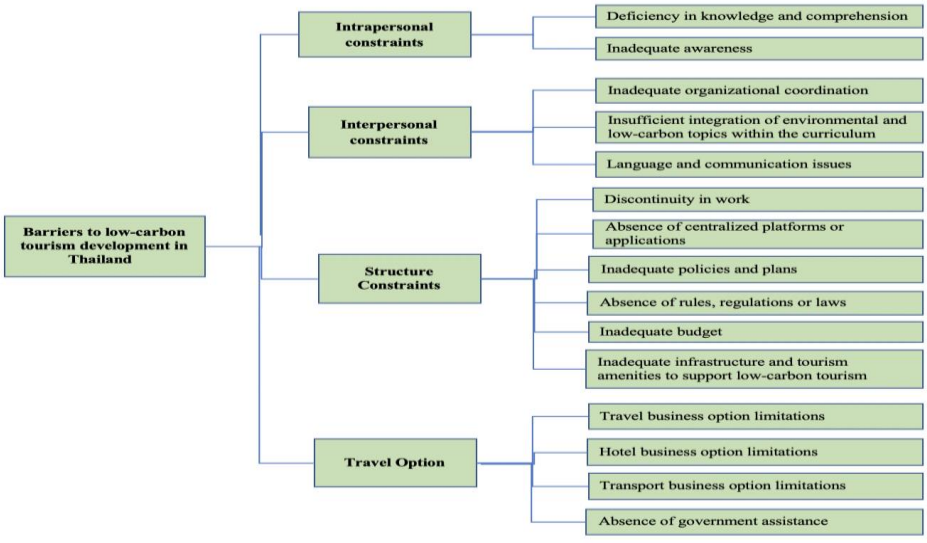

Figure 2 Coding hierarchy chart

The researcher provides a comprehensive overview of the results obtained from the analysis of barriers to developing low-carbon tourism in Thailand. These results are categorized into 4 main categories and further divided into 15 subcategories. The frequencies of each category and subcategory are presented in Table 3.

Table 3 Categories, subcategories, and frequency of barriers of low-carbon tourism development in Thailand

Categories and subcategories	frequency
1. Barriers of low-carbon tourism development in Thailand related to intrapersonal constraints	57
1.1 Lack of knowledge and understanding	44
1.2 Lack of awareness	13
2. Barriers of low-carbon tourism development in Thailand related to Interpersonal Constraints	20
2.1 Lack of coordination between organizations	11
2.2 Lack of teaching about the environment and low carbon in the curriculum.	5
2.3 Using language to communicate about environmental and low-carbon issues to those involved in tourism	4
3. Barriers of low-carbon tourism development in Thailand related to Structure Constraints	57
3.1 The work of the government sector lacks continuity.	3
3.2 Lack of centralized platforms or applications for low-carbon tourism	10
3.3 Government agencies do not have clear policies and plans for environmental protection and low-carbon tourism.	13
3.4 Lack of regulations or legislation related to carbon emission reduction and low carbon tourism.	12
3.5 Lack of government budgets for promoting low-carbon tourism	3
3.6 Tourism infrastructure and facilities are not conducive to low-carbon tourism.	16
4. Barriers of low-carbon tourism development in Thailand related to the limitations of Travel Option	23
4.1 There are few options for low-carbon tourism in tourism businesses.	2
4.2 There are few options for low-carbon tourism accommodation businesses.	1
4.3 There are few alternatives for low-carbon tourism transportation business.	7
4.4 Tourism-related enterprises lack government support in transitioning to low carbon	13

4.2 Results from data collection from questionnaires

4.2.1. Data verification before analysis

Prior to analysis, the collected data from the questionnaires underwent a verification process. The researcher examined and filtered the data by assessing the skewness and kurtosis of all observed variables, as well as the Variance Inflation Factor (VIF) and Tolerance. It was found that all observed variables met the specified criterion. Additionally, the VIF values of all variables were not greater than 10, and the Tolerance values were not less than 0.10, which align with the predetermined consideration criteria for data analysis.

4.2.2 Descriptive statistics analysis results

The results of the analysis pertaining to the respondents' personal data revealed that a majority of the participants were government personnel actively engaged in the field of tourism, accounting for 191 individuals (85.3%). Among the respondents, the majority were male, comprising 139 individuals (62.1%). Furthermore, a significant portion of the participants fell within the age range of 45-54 years, with 81 individuals (36.2%) falling into this category. Regarding educational qualifications, the sample group predominantly held a bachelor's degree, with 118 individuals (52.7%) attaining this level of education. More detailed information can be found in Table 4

Table 4 Results of general data analysis of respondents (n = 224)

Variable	Items	Number (%)
Operational unit	Personnel of government agencies involved in tourism	191 (85.3%)
	Academician in Tourism and Environment of the Academy	12 (5.4%)
	Personnel/operators of tourism-related service businesses	21 (9.3%)
Gender	Male	139 (62.1%)
	Female	82 (36.6%)

Variable	Items	Number (%)
	Not specified	3 (1.3%)
Age	20 – 24 years old	1 (0.4%)
	25 - 34 years old	45 (20.1%)
	35 - 44 years old	55 (24.6%)
	45 - 54 years old	81 (36.2%)
	55 years or older	42 (18.8%)
Education level	Undergraduate	1 (0.4%)
	Bachelor's degree	118 (52.7%)
	Master's degree	96 (42.9%)
	Ph.D	9 (4%)

4.2.3 Exploratory Factor Analysis (EFA) results

The researcher selected the 20 items that met the criteria for quality analysis and proceeded to conduct an Exploratory Factor Analysis (EFA) using the Principal Component Analysis (PCA) method in the SPSS program. The axes were then rotated using the Orthogonal Rotation method. In this stage, utilizing data collected from a sample of 224 participants, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test indicated a value of 0.931, surpassing the threshold of 0.5 and approaching 1 (Kerlinger, 1986).

Based on these findings, it can be concluded that this dataset is suitable for applying factor or component analysis techniques. In this study, a total of 20 factors were identified using the Varimax rotation method. It was observed that the factor loadings differed from those obtained without rotation. The data analysis revealed the presence of three factors derived from the EFA results concerning the barriers to developing low-carbon tourism in Thailand, as presented in Table 5.

Table 5 EFA analysis of the barriers of low carbon tourism development in Thailand (n = 224)

Factors/Items	Factor Loading	Eigenvalue	Cumulative Variation	Cronbach's α
Factor 1: Barriers related to structural constraints		10.65	53.26%	0.913
17. Do you think that low-carbon tourism transport services businesses have few options for serving low-carbon tourists.	0.81			
18. Do you think that there are few low-carbon tourism accommodation businesses for tourists to choose.	0.792			
19. Do you think that the low-carbon tourism business is still small compared to the demand for low-carbon tourists.	0.774			
15. Do you think that government agencies at the provincial and local levels do not have enough budgets to directly implement low-carbon tourism?	0.764			
16. Do you think that the tourism infrastructure and facilities are not favorable and inadeq uate for low-carbon tourism.	0.717			
20. You think that tourism and service businesses still lack government support in implementing the transition to low-carbon tourism.	0.679			
12. Do you think that Thailand currently does not have a centralized platform or application for tourism-related enterprises to take advantage of their service business activities to help reduce carbon emissions such as Calculate carbon footprint, database on carbon emissions of each type of activity, etc.	0.608			
Factor 2: Barriers related to intrapersonal constraints		1.75	62.00%	0.915
3. You think that government personnel still lack knowledge and understanding in applying technology to develop low-carbon tourism.	0.785			
1. You think that government personnel at different levels related to tourism still lack knowledge and accurate understanding of low-carbon tourism.	0.776			

Factors/Items	Factor Loading	Eigenvalue	Cumulative Variation	Cronbach's α
4. You think that at present, government agencies still lack the use of technology to create knowledge and understanding of low-carbon tourism.	0.765			
2. You think that hospitality and tourism personnel still lack accurate knowledge and understanding about low-carbon tourism.	0.709			
5. You think that local government officials lack awareness of the importance of low-carbon tourism.	0.673			
11.Do you think that the implementation of government agencies in relation to the development of low-carbon tourism is lacking continuity.	0.574			
14. Do you think that the government has no regulations or laws on carbon emission reduction and low carbon tourism applicable to tourism-related service businesses.	0.565			
13. Do you think that government agencies do not yet have clear policies and plans for environmental protection and low-carbon tourism.	0.531			
6. Do you think that establishments that are tourism service businesses still lack awareness and do not see the importance of low-carbon tourism.	0.745			
Factor 3: Barriers related to interpersonal constraints		1.02	67.08%	0.881
8. You think that government agencies still lack coordination and cooperation in the development of low-carbon tourism between government agencies and private sectors.	0.707			
9. Do you think that the education curriculum of educational institutions does not include tourism and environment/low-carbon education in the curriculum.	0.675			
10. Do you think that using language and communicating about the environment and low carbon to personnel in the workplace creates a problem with accurate and consistent awareness of the environment and low carbon.	0.659			
7. You think that government agencies still lack coordination and cooperation in the development of low-carbon tourism between government agencies and the government itself.	0.657			

Reliability and Validity Analysis

Reliability and validity analysis were conducted to assess the quality of the measurement instruments used in this study. Reliability refers to the consistency and stability of the measurements. Table 4 presents the Cronbach's α values for all factors related to barriers in the development of low-carbon tourism in Thailand. The obtained values exceed the recommended threshold of 0.70 (Hair et al., 1987; Hair et al., 2013). The overall reliability coefficient for the barriers of low-carbon tourism development in Thailand is 0.93, indicating a statistically high level of internal consistency. These results suggest that the measurement instruments used in this study are reliable for assessing the barriers to low-carbon tourism development in Thailand.

4.4.4 Confirmatory Factor Analysis (CFA)

To validate the measurement components against the proposed model or theory (Byrne, 2016), the researcher conducted Confirmatory Factor Analysis (CFA) using a statistical package. The indicators derived from the results of the confirmatory factor analysis demonstrated the alignment between the study's measures and the intended theoretical constructs. This CFA aimed to verify the model assessing the barriers to the development of supply-side low carbon tourism in Thailand, which was derived from the previous exploratory factor analysis (EFA). The CFA consisted of 3 latent variables and 20 observed variables, as outlined below:

1. The results of the Confirmatory Factor Analysis (CFA) for the supply-side barriers of low-carbon tourism development in Thailand related to structural constraints (STT), are presented in Table 5. This analysis involved the examination of 7 observed variables and their respective Pearson correlation coefficients, as well as an assessment of the model's concordance.

Table 6 Pearson correlation coefficients between observed variables of the barriers related to structure constraints (STT)

	STT1	STT2	STT3	STT4	STT5	STT6	STT7
STT1	1	.					
STT2	0.742	1					
STT3	0.713	0.774	1				
STT4	0.650	0.577	0.574	1			
STT5	0.644	0.666	0.602	0.638	1		
STT6	0.634	0.620	0.640	0.607	0.484	1	
STT7	0.520	0.596	0.586	0.452	0.551	0.506	1

The analysis of Table 6 revealed significant and positive Pearson correlation coefficients among the observed variables pertaining to the barriers of low-carbon tourism related to structure constraints (STT). The correlation coefficients ranged from 0.484 to 0.774, and all values achieved statistical significance at the 0.01 level, indicating a strong and consistent relationship between these variables.

Table 7 Consistency index of the confirmatory components of the barriers related to structural constraints variables (STT)

Statistics used in the audit	Criteria for consideration	Calculated value	Consideration results
x^2/df	$x^2/df < 3$	0.43	qualify
GFI	> 0.90	1.00	qualify
AGFI	> 0.90	1.00	qualify
CFI	≥0.95	1.00	qualify
RMSEA	< 0.05	0.00	qualify
SRMR	< 0.05	0.00	qualify

Based on the findings presented in Table 7, the confirmatory component consistency index of the variables related to structure constraints in the barriers of low-carbon tourism demonstrated favorable statistical values for evaluation. The chi-square value was non-significant (p-value = 0.92), indicating a good fit between the model and the observed data. Furthermore, the values of $\chi 2$/df =0.43, Comparative Fit Index (CFI) =1.00, Goodness-of-Fit Index (GFI) =1.00, Adjusted Goodness-of-Fit Index (AGFI) =1.00, Root. Mean Square Error of Approximation (RMSEA) =0.00, and Standardized Root Mean Squared Residual (SRMR)=0.00 all met the established criteria. These results indicate that the proposed model is consistent with the empirical data.

Table 8 Factor loading and the confidence value of measurement of barriers related to structural constraints (STT)

Factor	Item	Factor Loading	AVE	CR
STT	STT1	1.27	0.87	0.74
	STT2	0.95		
	STT3	0.89		
	STT4	1.03		
	STT5	1.00		
	STT6	1.13		
	STT7	0.98		

Based on the results presented in Table 8, the confirmatory components associated with structure constraints (STT) were examined. This component is comprised of 7 observed variables with factor loading values ranging from 0.89 to 1.27. It is worth noting that factor loading values greater than 0.40 were considered appropriate criteria (Hair, Black, Babin, Anderson, & Tatham, 2006). Furthermore, the Average Variance Extracted (AVE) value was calculated to be 0.87, which meets the recommended criterion of AVE ≥ 0.50 (Fornell, & Larcker, 1981; Hair et al., 2006). These statistical values provided insights into the barrier variables related to structure constraints (STT). Moreover, the reliability of the component measurement was evaluated using the Composite Reliability (CR), which yielded a value of 0.74. This value surpasses the recommended threshold of CR ≥ 0.70 (Bagozzi, & Yi, 1988; Hair Jr, Howard, & Nitzl,, 2020), indicating satisfactory reliability of the measurement for the identified barriers.

2. The results of the Confirmatory Factor Analysis (CFA) for the supply-side barriers of low-carbon tourism development in Thailand related to Intrapersonal Constraints (IAP), are presented in Table 9. This analysis involved the examination of 9 observed variables and their respective Pearson correlation coefficients, as well as an assessment of the model's concordance.

Table 9 Pearson correlation coefficients between observed variables of the barriers related to Intrapersonal Constraints (IAP)

	IAP1	**IAP2**	**IAP3**	**IAP4**	**IAP5**	**IAP6**	**IAP7**	**IAP8**	**IAP9**
IAP1	1								
IAP2	0.689	1							
IAP3	0.712	0.667	1						
IAP4	0.642	0.776	0.642	1					
IAP5	0.562	0.625	0.612	0.623	1				
IAP6	0.564	0.519	0.556	0.536	0.628	1			
IAP7	0.510	0.518	0.585	0.456	0.533	0.636	1		
IAP8	0.447	0.518	0.521	0.476	0.509	0.565	0.559	1	
IAP9	0.363	0.483	0.464	0.566	0.585	0.482	0.440	0.419	1

Based on the data presented in Table 9, it was observed that the Pearson correlation coefficients between the observed variables associated with the barriers of low carbon tourism concerning intrapersonal constraints (IAP) ranged from 0.363 to 0.776. Notably, all correlation values demonstrated statistical significance at a significance level of 0.01.

Table 10 Consistency index of the confirmatory components of the barriers related to intrapersonal constraints variables (IAP)

Statistics used in the audit	**Criteria for consideration**	**Calculated value**	**Consideration results**
x^2/df	$x^2/df<3$	0.52	qualify
GFI	> 0.90	1.00	qualify
AGFI	> 0.90	1.00	qualify
CFI	≥0.95	1.00	qualify
RMSEA	< 0.05	0.022	qualify
SRMR	< 0.05	0.00	qualify

Based on the statistical values presented in Table 10, the confirmatory component consistency index of the barriers variables related to intrapersonal constraints was examined. The chi-square value obtained was significant (p-value = 0.09622). Additionally, the model demonstrated a satisfactory fit as evidenced by the following indices: $\chi 2/df = 0.52$, Comparative Fit Index (CFI) = 1.00, Goodness-of-Fit Index (GFI) = 1.00, Adjusted Goodness-of-Fit Index (AGFI) = 1.00, Root Mean Square Error of Approximation (RMSEA) = 0.022, and Standardized Root Mean Squared Residual (SRMR) = 0.00. The fulfillment of all these criteria indicates that the model aligns well with the empirical data.

Table 11 Factor loading and the confidence value of measurement of barriers related to intrapersonal constraints (IAP)

Factor	**Item**	**Factor Loading**	**AVE**	**CR**
IAP	IAP1	0.50	0.86	0.77
	IAP2	0.64		
	IAP3	0.66		
	IAP4	0.71		
	IAP5	0.78		
	IAP6	0.82		
	IAP7	0.73		
	IAP8	0.69		
	IAP9	0.66		

Based on the results presented in Table 11, the confirmatory components associated with intrapersonal constraints (IAP) were examined. This component comprised 9 observed variables with factor loading values ranging from 0.50 to 1.82. It is important to note that factor loading values greater than 0.40 were considered appropriate criteria (Hair et al., 2006). Additionally, the Average Variance Extracted (AVE) value was calculated to be 0.86, which exceeds the recommended criterion of AVE ≥ 0.50 (Fornell, & Larcker, 1981; Hair et al., 2006). This indicates that the measurement of the barrier variables related to intrapersonal constraints (IAP) is appropriate. Furthermore, the reliability of the component measurement was evaluated using the Composite Reliability (CR), yielding a value of 0.77. This value surpasses the recommended threshold of CR ≥ 0.70 (Bagozzi, & Yi, 1988; Hair et al., 2020), indicating satisfactory reliability of the measurement for the identified barriers. These statistical values provide valuable insights into the measurement properties of the intrapersonal constraints (IAP) component.

3. The results of the Confirmatory Factor Analysis (CFA) for the supply-side barriers of low-carbon tourism development in Thailand related to Interpersonal Constraints (IEP), are presented in Table 12. This analysis involved the examination of 4 observed variables and their respective Pearson correlation coefficients, as well as an assessment of the model's concordance.

Table 12 Pearson correlation coefficients between observed variables of the barriers related to interpersonal constraints (IEP)

	IEP1	**IEP2**	**IEP3**	**IEP4**
IEP1	1			
IEP2	0.540	1		
IEP3	0.548	0.726	1	
IEP4	0.804	0.457	0.527	1

Based on the analysis presented in Table 12, the Pearson correlation coefficient between the observed variables associated with interpersonal constraints (IEP) in the barriers of low carbon tourism was examined. The correlation coefficients ranged from 0.457 to 0.804, and all values were found to be statistically significant at a significance level of 0.01.

Table 13 Consistency index of the confirmatory components of the barriers related to interpersonal constraints variables (IEP)

Statistics used in the audit	**Criteria for consideration**	**Calculated value**	**Consideration results**
x^2/df	$x^2/df < 3$	0.51	qualify
GFI	> 0.90	1.00	qualify
AGFI	> 0.90	1.00	qualify
CFI	≥0.95	1.00	qualify
RMSEA	< 0.05	0.00	qualify
SRMR	< 0.05	0.00	qualify

Based on the analysis presented in Table 13, the confirmatory component consistency index of the barriers variables related to interpersonal constraint (IEP) was examined. The statistical values used for examination are as follows: The chi-square value was found to be non-significant (p-value equal to 0.8521), indicating that the observed data fits the expected model well. The value of $\chi 2/df$ =0.51, The Comparative Fit Index (CFI), Goodness-of-Fit Index (GFI), and Adjusted Goodness-of-Fit Index (AGFI) all had perfect values of 1.00, The Root Mean Square Error of Approximation (RMSEA)=0.00, The Standardized Root Mean Squared Residual (SRMR) = 0.00. The passing of all these criteria suggests that the model, representing the barriers related to interpersonal constraint (IEP), is consistent with the observed data. These findings provide empirical evidence supporting the adequacy of the model and the relationships among the variables within the context of low carbon tourism.

Table 14 Factor loading and the confidence value of measurement of barriers related to interpersonal constraints (IEP)

Factor	Item	Factor Loading	AVE	CR
IEP	IEP1	1.50	0.86	0.74
	IEP2	0.89		
	IEP3	0.97		
	IEP4	0.68		

Based on the analysis presented in Table 14, the confirmatory components of the barriers related to interpersonal constraints (IEP) were examined. The statistical values used for examination are as follows: The factor loading values of the observed variables ranged from 0.68 to 1.50, indicating that these variables have a significant influence on the latent construct. Notably, all factor loading values exceeded the recommended threshold of 0.40, as established by Hair et al. (2006), suggesting the appropriateness of these variables in measuring the construct. The Average Variance Extracted (AVE) value was found to be 0.86, which exceeds the minimum threshold of 0.50 suggested by Fornell, and Larcker (1981) and Hair et al. (2006). This indicates that a substantial proportion of the variance in the observed variables is captured by the underlying latent construct. The reliability of the component measurement, assessed using the Composite Reliability (CR) criterion, was determined to be 0.74. This value surpasses the recommended threshold of 0.70, as proposed by Bagozzi, and Yi (1988) and Hair et al. (2020), implying adequate internal consistency and reliability of the measurement instrument. These findings highlight the appropriateness and reliability of the barriers variables related to interpersonal constraints (IEP) in capturing and assessing the construct within the context of low carbon tourism.

5. Discussion

This research employs a mixed-method approach, combining qualitative and quantitative methods, to investigate the barriers to low-carbon tourism development in Thailand from the supply-side perspective. Based on the findings of this study, a comprehensive model depicting the barriers to low-carbon tourism development in Thailand on the supply side was developed. Figure 3 illustrates the BLTD model, which encapsulates the identified barriers and their interrelationships. This model serves as a valuable framework for understanding and addressing the challenges hindering the advancement of low-carbon tourism in Thailand's supply sector.

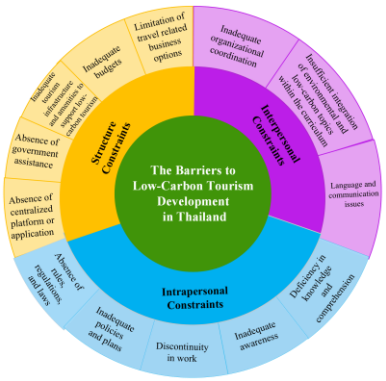

Figure 3 The BLTD Model

Explanation of the Model for Understanding the Barriers to Low-Carbon Tourism Development in Thailand: A Supply-Side Perspective

1. Barriers of low-carbon tourism related to structure constraints:

- Low-carbon hospitality businesses with limited options for travelers to choose from, including transport services, accommodation services, and tours, have been identified as a significant barrier. This finding aligns with the research conducted by Dai et al. (2022) and Pittaya (2011).
- Inadequate budgets allocated by local government agencies specifically for the development of

low-carbon tourism is another significant constraint. Currently, the budgetary allocation received by local government agencies is primarily directed towards general tourism development, rather than specifically supporting low-carbon initiatives. This observation is consistent with the research conducted by Changbo, and Jingjing (2011) and Rao (2018).

- Inadequate tourism infrastructure and facilities that are conducive to low-carbon tourism, such as low-carbon transport options, bike paths, and walking paths, pose a considerable barrier. This finding is in line with the research conducted by Luo et al. (2019) and Heung, Kucukusta, and Song (2011).
- The Absence of government assistance for tourism and service enterprises in implementing the transition to low-carbon tourism has hindered the progress of sustainable practices. This observation resonates with the findings of Luo et al. (2019) and Rao (2018).
- Thailand currently absence of centralized platform or application that could serve as a database-centric resource for businesses and tourists, offering functionalities such as carbon footprint calculation and a comprehensive database on the carbon emissions associated with various activities. This finding is consistent with the research conducted by Changbo, and Jingjing (2011).

It is important to acknowledge that the identified barriers are rooted in structural constraints within the supply side of the low-carbon tourism industry in Thailand. These barriers significantly impede the adoption and implementation of sustainable practices, highlighting the need for targeted interventions and policy measures to overcome these challenges.

2. Barriers of low-carbon tourism related to intrapersonal constraints:

- Deficiency in knowledge and comprehension among government personnel and individuals in the technology and low-carbon tourism service business has emerged as a significant barrier. This finding is consistent with the research conducted by Dai et al. (2022) and Changbo, and Jingjing (2011).
- Inadequate awareness regarding the importance of low-carbon tourism among local government officials and hospitality establishments has resulted in a lack of proactive engagement in low-carbon initiatives. This observation aligns with the research findings of Dai et al. (2022), Rao (2018), Khalid, Saad, and Mahadi (2013) and Changbo, and Jingjing (2011).
- Discontinuity in the implementation of low-carbon tourism projects by government agencies has been identified as a significant constraint. Upon completion of a project, there is often a lack of follow-up or sustained action to ensure the long-term sustainability of low-carbon initiatives. This finding is in line with the research conducted by Dai et al. (2022) and Rao (2018).
- Government agencies' inadequate policies and plans, including the absence of regulations or laws pertaining to carbon emissions reduction and low-carbon tourism, have contributed to the neglect of compliance among tourism stakeholders across sectors. This observation is consistent with the research conducted by Luo et al. (2019), Heung et al., (2011), and Rao (2018).

These intrapersonal constraints significantly impede the progress of low-carbon tourism development in Thailand. Addressing these barriers requires targeted efforts to enhance knowledge and awareness, establish comprehensive policies and regulations, and ensure the continuity and sustainability of low-carbon initiatives.

3. Barriers of low-carbon tourism related to interpersonal constraints:

- Inadequate coordination and cooperation in the development of low-carbon tourism between government agencies, as well as between government agencies and the private sector, has emerged as a significant barrier. This lack of coordination leads to inconsistent approaches and makes it challenging to achieve the common goal of low-carbon tourism development. This finding aligns with the research conducted by Davras, Caber, and Crawford (2019), Khalid, Saad, and Mahadi (2013) and Samardali Kakai (2013).
- The absence of tourism and environment/low-carbon education in the curriculum of educational institutions has resulted in a lack of understanding and knowledge regarding the environment and low-carbon practices among students. This deficiency hinders the proper adoption and implementation of low-carbon

initiatives. This observation is consistent with the research findings of Dai et al. (2022), Luo et al. (2019) and Rao (2018).

- Challenges arise in effectively communicating environmental and low-carbon issues to personnel in hospitality enterprises. Language barriers and difficulties in conveying accurate and consistent understanding of the environment and low-carbon practices pose significant challenges. It is important to note that personnel in tourism-related service businesses in Thailand comprise not only Thai individuals but also workers from other ASEAN countries. This finding is consistent with the research conducted by Heung et al. (2011), Samardali-Kakai (2013), Rokni, Turgay, and Park (2017), and Davras et al. (2019).

These interpersonal constraints significantly impede the progress of low-carbon tourism development in Thailand. Addressing these barriers necessitates enhancing coordination and cooperation among relevant stakeholders, integrating tourism and environment/low-carbon education in the curriculum, and establishing effective communication strategies for environmental and low-carbon issues within the hospitality sector.

6. Conclusions

6.1 Study results according to objective 1) To explore barriers hindering the development of low carbon tourism in Thailand from the supply side perspective. Key informants for this study included 17 individuals involved in the tourism supply sector. Data analysis using the NVivo20 program yielded 175 data units, which were then categorized into 4 main categories and 15 subcategories related to the barriers of low carbon tourism development in Thailand. The study identified 4 aspects of barriers to low carbon tourism development in Thailand, consisting of intrapersonal constraints, interpersonal constraints, structural constraints, and limitations in travel options. These findings provide a comprehensive understanding of the barriers to low carbon tourism development in Thailand, shedding light on various aspects that need to be addressed to promote sustainable and low-carbon practices in the tourism industry.

6.2 Study results according to objective 2) To conduct Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) on the identified barriers of low carbon tourism development in Thailand. Data analysis was conducted on in-depth interviews categorized using NVivo 20 software, and a closed-ended questionnaire was prepared. Data were collected from 224 individuals, including personnel from government agencies, private sectors related to tourism, personnel in tourism-related service businesses, and academics in tourism and the environment.

The results of the Confirmatory Factor Analysis (CFA) validated the model assessing the barriers to supply-side low carbon tourism development in Thailand, derived from the previous EFA findings. The CFA involved 3 latent variables and 20 observed variables. The barriers related to structure constraints emerged as the first dimension, encompassing 7 sub-variables. The confirmatory component consistency index for the structure constraint variables, the results indicated that the model exhibited a good fit with the empirical data. Dimension 2: the barriers of low carbon tourism development in Thailand related to intrapersonal constraints, consisting of 9 sub-variables. The confirmatory component consistency index of the barriers variables, the results indicated that the model was consistent with the empirical data. Dimension 3: This study examined the barriers to low carbon tourism development in Thailand associated with interpersonal constraints. These constraints encompassed 4 sub-variables. The confirmatory component consistency index for the interpersonal constraint variables, the results indicate that the model exhibited a good fit with the empirical data.

The model used to explore the barriers to low carbon tourism development in Thailand on the supply side successfully met all statistical criteria. The confirmatory components, including three variables and 20 sub-variables, demonstrated consistency with the empirical data, affirming the validity of the model in examining the barriers to low carbon tourism development in Thailand.

In conclusion, this study explored the barriers to low-carbon tourism development in Thailand from a supply-side perspective. The findings shed light on various dimensions of barriers, including structure constraints, intrapersonal constraints, and interpersonal constraints. These barriers pose significant challenges to the implementation of low-carbon practices in the tourism sector. These findings highlight the need for substantial investments and policies to address these structural shortcomings. To reduce intrapersonal barriers, necessitate targeted educational and awareness programs, along with the formulation of

comprehensive policies to foster sustainable low-carbon practices. Furthermore, the study highlighted the interpersonal constraints that require enhanced collaboration, curriculum revisions, and effective communication strategies among stakeholders. Overall, the findings of this study contribute to a deeper understanding of the barriers inhibiting low-carbon tourism development in Thailand from a supply-side perspective. The identified constraints call for a holistic approach involving policymakers, government agencies, educational institutions, and industry stakeholders to create an enabling environment for sustainable low-carbon tourism. By addressing these barriers, Thailand can strive towards a more environmentally friendly and resilient tourism industry in the future.

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