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Research Article

Sustainable Tourism and Public Health: Understanding the Environmental Factors Shaping Low-Carbon Travel Behavior

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ABSTRACT

With increasing concerns about climate change and environmental sustainability, low-carbon tourism has gained attention as a means to mitigate environmental impacts while promoting public health benefits. This study explores the environmental factors influencing low-carbon travel behavior and examines its potential contributions to individual well-being. Using a grounded theory approach, we conducted in-depth interviews with tourists, tourism practitioners, and sustainability advocates in Guizhou Province, China. The findings reveal that environmental knowledge, awareness, concern, values, and responsibility significantly shape low-carbon tourism behaviors. Moreover, engagement in low-carbon travel—such as eco-friendly transportation, nature-based activities, and sustainable accommodations—offers physical and mental health benefits, including stress reduction, increased physical activity, and enhanced well-being. These insights highlight the interconnectedness of sustainable tourism and public health, providing valuable implications for policymakers, tourism industry stakeholders, and public health professionals seeking to integrate sustainability into health promotion strategies.

Keywords: Low-carbon tourism, Sustainable travel, Public health, Environmental drivers, Health benefits, Tourism behavior, Well-being Province.

Introduction

As one of the fastest-growing and largest sectors in the global economy, the tourism industry has a profound impact on the environment, culture, society, and economy (Mofijur, 2021). While tourism can potentially be a significant driver of economic development, a lack of scientific and rational planning can lead to severe damage to biodiversity and the natural environment, resulting in the over-exploitation of natural resources such as freshwater, forests, and oceans (Dai et al., 2022). One of the notable negative impacts of tourism on the environment is the pollution of soil, air, and water bodies (Manikateva, 2021). According to research by the World Tourism Organization and the United Nations Environment Programme, carbon emissions from tourism account for approximately 4.9% of total anthropogenic emissions globally, with the resulting greenhouse effect contributing about 14% to global warming. This phenomenon not only exacerbates the trend of global warming but also poses a threat to the sustainable development of the tourism industry (Sung et al., 2021). Forecasts indicate that the annual

growth rate of global carbon emissions is expected to reach 3.2% by 2035 (Gühnemann et al., 2021). As one of the largest and fastest-growing industries globally, the impact of carbon dioxide emissions from tourism on climate change cannot be overlooked, and the sensitivity of tourism development is closely related to climate change (Cheer, 2017).

Facing these challenges, sustainable tourism is gradually integrated into people's lives. Among them, low-carbon tourism as an innovative sustainable tourism model, more and more attention. The model emphasizes reducing the carbon emissions associated with tourism activities, advocating the use of environmentally friendly transport, choosing sustainable accommodation and participating in eco-conscious activities for a greener travel experience (Mao et al., 2022). Low-carbon tourism not only mitigates the adverse impacts of the tourism industry on the environment but also fosters sustainable development and encourages the rational utilization of resources and the preservation of ecological systems (Fakfare & Wattanacharoensil, 2023b). By promoting low-carbon tourism, the sector can contribute to sustainable local economic growth while simultaneously safeguarding the natural environment(Baumber et al., 2021).Furthermore, low-carbon tourism exerts a beneficial influence on public health (Lin et al., 2022). Participation in low-carbon tourism activities—such as hiking, cycling through natural landscapes, and opting for green accommodations—not only enhances physical activity levels but also alleviates psychological stress and improves overall mental and physical well-being (Song et al., 2024). Empirical research has demonstrated that engagement with the natural environment has a significant positive effect on mental health, and low-carbon tourism provides individuals with opportunities to connect with nature and enjoy fresh air, thereby enhancing overall quality of life (Li et al., 2022).

In recent years, due to Guizhou's unique climate advantages and rich tourism resources, more and more tourists choose Guizhou as a tourist destination. As can be seen from the following table, the number of tourists in Guizhou Province increased year by year from 2017 to 2019. However, the global outbreak of the novel coronavirus at the end of 2019 seriously affected the global tourism industry, until the beginning of 2023, Guizhou's tourism industry is about to usher in a wave of explosive tourism boom. In September 2024, the number of tourists in Guizhou has reached 777 million, and the tourism income has reached 759.927 billion yuan, an increase of more than 35%. The number of tourists and revenue ranked first in the country (Summer 2024 Tourism Big Data Report). The tourism data are shown in Table 1:

Table 1 Statistical table of tourism number and income in Guizhou Province

Year	Number of Tourists	National Ranking	Tourism Income
2017	744 million	3	711.681 billion
2018	969million	1	947.103 billion
2019	1133million	3	1,232.18100.3 billion
2020	617million	3	579.125 billion
2021	644million	10	664.216 billion
2022	502million	1	457.279 billion
2023	1284million	1	1.46 trillion

Data source: Statistical Bulletin of National Economic and Social Development of Guizhou Province, Guizhou Bureau of Statistics

As the number of tourists continues to rise, Guizhou province is also facing the problem of carbon emissions. However, some scholars have found that with the development of tourism, the ecological environment of Guizhou Province has also been affected (Meng et al., 2023). Specifically, the growth of a range of industries such as transportation, accommodation and catering brought about by tourism activities has led to a significant increase in carbon emissions (Su, 2019).Studies have shown that there is a close relationship between carbon emissions and tourism development in Guizhou Province (Jiao et al., 2023). In order to effectively control environmental

pollution, many experts have conducted relevant studies, identified many pollution sources and influencing factors, in-depth analyzed the potential harm of environmental pollution to the ecosystem and human health, and put forward a series of solutions.However, previous research has focused on the implementation and policy aspects of low-carbon tourism, such as carbon emission control, changes in transportation modes, and the promotion of eco-friendly facilities (Fakfare & Wattanacharoensil, 2023a; Kanwal et al., 2024). Although these studies are of great value for promoting the theory and practice of low-carbon tourism, the discussion of tourists' motivation and psychological mechanism of low-carbon tourism choice is still insufficient (Shanshan et al., 2023). In fact, tourists' low-carbon tourism behavior is not only influenced by external environmental factors, such as policies and regulations, market supply and public opinion, but also driven by internal psychological factors, including personal values, environmental awareness and social responsibility (Wu et al., 2023).

Through qualitative research, we can deeply explore the internal driving factors affecting tourists' low-carbon tourism behavior, better understand the psychological needs and motivations of tourists, and verify the path and mechanism of environmental driving factors affecting low-carbon tourism behavior. This research approach can tap into the complexity of the psychological barriers, emotional drives and cognitive biases that tourists face when choosing low-carbon tourism. Improving the inner driving force of tourists combined with reasonable constraints of the external environment will help achieve the ultimate goal of low-carbon tourism and promote the sustainable development of tourism.

Literature Review

2.1 Low Carbon Tourism Behavior

As an important means of sustainable tourism, Low-carbon tourism behavior refers to the actions taken by tourists to minimize carbon dioxide emissions when selecting destinations, eco-friendly transportation, and environmentally certified hotels (Fakfare & Wattanacharoensil, 2023b). Low-carbon tourism behavior encompasses the efforts of the public to reduce carbon emissions through lifestyle and consumption choices, actively protecting the ecological environment of tourist destinations across various aspects of travel, including accommodation, transportation, shopping, and entertainment (Liming et al., 2015). Overall, low-carbon tourism behavior can be defined as a series of actions and choices aimed at reducing carbon emissions and environmental impacts during the tourism process. The primary objective of this behavior is to mitigate the negative effects of tourism activities on climate change and the environment, thereby promoting sustainable tourism development. Low-carbon tourism behavior involved in three types: purchase-oriented low-carbon tourism behavior, reduction-oriented low-carbon tourism behavior, and maintenance-oriented low-carbon tourism behavior (Cheng et al., 2021).

2.2 Environmental knowledge and low-carbon tourism behavior

When consumers have sufficient environmental knowledge, they are more aware of the seriousness and urgency of environmental problems, and recognize the impact of tourism behavior on carbon emissions and resource consumption (Ardoin et al., 2020), this knowledge inspires their positive attitude towards low-carbon tourism(Krasny, 2020). They are increasingly aware of the importance of choosing sustainable modes of transport, reducing energy use, choosing eco-friendly accommodation, and supporting local communities and environmental projects (Geiger et al., 2019).

2.3 Environmental awareness and low-carbon tourism behavior

Environmental awareness enables individuals to gain a deeper understanding of the impacts their decisions have on the environment, and it is considered a crucial step in preparing individuals to address environmental issues (Begum et al., 2021). High levels of environmental awareness can encourage tourists to engage in sustainable behaviors (Sekhokoane et al., 2017). Conversely, a lack of this awareness may lead to indifference towards environmental issues, minimal changes in personal behavior, and an over-reliance on governmental actions (Kousar et al., 2022). Therefore, environmental awareness is regarded as one of the necessary prerequisites for

adopting environmentally friendly behaviors.

2.4 Environmental concern and low-carbon tourism behavior

Environmental concern refers to the degree of attention and interest individuals have towards environmental issues, including the importance of topics such as environmental protection, sustainable development, and climate change(J. Aman et al., 2021). The deep concern for environmental issues can lead individuals to exhibit responsible behaviors towards the environment (Malik et al., 2020). Environmental concern is regarded as a necessary condition for promoting environmentally friendly behaviors (S. Aman et al., 2021). Environmental concern enhances individuals' awareness of environmental issues and improves their understanding of low-carbon tourism (Daniels et al., 2012). Travelers who possess environmental concern are more likely to recognize the impacts of tourism activities on the environment, including energy consumption, waste generation, and carbon emissions. Their environmental knowledge motivates them to take action and choose low-carbon tourism options (Wang et al., 2020).

2.5 Environmental values and low-carbon tourism behavior

Environmental values represent an individual's perception, importance, and significance regarding the environment (Layzer & Rinfret, 2019). Consumers' environmental values have a profound impact on low-carbon tourism behaviors (Szabo & Webster, 2021). When consumers place a high emphasis on environmental protection, sustainability, and social responsibility, they are more likely to choose low-carbon travel options (Dunlap et al., 2019). Specifically, they tend to use public transportation, select eco-friendly hotels or guesthouses, purchase organic food and environmentally friendly souvenirs, avoid single-use plastic products, and show greater respect for and protection of the local natural environment (Bouman et al., 2021).

2.6 Environmental responsibility and low-carbon tourism behavior

Environmental responsibility is an intrinsic awareness and ethical concept that encompasses a sense of obligation to care for, respect, and protect the environment (Bouman et al., 2020). This awareness arises from a profound recognition of the Earth as our shared home and an understanding of the impact our actions and decisions have on the environment (Su & Swanson, 2019). Environmental responsibility not only motivates individuals and organizations to actively assume the responsibility of protecting the environment but also encourages them to adopt environmentally friendly practices at a personal level, such as conserving energy, reducing waste, and minimizing pollution. Furthermore, environmental responsibility fosters the dissemination of environmental awareness and participation in environmental actions (Hong & Guo, 2019; Szabo & Webster, 2021; Vermeir et al., 2020).

Methods

3.1. Study Area

This study focuses on Guizhou Province in China. Firstly, Guizhou is renowned for its rich cultural diversity and is one of the regions in China with a high concentration of ethnic minorities, possessing unique and varied ethnic cultures. Among the 56 ethnic groups in China, the Han ethnic group is the largest, while the remaining 55 groups are considered ethnic minorities. As a province in southwestern China, Guizhou is home to 17 ethnic minorities, ranking second in the country in terms of the population of ethnic minorities (Zheng et al., 2022).Secondly, Guizhou Province boasts an exceptionally high quality of ecological environment. According to data from the Guizhou Provincial Ecological Environment Protection Work Conference, since 2021, Guizhou has made significant strides in high-level ecological protection, with the overall ecological environment quality consistently maintained at a good level, continuing to rank among the top in the country (http://sthj.guizhou.gov.cn).In addition, during the 2024 May Day holiday, Guizhou Province recorded a total of 34.9177 million tourist visits, reflecting a year-on-year increase of 15.7%. This included 27.4584 million tourists from within the province and 7.4593 million tourists from outside the province, indicating a growing attractiveness

of Guizhou as a tourist destination (2024 Summer Tourism Big Data Report).Finally, influenced by tourism development trends, the popularity of "healing landscapes" has continued to rise. Destinations featuring pristine natural scenery, tranquil fields, romantic flower seas, forest pastures, small-town streams, and the sunrises and sunsets of ancient towns have become popular choices for travel during this year's May Day holiday, garnering significant appreciation from numerous consumers (https://finance.sina.com.cn/).

3.2. Data collection

3.2.1 Stakeholder definition

In this study, qualitative research primarily focuses on three groups of stakeholders: tourists, tourism practitioners, and low-carbon tourism advocates, who are distributed across five categories of A-level scenic areas.

Tourists: Tourists are chosen as the target group because they are direct participants in low-carbon tourism behaviors. Understanding the motivations and behaviors of tourists will reveal their willingness and actions regarding low-carbon tourism, thereby helping us comprehend the actual performance and influencing factors of low-carbon tourism behaviors.

Tourism Practitioners: Tourism practitioners are selected as a target group due to their significant role in the tourist experience. Their behaviors, attitudes, and perceptions may have direct or indirect impacts on tourists' low-carbon tourism behaviors. Understanding their awareness, attitudes, and practices regarding low-carbon tourism can help us identify their potential role in promoting low-carbon tourism.

Low-Carbon Tourism Advocates: This group includes advocates and experts from government agencies, non-governmental organizations, environmental organizations, or the tourism industry. Low-carbon tourism advocates are chosen as a target group because they possess expertise and experience in the field of low-carbon tourism. Their research, advocacy, and practices play a crucial role in promoting low-carbon tourism behaviors. By understanding their perspectives, strategies, and opinions, we can gain in-depth insights into low-carbon tourism behaviors and draw on their experiences to facilitate the development of low-carbon tourism.

3.2.2. Data Collection

China's tourism planning standards categorize the quality levels of tourist attractions into five tiers, listed in descending order as AAAAA, AAAA, AAA, AA, and A. The evaluation of the quality grading of scenic spots is conducted based on several criteria, including transportation accessibility, sightseeing opportunities, tourism safety, health services, telecommunications, shopping facilities, operational management, resource and environmental protection, the attractiveness of tourism resources, market appeal, annual visitor numbers, and the satisfaction rates derived from tourist sampling surveys.

According to survey data, Guizhou Province boasts a total of 570 A-level scenic areas, which are distributed as follows: 5 AAAAA-grade scenic spots, 8 AAAA-grade scenic spots, 133 AAA-grade scenic spots, 375 AA-grade scenic spots, 47 A-grade scenic spots, and 7 A-level scenic spots (Guizhou Provincial People's Government website: http://www.guizhou.gov.cn). This distribution is illustrated in Table 2：

Table 2 Distribution of A-level scenic spots in Guizhou Province

Scenic Area Rating	Number
5A	8
4A	133
3A	375
2A	47
1A	7
Total	570

To ensure the representativeness of the sample, participants will be selected from each A-level scenic area in Guizhou Province. Specifically, from the 5A scenic spots, 2 tourists, 2 tourism practitioners, and 2 low-carbon tourism advocates will be chosen. The same selection criteria will apply to the 4A, 3A, 2A, and 1A scenic spots, resulting in 2 tourists, 2 tourism practitioners, and 2 low-carbon tourism advocates from each category. Consequently, the total sample will comprise 10 tourists, 10 tourism practitioners, and 10 low-carbon tourism advocates, amounting to 30 participants in total.The distribution is shown in Table 3:

Table 3 Stakeholders for Interview

Tourist attraction grade	Identity Number		
	Tourists	Workers	Proponent
5A scenic spot	T1	W1	P1
4A scenic spot	T2	W2	P2
3A scenic spot	T3	W3	P3
2A scenic spot	S4	W4	P4
1A scenic spot	T5	W5	P5
Total（n=30）	10	10	10

3.3 Data Analysis

Personal interviews serve as a traditional method for collecting micro-level data from tourists. This questionnaire is divided into four sections to ensure that no personal privacy information, such as names, identification numbers, or home addresses, is included. The first section focuses on the demographic characteristics of the tourists, including monthly income, age, gender, education level, and place of residence. The second section gathers travel-related characteristic information (Qiang et al., 2020), encompassing personal expenditures during the trip, duration of stay, size of the travel group, transportation costs, and past travel experiences. The third section aims to explore the factors influencing consumers' low-carbon travel behavior, including the significance, manifestations, motivations, willingness to participate, and attitudes toward low-carbon tourism. The fourth section examines the relationship between low-carbon tourism and public health, specifically assessing the impact of participation in low-carbon tourism on stress reduction, increased physical activity, and overall enhancement of physical and mental well-being.

This study initially delineated the research objectives and pertinent issues, specifically the influencing factors of low-carbon tourism behavior, to ensure alignment between the research design and qualitative methodologies employed. Subsequently, data pertinent to low-carbon tourism behavior were collected, encompassing interview transcripts, observational notes, questionnaire responses, and logs, thereby ensuring diversity and appropriateness of data sources.Following data collection, the information was imported into NVIVO software, where corresponding folders and labels were created for various data types to facilitate organization and management. Nodes and labels were established in accordance with the research objectives, and the data were encoded and classified to maintain the consistency and accuracy of the coding process. Utilizing NVIVO's comparative analysis tools, the relationships among different nodes and themes were investigated, thereby uncovering commonalities, discrepancies, and interconnections within the data, which further informed the exploration of the influencing factors of low-carbon tourism behavior.Furthermore, NVIVO's visualization tools—including charts, word clouds, and network graphs—were employed to visually represent the analytical outcomes and produce reports that effectively convey the research findings and insights. In addition, a portion of the questionnaire data was imported into AMOS software, where structural equation modeling was applied to analyze the impact of low-carbon tourism on public health.

The interview data were processed using NVIVO 14.0 and AMOS 27.0 software. Content analysis and word cloud technology were utilized to analyze the subject text, supplemented by frequency analysis, correlation analysis, and hierarchical analysis for comprehensive exploration (Mortelmans, 2019). The researchers first converted the interview transcripts into approximately 55,351 Chinese characters, which were subsequently translated into around 35,000 English words. Following this, 30 English texts were imported into NVIVO 14.0 for case analysis and into AMOS 27.0 for structural equation modeling. Relevant data points were classified, and pertinent themes were generated for comparative analysis alongside the questionnaire results, thereby elucidating the survey findings.

Results

4.1 Descriptive analysis

This interview covers different types of tourists, who travel to different places and have different professional backgrounds. Through descriptive statistical analysis of these qualitative data, we can deeply understand the diversity of various participants in tourism activities and their views and practices on low-carbon tourism, so as to provide a more comprehensive perspective and background for subsequent research.

Table 4 Descriptive statistics of respondents

NO.	Age	Gender	Places travelled	Careers
1	20	Female	Guang Xi, Sichuan	University students (environmental sciences)
2	35	Male	Lanzhou, Ning xia, Yuncheng	Freelance (photographer)
3	28	Female	Hong Kong, Guangzhou, Shanghai, Suzhou, etc.	Corporate White Collar (Marketing)
4	45	Female	Xi'an, Beijing	Secondary School Teacher (History Teacher)
5	30	Female	Nanjing, Suzhou, Hangzhou, Chongqing, Nanchang	functionary
6	40	Male	Chongqing, Western Sichuan	Entrepreneur (catering industry)
7	38	Male	Xinjiang, Tibet	Outdoor Adventure Leader
8	29	Female	Iceland, Antarctica, Spain, etc.	travel blogger
9	50	Female	Yunnan, Guizhou, Sichuan, Tibet	Retirees (formerly corporate executives)
10	32	Female	Africa, United States	Volunteers of environmental organisations
NO.	Age	Gender	Birthplace	Careers
1	25	Female	Tianjin	Landscape consultants
2	30	Male	Yunnan	Guide
3	28	Female	Shanghai	Travel agency staff
4	32	Male	Nanjing	Guide
5	27	Female	Chengdu	Tourism counsellor
6	29	Female	Da tong	Scenic Area Managers

7	31	Male	Suzhou	ticketing staff
8	33	Female	Xinjiang	Guide
9	35	Male	Changsha	Guide
10	26	Female	Qinghai	Guide
NO.	Age	Gender	Birthplace	workplace
1	38	Male	Beijing	Policy Research Office of the Environmental Protection Bureau
2	32	Female	Shanghai	PRC National Transport Bureau (NTP)
3	45	Male	Guangzhou	Market Development Division
4	40	Female	Chengdu	Energy Division of the Development and Reform Commission
5	35	Male	Nanjing	Waste Separation Office, Urban Management Bureau
6	30	Female	Hangzhou	Housing and Urban-Rural Development Bureau
7	42	Female	Wuhan	Natural Resources Bureau (NRB)
8	29	Female	Jinan	Publicity and Promotion Section, Culture and Tourism Bureau
9	36	Male	Shanxi	Office of Air Pollution Control, Environmental Protection Agency
10	31	Female	Fujian	Marine Resources Protection Section, Bureau of Ocean and Fisheries

The demographic information of the 30 participants is shown in Table 4. First, among the participants, there were 11 men (36.67%) and 19 women (63.33%), indicating a higher proportion of female respondents in the sample. Secondly, the age distribution of respondents is mainly concentrated in the 30-40 age group, accounting for about 50% of the participants. Third, respondents come from different occupational backgrounds, including education, healthcare, technology, finance and tourism, reflecting different views and attitudes towards low-carbon tourism in different industries. Finally, the participants lived in various provinces in China, such as Beijing, Guangdong, Sichuan, and Zhejiang, and this geographical diversity allowed the study to cover a wide range of cultural and economic backgrounds.

4. 2 Word frequency analysis

Figure 1. Word frequency analysis diagram

Through Figure 1, the research finds that several core themes are highly concentrated. Among them, "tourism", as the basic context of the interview, is naturally the most frequently used word, reflecting the direct relevance of the interview content. This was followed by "low carbon" and "environment", both of which appeared with high frequency, highlighting the centrality of environmental protection in the issue of low carbon travel and demonstrating people's deep concern about the environmental impact of travel activities. The frequent occurrence of the word "protection" reveals the public's urgency and sense of responsibility for the maintenance of ecological environment, reflecting people's emphasis on sustainable development and hope to reduce the consumption of natural resources through their own behavior. "Sustainable", as the goal of low-carbon tourism, conveys the expectation of future tourism methods and emphasizes that ecological balance and sustainable use of resources must be taken into account while meeting the needs of contemporary tourists. "Health" is frequently mentioned, which shows that tourists are not only concerned about the experience and enjoyment of tourism activities, but also pay more attention to its impact on physical and mental health. This health-conscious trend shows that people want to pursue greener and healthier lifestyles while traveling, further echoing the strong link between the concept of low-carbon travel and public health. As the main body of low-carbon tourism, tourists' attitude, behavior and choice are the important entry point of this study.Behaviors and methods are action-oriented terms that together form key elements of low-carbon travel practices. Tourists, governments and the tourism industry are all exploring greener, low-carbon ways to travel and enjoy travel while reducing the negative impact on the environment. The close connection between travel and transportation reveals the importance of low-carbon transportation in low-carbon travel. Choosing low-carbon modes of travel, such as public transport, cycling or walking, is an important way to reduce carbon emissions and promote sustainable tourism. In addition, the mention of activities and feelings reflects that low-carbon travel is not just a behavioral choice, but a travel experience and emotional resonance. By participating in environmental protection activities, tourists can not only gain a unique travel experience, but also deepen their understanding and recognition of environmental protection concepts. As an important part of tourist accommodation, hotel's low-carbon transformation has also become a hot topic in the interview. Choosing a low-carbon hotel and reducing the use of disposable items has become an important consideration for tourists when choosing accommodation.

In summary, in the interview, we found that low-carbon tourism, as a form of sustainable tourism, has attracted wide attention and is considered to have an important impact on public health. By analyzing high-frequency words, we can outline multiple dimensions of influencing factors of low-carbon tourism, including environmental knowledge, environmental awareness, environmental concern, environmental values and environmental responsibility. These dimensions together constitute the basis for understanding the connotation and influencing factors of low-carbon tourism, and provide strong support for further research. In addition, low-carbon tourism not only helps to protect the ecological environment, but also encourages people to adopt healthier lifestyles, thereby contributing to the overall well-being of individuals and society.

4.3 Cluster Analysis

In this study, a cluster analysis of the interview texts was conducted with the aim of revealing potential patterns of correlation between the 30 interviews. Relying on deep lexical level profiling, the researcher constructed a network of correlations between the interviewees in the total textual dataset. This analysis not only deepened the understanding of interviewees' exact positions and insights, but also led to natural groupings based on these differences, which are clearly illustrated in Figure 2.

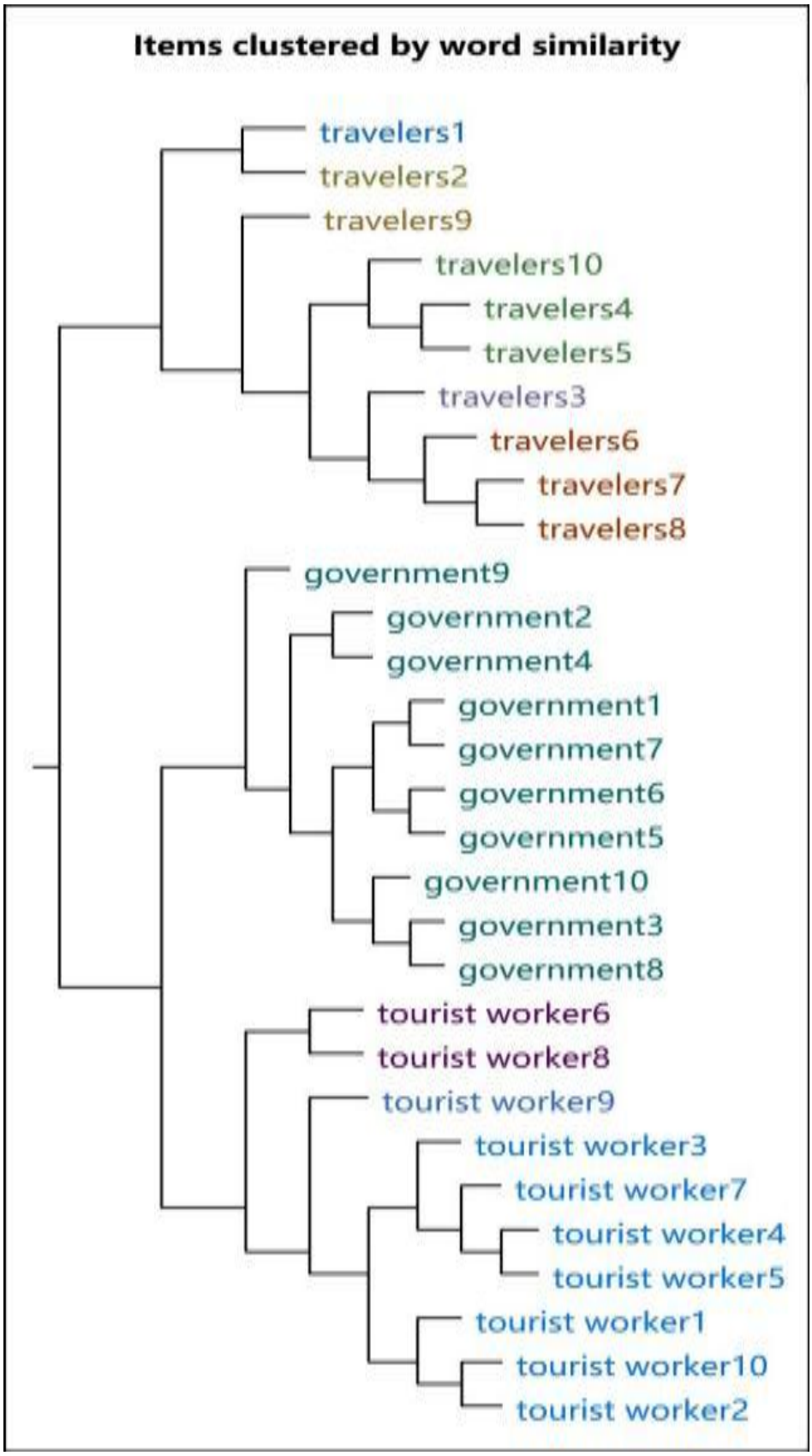

Figure 2. Interview clustering map

Thirty interview transcripts were analysed in depth, which corresponded to different participants' interviews. The insights and positions of the interviewees on the core issues in these interviews form an important case base for exploring the drivers of low carbon travel. In the subsequent data visualisation, three significant clustering groups were identified: the first group consists of interviewees numbered government1 to government10, demonstrating the set of perspectives from a particular viewpoint; the second group encompasses interviewees from tourist worker1 to tourist worker10, representing the unique views of tourism practitioners' unique perceptions of low carbon travel; the remaining respondents were categorised as the third group, which provided a wealth of additional information for the study of factors influencing low carbon travel.

4.4 Code analysis

After importing the organized literature into NVIVO 14.0 software, the first step involved constructing a node system. On the main interface of NVIVO 14.0, the researcher created new free nodes and assigned specific names to these nodes. Each newly created node represents a preliminary classification category, under which it encompasses text information extracted from the interview materials, serving as raw coding. In the classification of nodes, they are typically divided into free nodes and tree nodes. For data that cannot be clearly classified at the moment, it is temporarily marked as free nodes. During the open coding process, researchers have various coding options, including browsing coding, vitality coding, or automatic coding. In this study, we chose to combine browsing coding and vitality coding to construct a native coding system. Browsing coding requires the researcher to assign the raw data to the designated nodes.

This process necessitates that the researcher first establishes the corresponding free nodes based on the specific content of the study. Vitality coding is a more dynamic coding approach, in which the researcher identifies keywords within the raw data, quickly generates nodes, and then codes the selected content.Initially, we conducted a preliminary review of the raw text with an open attitude, without any preconceived notions, and performed open coding on the primary material. During the coding process, we extracted and named concepts from sentences within the raw materials, ultimately identifying 45 concepts related to fundamental environmental protection concepts, the significance of low-carbon travel, principles of sustainable tourism, impacts of global climate change, environmental effects of tourism activities, and environmental costs associated with different modes of travel.

We then reexamined the open coding and performed a cluster analysis of the 45 preliminary concepts, categorizing them into different domains to form potential contexts. After categorizing and logically organizing the domains, we identified 15 categories, including the foundational environmental knowledge, understanding of environmental issues, awareness of low-carbon technologies, perception of environmental problems, comprehension of low-carbon behaviors, and the relationship between the environment and travel. Furthermore, we established connections among these categories, conducted further extraction and in-depth analysis of the categories from the two rounds of coding, and repeatedly compared them with the original materials. Ultimately, these 15 categories were consolidated into 5 core dimensions: environmental knowledge, environmental cognition, environmental concern, environmental values, and environmental attention (see Table 5).

Table 5 Interview transcript coding form

selective coding	Spindle code	Open Codes
Environmental knowledge	Basis of environmental knowledge	Basic concepts of environmental protection
		The significance of low-carbon travel
		Principles of sustainable tourism
	Understanding of environmental issues	Global climate change impacts
		Environmental impacts of tourism activities
		Environmental costs of different modes of travel

	Low carbon technology awareness	Low-carbon transport understanding
		Application of energy-saving and emission reduction technologies
		Environmentally friendly accommodation and catering services
Environmental awareness	Perception of environmental issues	Perceived severity of environmental problems
		Perceived environmental impacts of tourism activities
		Perceived impact on individual travel behaviour
	Low carbon behavioural understanding	Understanding of the behavioural implications of low-carbon travel
		Perceived effects of individual low-carbon behaviours
		Attitudes towards the low carbon behaviour of others
	Environment and travel linkages	The relationship between environmental protection and the travelling experience
		Perceived destination impacts of low-carbon travel
		The link between personal travel choices and environmental responsibility
Environmental concerns	Environmental Issues of Concern	Attention to environmental news and policy
		Concerns about environmental issues in tourism
		Concerns about trends in low-carbon travel
	Reflections on Personal Behaviour	Reflections on personal travel habits
		Self-evaluation of low-carbon travel behaviour
		Reflections on improved modes of travel
	Social Opinion Interaction	Discussion on low carbon travel in public opinion
		Participation in environmental issues on social networks
		Evaluation and feedback on others' low-carbon behaviour
Environmental values	Environmental ethics	Attention to ecological balance
		A sense of responsibility for the environment of future generations
		Support for sustainable consumption
	consumer concept	A critique of overconsumption
		Preferences for green products and services
		Understanding of the relationship between quality of life and environmental protection
	Quality of life concept	The quest for a low-carbon lifestyle
		Recognition of the value of simple living
		Attention to ecological balance
environmental responsibility	Personal responsibility	Responsibility for personal travel behaviour
		Development of low-carbon travel habits
		Personal commitment to environmental impact

	social influence	Promoting low-carbon travel through social media
		Promote environmentally friendly behaviour at work or in the community
		Encouragement and influence on others to travel low carbon
	Policy engagement	Participation in policy discussions related to low-carbon travel
		Support and advice on environmental policies
		Choosing products and services that support environmental policies while travelling

As can be seen from the above table, the promotion and practice of low-carbon travel are strongly influenced by the environmental knowledge base. With solid environmental knowledge, individuals are able to deeply understand the serious environmental issues they are currently facing, such as global warming caused by greenhouse gas emissions, loss of biodiversity, and environmental pollution. At the same time, environmental knowledge helps people to realize the important role of sustainable tourism for public health. By understanding the impact of tourism activities on the ecological environment, tourists can realize that choosing low-carbon travel not only helps to protect the natural environment, but also directly contributes to physical and mental health. For example, choosing low-carbon modes of travel, such as walking, cycling or using public transport, not only reduces greenhouse gas emissions, but also encourages physical activity and increases fitness, helping to reduce health risks such as obesity and cardiovascular disease. In addition, engaging in nature can reduce stress, improve mental health, and increase happiness. Therefore, low-carbon tourism is not only an environmentally friendly way to travel, but also a good choice to promote people's physical and mental health. At the same time, knowledge of low-carbon technologies is also key, including understanding of clean energy, energy saving and emission reduction technologies, and carbon capture and storage technologies. This knowledge and technological awareness drives travelers to prefer options that have lower carbon emissions and lower environmental impact when choosing a mode of travel. With the progress of science and technology, low-carbon technologies continue to emerge, providing more possibilities for low-carbon travel. Awareness of low-carbon technologies, such as electric mobility, green building materials and energy-efficient accommodation facilities, has a direct impact on travelers' decisions when planning their trip. This awareness not only improves the environmental friendliness of travel, but also promotes the popularization and application of low-carbon technologies, further enhancing the positive role of sustainable tourism on public health.

Tourists' awareness of environmental issues directly affects their choice of low-carbon behavior. When people are aware of the pressure their actions put on the environment, they will tend to adopt more environmentally friendly ways of traveling. In addition, an understanding of low-carbon behaviour is crucial, including knowledge of specific measures to reduce carbon footprint, identification of environmentally friendly tourism products, and low-carbon tourism strategies. These insights help travelers implement low-carbon concepts in practice. Environmental awareness not only influences the behavior choices of tourists, but also makes people realize the important role of sustainable tourism for public health. By raising awareness of environmental protection, tourists can understand the positive impact of low-carbon travel choices on their physical and mental health. For example, engaging in low-carbon tourism activities, such as hiking, cycling or ecotourism, not only promotes physical activity and enhances fitness, but also reduces the health risks associated with a sedentary lifestyle. At the same time, contact with the natural environment can reduce stress, improve psychological state, enhance happiness, so that travelers enjoy the beautiful scenery at the same time, experience physical and mental relaxation and pleasure.

With the increasingly prominent environmental problems, tourists' attention to related issues is also increasing. They begin to pay attention to the environmental protection status of tourist destinations, the sustainability of tourism activities and other issues, and reflect on their own tourism behavior. This reflection has prompted travelers to pay more attention to environmental protection and reduce unnecessary waste and pollution in their future trips. At the same time, increased environmental concerns have also led to increased attention to the role of sustainable tourism in public health. With greater awareness of environmental issues, tourists are beginning to realize that their travel choices not only affect the natural environment, but also directly affect the physical and mental health of individuals. For example, participation in low-carbon tourism activities, such as ecological hiking and cycling, can promote physical exercise, enhance physical fitness, and reduce health risks such as cardiovascular disease. In addition, exposure to the natural environment, away from the hustle and bustle of the city, can help reduce stress, improve mental health, and enhance happiness.

Environmental values are an important driving force for low-carbon travel, emphasizing the concept of harmonious coexistence between people and nature, advocating the values of respecting nature and protecting the environment. This concept encourages travelers to pay more attention to environmental protection in their travels, follow the principles of sustainable tourism, and reduce environmental damage and pollution. At the same time, the promotion of environmental values also makes people pay more attention to the positive effect of sustainable tourism on public health. With the enhancement of awareness of environmental protection, tourists gradually realize that choosing sustainable tourism is not only a way to protect the ecological environment, but also an important way to promote their own physical and mental health. For example, participating in low-carbon tourism activities, such as hiking, cycling or participating in ecological volunteering, can effectively improve physical fitness, enhance fitness and reduce the risk of chronic diseases. In addition, exposure to natural environments can reduce psychological stress, improve mental health, and increase happiness and life satisfaction. Low-carbon travel also involves a shift in consumption attitudes. Traditional tourism consumption concepts often pursue luxury and enjoyment, while low-carbon tourism advocates a simple and environmentally friendly consumption mode. This shift in consumption attitudes will not only help reduce carbon emissions from tourism, but also improve the quality of life for visitors. By choosing environmentally friendly travel methods, travelers not only achieve harmony with nature while enjoying the pleasure of travel, but also gain a healthier life experience both physically and mentally.

Low-carbon travel requires travelers to have a strong sense of personal responsibility. They should recognize the environmental impact of their travel behavior and take proactive steps to reduce that impact. This sense of responsibility is not only reflected in the specific actions taken during the trip, but also in the dissemination of environmental knowledge and the advocacy of environmental protection concepts. Through their own actions and influence, travelers can push more people to join the ranks of low-carbon travel. At the same time, increased environmental responsibility has led to greater attention being paid to the role of sustainable tourism in public health. Travelers are aware that choosing low-carbon travel is not only a responsible choice for the environment, but also an investment in their own physical and mental health. For example, low-carbon travel activities, such as hiking, biking or participating in ecological conservation projects, can not only improve physical fitness and heart and lung function, but also reduce stress and improve mental health. While enjoying nature, travelers can obtain peace of mind and pleasure, so as to achieve comprehensive physical and mental health. Low-carbon travel also has important social implications. The low-carbon behavior of tourists can stimulate more people's environmental awareness and promote the overall development of society in the direction of low-carbon environmental protection. By actively advocating and practicing low-carbon travel, travelers can not only influence those around them, but also promote the importance of a healthy lifestyle in society and form a broader public health awareness. In addition, tourists and related organizations should actively participate in the formulation and implementation of

policies to provide policy support and guarantee for the development of low-carbon tourism. Such policy participation will not only help solve the current environmental problems, but also lay a solid foundation for the sustainable development of tourism, and ultimately achieve a win-win situation for environmental protection and public health.

4.5 Emotional attitude analysis

Affective tendency analysis, as a key part of text data analysis, aims to deeply analyse and explore the emotional states and attitudes embedded in texts. This process not only helps scholars to understand the emotional tendency of textual expressions, but also further reveals the emotional responses and value orientations of the public or individuals towards specific issues, concepts and problems. The core features of affective tendency analysis include emotion identification, emotion categorisation, emotion distribution analysis, and in-depth interpretation of context.

Within the framework of NVIVO 14.0 software, the Affective Disposition Analysis module provides researchers with an efficient platform for mining and analysis emotional data and exploring emotional attitudes in detail. The software empowers the researcher to accurately extract emotion signals from complex textual data, and by analysis the distribution patterns of these emotion expressions and the contextual backgrounds in which they are embedded, to achieve a comprehensive and deep insight into the emotional attitudes of the research subjects.

Table 6 Interviewee Emotional Attitude Scale

	A:very negative	B:more negative	C:Very positive	D:More positive
tourist worker1	3	2	13	2
tourist worker2	2	2	15	1
tourist worker3	6	0	13	1
tourist worker4	5	2	13	0
tourist worker5	5	2	13	0
tourist worker6	6	1	16	1
tourist worker7	5	0	13	0
tourist worker8	0	0	4	0
tourist worker9	0	0	4	0
tourist worker10	5	1	12	1
travelers1	2	3	17	1
travelers2	2	2	9	3
travelers3	3	2	17	1
travelers4	2	3	12	4
travelers5	6	3	17	2
travelers6	5	1	17	1
travelers7	4	2	16	9
travelers8	3	1	19	3
travelers9	3	0	12	5
travelers10	6	1	16	0
Low Carbon Tourism Advocates1	2	1	18	1
Low Carbon Tourism Advocates2	3	0	14	1
Low Carbon Tourism Advocates3	2	1	16	0
Low Carbon Tourism Advocates4	1	1	17	0

Low Carbon Tourism Advocates5	3	1	16	1
Low Carbon Tourism Advocates6	2	1	18	0
Low Carbon Tourism Advocates7	6	0	20	0
Low Carbon Tourism Advocates8	3	1	15	0
Low Carbon Tourism Advocates9	1	0	14	0
Low Carbon Tourism Advocates10	2	1	15	0

As shown in the table 6, the researchers obtained each respondent's insights and suggestions on the factors influencing low-carbon travel, and carefully classified them into positive and negative categories based on four different dimensions. During the interview, 77.91% of the respondents have a positive attitude towards low-carbon tourism behavior. They have some understanding of environmental damage and protection, pay more attention to environmental issues, have a high sense of social responsibility, and are very supportive of environmental protection. Some respondents (22.09% of the total) hold a negative attitude towards low-carbon tourism behavior. During the interview, it is found that these people tend to choose more comfortable and convenient travel behaviors due to convenience, price, enjoyment and other reasons. Overall, the vast majority of respondents showed positive feedback on low-carbon tourism, highlighting the obvious advantages of a positive attitude. This indicates that respondents are optimistic about the low carbon mobility factor and have positive expectations for the development of the field. Therefore, it can be inferred that, overall, respondents are optimistic about the drivers of low-carbon tourism.

Discussion and conclusion

This study conducted an in-depth analysis of the interview results of 30 stakeholders and found that the environmental drivers that affect people's low-carbon tourism behavior mainly focus on five aspects: environmental knowledge, environmental awareness, environmental concern, environmental values and environmental responsibility. These findings not only enrich the existing literature, but also supplement and extend the previous studies in some aspects.

To be specific, existing studies usually emphasize the importance of environmental knowledge in promoting green behavior, but this study further reveals the direct correlation between environmental knowledge and low-carbon tourism behavior. When people have a certain environmental knowledge base, they are more likely to have low-carbon tourism behaviors. This conclusion echoes Varela (Varela-Candamio et al., 2018) 's research on the impact of environmental education on sustainable tourism behaviors. In terms of environmental awareness, existing literature (Li et al., 2023) points out that the enhancement of environmental awareness can promote low-carbon travel behavior. However, this study further points out that the depth of an individual's awareness of the environmental impact of their behavior directly affects their initiative to change behavior. For example, when tourists realize that the way they travel has a negative impact on the natural environment, they will be more conscious to adopt low-carbon travel measures. This finding provides a more nuanced perspective to existing research on the relationship between environmental awareness and behavior change. In addition, environmental concerns, as another important factor affecting low-carbon tourism behavior, have not been fully explored in the existing literature. This study notes that those who are more concerned about environmental issues are generally better able to identify environmental hazards and therefore pay more attention to environmental protection in their tourism activities. This finding complements the work of Trudel (Trudel, 2019), which focuses on the impact of environmental concerns on consumer behavior, while this study applies it specifically to the choice of travel behavior. Regarding the impact of environmental values, the results of this study are consistent with previous studies (Ma et al., 2024), emphasizing how individual consumption concepts, environmental ethics and quality of life affect travel choices. Finally, environmental responsibility is often regarded as a background variable in previous studies, but this study puts forward it independently, emphasizing how individuals' sense of responsibility

for environmental protection can promote low-carbon tourism behavior. This finding helps to enrich the understanding of the motivation of low-carbon behavior and is expected to provide new ideas for future research.In addition, the promotion of low-carbon tourism behavior not only contributes to environmental protection, but also leads people to pay attention to the positive effect of sustainable tourism on public health (Chang et al., 2020). Participation in low-carbon tourism activities (such as hiking, cycling, etc.) can effectively enhance physical health, improve cardiopulmonary function, reduce stress, and promote mental health (Lin et al., 2022). While enjoying nature, tourists can obtain physical and mental peace and pleasure, so as to achieve comprehensive health (Hu et al., 2024). This improvement in physical and mental health also makes low-carbon tourism regarded as a new means of sustainable tourism, which not only pays attention to environmental protection, but also pays attention to human health and well-being (Bhaktikul et al., 2021).

To sum up, through in-depth analysis of the interaction of multiple factors such as environmental knowledge, awareness, concern, values and responsibility, this study not only confirms part of the conclusions of previous studies, but also provides a new perspective and theoretical contribution to understanding low-carbon tourism behavior. These findings provide a more comprehensive understanding for policy makers and tourism practitioners to take more effective measures to promote low carbon tourism, while also highlighting the importance of low carbon tourism in promoting public health.

This study also has several practical contributions. For government managers and tourism practitioners, exploring the impact mechanism of drivers of low-carbon tourism behavior can help them rethink how to promote tourists to develop low-carbon tourism behavior, ensure that drivers play a positive role in low-carbon tourism behavior, and minimize the negative impact on the environment. In addition, the findings of this study will help promote sustainable tourism development and help the tourism industry find a more reasonable balance between environmental protection and economic growth. This will not only enhance the ecological value of the tourist destination, but also attract more and more sustainable tourists, thus driving the entire industry in a greener and more sustainable direction. At the same time, the research results can also help travel consumers have a deeper understanding of low-carbon tourism, so as to improve their own low-carbon travel behavior. By increasing awareness of low-carbon tourism, low-carbon options not only help reduce the ecological burden, but also have a positive impact in terms of physical and mental health. Participating in low-carbon tourism activities, such as hiking and cycling, can enhance physical health and psychological well-being, and provide visitors with a unique experience of returning to nature and relaxing, thus achieving both physical and mental improvement. Visitors can become more aware of how their choices affect the environment and society, and become actively involved in sustainable tourism practices..

However, the study was not without limitations. The cross-sectional design and self-reported nature of the data may limit the ability to establish causality and control for potential bias. Future studies could employ longitudinal designs and objective measures of low-carbon tourism behavior to provide stronger evidence for the proposed relationship. In addition, the study focuses on a specific geographical context (Guizhou Province) and limited environmental drivers, which may affect the generalization of the findings to other contexts and variables. Despite these limitations, this study provides a theoretical basis for understanding the role of environmental drivers in promoting sustainable tourism behavior, making a significant contribution to the low-carbon tourism literature. The findings lay the foundation for future research and inform the development of effective strategies for managing low-carbon tourism destinations.

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