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Exploring Airline Passengers' Environmental Attitudes and Behaviors: Factor Analysis of Carbon Emission Reduction Strategies

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ABSTRACT

This study investigates the environmental attitudes and behaviors of airline passengers in relation to their willingness to pay for carbon credits, utilizing exploratory factor analysis (EFA) on survey data collected from passengers of full-service airlines in Thailand. The methodology involved structured questionnaires assessing seven key dimensions: Environmental Knowledge, Environmental Concern, Connectedness to Nature, Subjective Norms, Perceived Behavior Control, Attitude, and Willingness to pay for Carbon. The results reveal seven main factors influencing passenger behavior in the context of rising climate change concerns. Notably, higher environmental knowledge is associated with more informed decision-making regarding sustainable travel, while social influence and perceived behavioral control significantly increase the likelihood of participation in carbon offset programs. The findings underscore the importance of social dynamics and community involvement, particularly the role of emotional bonds to nature, in shaping pro-environmental behaviors. These insights suggest that airlines should leverage targeted environmental policies and marketing strategies such as educational campaigns and open access to carbon offset programs that directly address these factors. Such initiatives can enhance passenger engagement, boost support for environmental projects, and contribute to reducing greenhouse gas emissions within the aviation sector. Moreover, the study finds that passengers are willing to pay approximately 170 THB per person for international flights, with 94.5% of travelers expressing a readiness to pay for environmental initiatives.

1. INTRODUCTION

In recent decades, climate change has emerged as one of the most pressing global challenges, driven predominantly by human activities that alter greenhouse gas concentrations in the atmosphere. scientists believe that the rising global temperatures are a consequence of the greenhouse effect, resulting from excessive accumulation of greenhouse gases that trap heat in the atmosphere [1]. Among the contributors to this phenomenon, the transportation sector, specifically aviation, plays a significant role in greenhouse gas emissions, accounting for approximately 2% of global emissions [2]. To meet ambitious international emission reduction commitments, such as those outlined in the Paris Agreement, not only must technological advancements and policy interventions be implemented, but also widespread behavioral change among consumers is essential. Passenger behavior directly influences airline operations and corporate strategies [3], as travelers' preferences for sustainable options can incentivize airlines to adopt greener practices, invest in low-carbon technologies, and support initiatives like carbon offsetting. As global emission targets aim to limit temperature rise to well below 2°C, preferably to 1.5°C, public engagement and behavior are recognized as vital components in achieving these goals. In essence, the collective choices and actions of travelers serve as a driving force that encourages the aviation industry to transition toward more sustainable practices, thus playing a crucial role in fulfilling international climate commitments [3].

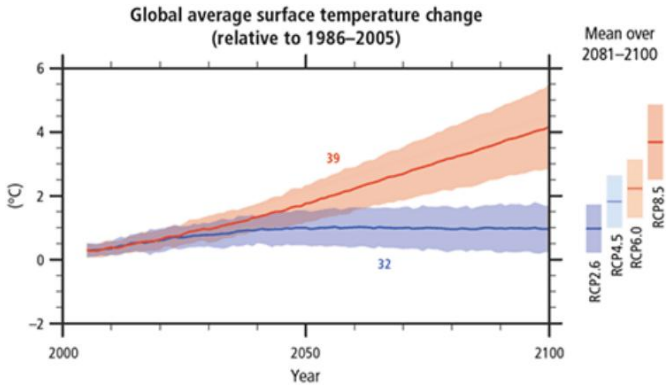

Figure 1. Average global surface temperature changes under various greenhouse gas emission scenarios from 2000 to 2100 [4]

As depicted in Figure 1, average global surface temperatures are projected to rise significantly under various greenhouse gas emission scenarios from 2000 to 2100. This trend emphasizes the urgency of addressing emissions in

various sectors, including aviation, which is crucial for facilitating rapid and safe travel while simultaneously being a major source of carbon dioxide (CO_2) emissions. The anticipated increases in global temperatures expected to exceed 1.5°C by the end of the 21st century under certain scenarios highlight the need for immediate action to mitigate climate impacts and prevent further global warming [5].

The International Civil Aviation Organization (ICAO), a specialized agency of the United Nations, has recognized the need for intervention and initiated the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which aims to monitor and offset CO_2 emissions from international flights. Since January 1, 2021, CORSIA requires airlines to report their emissions annually and implement strategies to compensate for any additional emissions, advancing towards a future with net-zero carbon emissions. This initiative is critical for raising awareness within the aviation sector about its environmental responsibilities and the potential solutions for reducing carbon footprints [6].

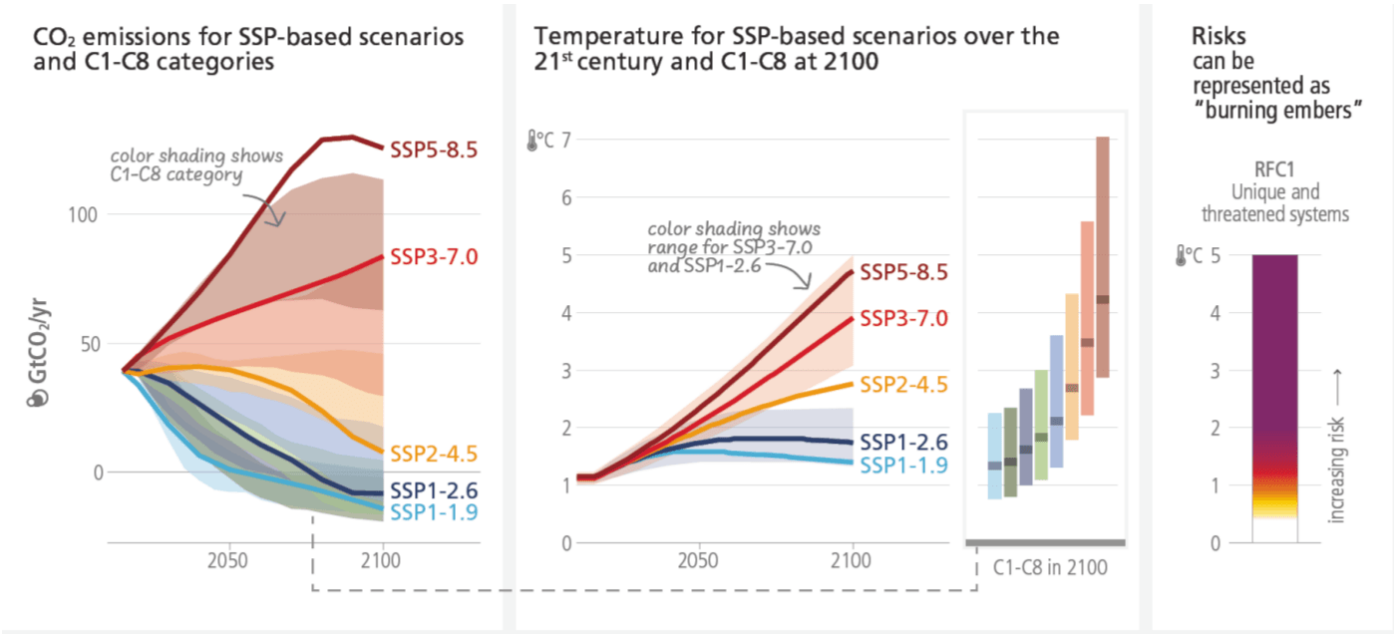

Figure 2. The relationship between greenhouse gas emissions, temperature changes, and climate change risks across different SSP scenarios [4]

Although considerable emphasis has been placed on carbon offsetting, the aviation industry continues to pursue innovative technological solutions to achieve further carbon reductions, including the adoption of Sustainable Aviation Fuel (SAF) and improvements in fuel efficiency. As illustrated in Figure 2, the interconnected relationships among greenhouse gas emissions, temperature fluctuations, and climate change risks highlight the necessity of assessing multiple scenarios, such as the Shared Socioeconomic Pathways (SSP), to inform future planning and policy formulation. In parallel with these industry-led initiatives, there is an increasing societal expectation for enhanced environmental accountability within both the aviation and tourism sectors.

Tourism is a key sector of the global economy, relying on the international movement of a vast number of travelers each year. The tourism sector contributes approximately 5% of global CO_2 emissions, and in some countries, tourism is responsible for an even greater share of carbon output than the global average. Although the future trajectory of emissions from tourism remains uncertain, the sector is expected to continue expanding, resulting in a growing proportion of global greenhouse gas emissions, especially if other sectors succeed in reducing their emissions [7].

Concurrently, airlines are under mounting pressure to enhance their environmental practices in response to growing consumer expectations concerning the impacts of climate change. Empirical studies have demonstrated that passengers are increasingly aware of and concerned about their carbon footprints associated with air travel, resulting in heightened demand for airlines to implement environmentally sustainable practices [8]. This heightened awareness is translating into consumer behavioral intentions, with travelers exhibiting a stronger propensity to support airlines that maintain robust and transparent environmental policies, thereby signaling a notable shift towards sustainability in travel preferences.

Key trends identified among airline passengers include a preference for eco-friendly airlines, support for renewable energy initiatives, waste management strategies [9], and a willingness to participate in carbon offset programs. By incorporating these behaviors, airlines can cultivate positive environmental attitudes and enhance their reputations among environmentally conscious consumers. Additionally, empirical evidence suggests that passengers' awareness and understanding of environmental issues directly correlate with their likelihood of engaging in sustainable travel behaviors [10].

The context of aviation's environmental impact creates an opportunity for examining the relationships among passengers' environmental attitudes, behavioral intentions, and actual behaviors. Hence, this study adopts an exploratory factor analysis methodology to identify key components influencing airline passengers' environmental behaviors [10]. Conducting such analyses can yield valuable insights into common patterns and preferences, facilitating the design of effective policies to mitigate emissions in the aviation sector.

It is crucial to understand the underlying beliefs, emotions, and intentions that shape passenger behaviors related to environmental sustainability. By assessing these factors,

airlines can tailor their strategies to better align with consumer expectations while achieving broader environmental objectives [11]. This investigation will not only contribute to scholarly discourse on environmental behavior in aviation but also support actionable insights for industry stakeholders seeking to foster sustainable practices.

In conclusion, the aviation industry faces a critical juncture where addressing environmental concerns through passenger engagement and innovative practices is essential. Recognizing tourism's significant contribution to global emissions emphasizes the importance of integrated sectoral approaches to environmental sustainability. By leveraging insights from exploratory factor analysis, airlines can explore the nuances of environmental attitudes, enabling them to implement strategic interventions that resonate with their customers and contribute effectively towards reducing their carbon emissions.

2. MATERIALS

2.1 The Theory of Planned Behavior (TPB)

TPB was developed by Ajzen in 1991 and is supported by empirical evidence suggesting that intentions to exhibit behaviors can be predicted by attitudes, subjective norms, and perceived behavioral control [12]. However, the nature of the relationships among these factors remains unclear. Expectations and configurations have shown limited success in addressing these relationships, and there are still limitations in measuring actual behavior [13]. TPB is an extension of the Theory of Reasoned Action (TRA), focusing on perceived behavioral control as a determinant of whether an individual succeeds or fails in controlling behavior and its consequences [14]. This factor is influenced by attitudes, intentions, and personal norms, where the perceived likelihood of success or failure in behavior is linked to compliance with referent influences [15]. TPB comprises three main components: attitudes, subjective norms, and perceived behavioral control, which are crucial for measuring and testing the theory's adequacy [16]. The model fundamentally comprises three main components: attitudes toward the behavior, which reflect an individual's positive or negative evaluations; subjective norms, representing perceived social pressures; and perceived behavioral control, indicating confidence in one's ability to execute the behavior and influence its outcomes. To enhance its applicability to environmental behaviors [16], the current study evaluates these components through a structured questionnaire encompassing seven key dimensions: Environmental Knowledge, Environmental Concern, Connectedness to Nature, Subjective Norms, Perceived Behavioral Control, Attitude, and Willingness to Pay for Carbon Credits. Specifically, attitudes are assessed via the "Attitude" dimension, subjective norms through the "Subjective Norms" dimension, and perceived behavioral control through the "Perceived Behavioral Control" dimension [17]. Moreover, to deepen understanding of the attitudinal and normative influences on behavioral intentions, the study incorporates additional constructs, including Environmental Knowledge and Connectedness to Nature. These dimensions align with recent extensions of the TPB that highlight the role of environmental consciousness and emotional connectedness in shaping pro-environmental actions. By explicitly mapping these factors onto the TPB framework [12], this study aims to provide a comprehensive perspective on the psychological determinants influencing travelers' willingness to pay for carbon credits and to assess the extended model's effectiveness in predicting sustainable behaviors.

2.2 Willingness to pay (WTP) to carbon credits

WTP is the total amount of money people or businesses are ready to spend to buy carbon credits, therefore reducing their greenhouse gas emissions. In other greenhouse gases, carbon credits are a decrease or elimination of one metric ton of carbon dioxide (CO_2) [18]. Encouragement of investment in projects aiming to lower emissions such as renewable energy projects, forestry efforts, and energy efficiency improvements depends on the WTP for carbon credits. Understanding the value people are ready to pay for carbon credits would enable companies and legislators to better create incentive programs to include people and businesses in environmental initiatives, therefore reducing the effects of climate change [19].

Moreover, WTP is influenced by several factors, including environmental awareness, perceived effectiveness of carbon offset programs, income level, and social norms. Consumers who recognize the link between their own activities such as air travel and climate change are often more willing to pay for offsets, especially when the benefits are clearly communicated and transparently reported [20]. Additionally, trust in the organizations managing carbon credit schemes plays a critical role; programs perceived as credible, verifiable, and aligned with recognized environmental standards tend to attract higher WTP. From a policy perspective, integrating WTP insights into climate strategies can help align market mechanisms with sustainability goals, ensuring that financial contributions translate into measurable emission reductions. By fostering both awareness and trust, stakeholders can expand the voluntary carbon market and accelerate the transition toward a low-carbon economy [20].

2.3 Environmental awareness (EA)

Environmental awareness shapes perceptions and actions taken on environmental problems. It promotes community involvement and social capital [21]. When considering different cultural contexts, research indicates that environmental consciousness and behavioral responses can vary significantly between regions. For instance, cross-cultural studies have shown that Asian passengers, including those in Thailand [21], often demonstrate a more collective approach and higher trust in community-led environmental initiatives compared to Western counterparts, who may emphasize individual responsibility and market-based solutions [22]. Understanding these differences is crucial for airlines operating internationally, as they must tailor their communication and engagement strategies to resonate with diverse cultural values and perceptions of environmental responsibility [23]. EA advances knowledge of the interdependence between human actions and environmental damage [24]. By raising awareness and supporting resident cooperative efforts, airlines can adopt responsible practices that result in coordinated voluntary measures for environmental stewardship. Effective communication of environmental implications by airlines helps passengers to make wise decisions regarding their carbon footprint and environmental impact, hence supporting sustainability initiatives [25].

Environmental knowledge (EKN) is the awareness of

associated issues and natural surroundings [26]. It calls for spotting and assessing problems like pollution, climate change, and ecological functions. Important factors are knowing local and worldwide environmental issues, which improve community mobilization for projects. Through requiring carbon credit purchases [27], the CORSIA program seeks to offset aircraft greenhouse gas emissions. Encouragement of responsible environmental activities depends on a well-informed population since information directly shapes decisions about sustainable development and conservation.

Connectedness to Nature (CTN) denotes an emotional link with the natural surroundings [28], so guiding pro-environmental actions [29]. Strongly connected people often show more concern for environmental problems and engage in active conservation activities. These people advocate for environmentally beneficial behaviors and grow more conscious of their environmental effects by realizing they belong to nature. Improved contact to nature not only helps to lower stress but also enhances communal ties and the accountability people feel towards environmental preservation [30].

Environmental Attitude (EAE) refers to ideas, feelings, and goals directed towards environmental problems. Particularly in the aviation industry, where consumers demand ecologically friendly practices [31]. Positive attitudes greatly influence pro-environmental behaviors. Airlines' improved openness about their environmental strategies will help to build consumer confidence and involvement. Airlines must match consumers' growing environmental concerns by means of initiatives such as sustainable aviation technologies and carbon offset programs, therefore strengthening their commitment to environmental responsibility [32].

Environmental Behavior (EBR) can be divided into ecological management, consumer actions, social influence, political participation, and legal action; it is the individual acts effecting the environment. Positive behavior changes [33], such as growing environmental literacy and societal values, play a crucial role. While convenience obstacles may reduce willingness to act, outside factors including community support and incentives might help to encourage sustainable habits [34]. In the aviation setting, passengers increasingly embrace environmentally friendly airlines and carbon-reducing policies [35], thereby impacting industry standards and sustainability initiatives [36].

An analysis of the studies summarized in Table 1 reveals clear patterns that justify the selection of factors in this research. Most prior work predominantly emphasizes Environmental Knowledge (EKN) and Environmental Concern (ECN), highlighting the critical roles of awareness and emotional engagement in shaping pro-environmental behaviors. These studies underscore knowledge and concern as key drivers of sustainable actions, aligning with the current focus on these constructs. However, comparatively less attention has been given to Connectedness to Nature (CTN), which reflects emotional bonds with the environment that can motivate conservation efforts. This underrepresentation indicates a gap in understanding the affective components of environmental attitudes that influence behavior. Recognizing these patterns, the present study incorporates CTN alongside EKN, ECN, and other factors to offer a more comprehensive view of environmental psychology within the context of aviation. By addressing this gap, the research aims to contribute new insights into both the cognitive and emotional drivers of sustainable passenger behavior, ultimately supporting the development of more effective environmental iniziative in the industry.

Table 1. Paper classification according to source of environmental awareness

Ref.	Researchers	EKN	ECN	EBR	EAE	CTN
[37]	Korba, P. et al., (2023)	X	X			
[38]	Wong, L. J et al., (2020)		X			X
[39]	Yavas, V., & Dedeoglu, A. O. (2024)	X	X			X
[40]	Alfaro, V. N., & Chankov, S. (2022)		X			
[41]	Baumeister, S et al., (2022)		X			
[42]	Loureiro, S. M. C., et al., (2022)	X	X			X
[43]	Amicarelli, V., et al, 2021	X				X
[44]	Kumar, T. P., & Dulloo, R. (2024)	X				X
[45]	Dimitriou, D., & Karagkouni, A. (2022)	X				X
[46]	de Mello, F. P. (2024)	X	X	X	X	X
[47]	Teixeira, A., et al., (2023)	X	X			X
[48]	Najam, A., (2023)	X				X
[49]	Kousar et al., (2022)	X	X			
[50]	Xu, B, et al., (2022)	X	X	X	X	
[51]	Huang, G. et al. (2022)	X		X	X	
[52]	Han, H. (2021)	X	X			
[53]	Si et al., (2022)	X	X			X
[54]	Agissova and Sautkina, (2020)			X	X	
[55]	García-Salirrosas et al., (2023)	X	X	X	X	
[56]	Sieg and Dreesmann, (2021)		X	X	X	
[57]	Galhoz, I., et al., (2024)	X	X	X	X	X
[58]	Maurer, M., & Bogner, F. X. (2020)	X	X	X		
[59]	Karimi et al., (2021)	X	X	X		
[60]	Despotović, J., et al., (2021)	X	X		X	X

3. METHODS

The methodology employed in this study centers around Exploratory Factor Analysis (EFA) to investigate the underlying dimensions of environmental awareness and behaviors influencing passengers' willingness to pay for carbon credits in the aviation sector. EFA is used to uncover the relationships between various observed variables and to identify factors that contribute to environmental attitudes and behaviors among airline passengers.

3.1 Sampling and data collection

Data were collected from a stratified random sample of airline passengers in Thailand using a structured questionnaire that included measures for seven key factors: 1. Environmental Knowledge, 2. Environmental Concern, 3. Connectedness to Nature, 4. Subjective Norms, 5. Perceived Behavioral Control, 6. Attitude, and 7. Willingness to Pay for Carbon Credits. A stratified random sampling technique was employed to ensure a diverse and representative participation across different demographics, including age, gender, and travel frequency.

The total sample size was 400 respondents, with a response rate of 100%, resulting in 398 completed questionnaires. Based on Krejcie and Morgan's (1970) sampling size determination, a sample of 384 was deemed adequate to ensure data reliability and representativeness. This study was conducted in accordance with ethical standards and received human ethics approval from Mahasarakham University, Thailand, under the reference number 086-106/2025.

Most respondents were female (62.7%), accounting for 251 individuals, while males comprised 37.3% with 149 respondents. Most participants were between 20 and 29 years old, representing 68.5% (274 respondents). The next largest age group was 30-39 years (23.5%, 94 respondents), followed by those aged 40-49 years (5.5%, 22 respondents), 50-59 years (1.5%, 6 respondents), and 60 years and above (1%, 4 respondents).

Regarding marital status, most respondents were single (70%), with 280 individuals, followed by married (25%, 100 respondents), separated or divorced (4.5%, 18 respondents), and living separately (0.5%, 2 respondents). In terms of occupation, most participants were private company employees (67.5%, 270 respondents), followed by self-employed or business owners (22.5%, 90 respondents), government employees or civil servants (5.8%, 23 respondents), unemployed or not engaged in any occupation (2.2%, 9 respondents), and state enterprise employees (2%, 8 respondents). Regarding income, the most common range was 20,001–30,000 Baht (23.8%, 95 respondents), followed by 10,001–20,000 Baht (23.5%, 94 respondents), and 30,001–40,000 Baht (19.8%, 79 respondents).

To ensure the reliability of the measurement instrument, the questionnaire demonstrated excellent internal consistency, with a Cronbach's alpha of 0.990 for the overall scale.

3.2 Preliminary data analysis

Before conducting the exploratory factor analysis (EFA), preliminary tests were performed to evaluate the suitability of the data for factor analysis. The key statistical measures included the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's Test of Sphericity. The KMO value was 0.931, which indicates excellent sampling adequacy, while Bartlett's test was highly significant (χ^2 = 25,630.260, df = 1711, $p < .001$), confirming that the correlations among the variables were sufficiently strong to justify factor analysis.

The questionnaire used in the study comprised 56 items, developed through a comprehensive review of existing scales on environmental attitudes and behaviors from previous research, as detailed in Table 1. To ensure content validity and cultural relevance within the Thai context, these items were reviewed and validated by a panel of three experts in environmental psychology and aviation sustainability. The development process involved adaptation, contextualization, and refinement to align the items with the characteristics of the target population.

Following the adequacy assessment, was performed for factor extraction. An oblique rotation method was applied, which allows for potential correlations among factors—an approach appropriate for psychological constructs involving attitudes and perceptions. The rotated solution facilitated clearer interpretation of the factors by maximizing loadings on individual items while accommodating correlations among factors. This rigorous process, including the development, validation, and application of orthogonal rotation using the Varimax method, ensures that the factors are both well-defined and interpretable. These steps provide a strong foundation for subsequent analyses of environmental attitudes and behaviors among airline passengers.

From Table 2, A KMO value of .931 indicates an excellent adequacy for factor analysis. Additionally, Bartlett's test revealed a significant result ($p < .001$), affirming that the correlations among the variables warrant further investigation via factor analysis [54].

Table 2. KMO and Bartlett's test results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Barlett's Test of Sphericity		
	Approx. Chi Square	df	Sig
.931	25630.260	1711	<.001

3.3 Factor extraction and analysis (EFA)

Following the adequacy assessment, a Principal Component Analysis (PCA) was performed to extract the underlying factors. The analysis identified multiple components associated with the dimensions of environmental awareness and behaviors. Each component's eigenvalues and the percentage of variance they explained were determined [61].

Table 3. Eigenvalues and variance explained

Factor	Eigenvalue	% of Variance	Cumulative %
1	7.606	12.891	12.891
2	7.389	12.523	25.414
3	6.562	11.122	36.536
4	6.188	10.488	47.024
5	5.404	9.159	56.183
6	5.116	8.671	64.854
7	4.146	7.027	71.880

From Table 3, it shows the number of components, eigenvalues, percentage of variance, and cumulative percentage of variance for each component. It can be concluded that from the total of 7 observed variables, these can be categorized into 7 factors. Factor 1 is the most significant,

explaining 12.891% of the variance in the dataset. Factor 2 explains 12.532%, Factor 3 explains 11.122%, Factor 4 explains 9.159%, Factor 5 explains 9.159%, Factor 6 explains 8.671%, and Factor 7 explains 7.027% of the variance.

The analysis identified seven key factors related to environmental awareness and behaviors that influence passengers' willingness to pay for carbon credits in the aviation sector in Thailand [62]. The factors were extracted using orthogonal rotation with the Varimax method, and are presented as Factor 1 through Factor 7. The detailed descriptions of these factors are as follows:

Factor 1, designated as Environmental Knowledge, comprised six variables, including statements such as "I have knowledge about climate change issues," "I am aware of projects or activities that help reduce carbon emissions," and "I understand the environmental impacts of air travel." The loadings for these items were robust, ranging from 0.787 to 0.888, reflecting a strong understanding of relevant environmental issues among passengers.

Factor 2 focused on Environmental Concern and contained ten variables, indicating significant anxieties among respondents regarding climate change, air travel impacts, and the necessity of carbon compensation. Items such as "I am very concerned about the impacts of climate change on the planet" and "I believe that reducing greenhouse gas emissions is crucial for humanity's future" demonstrated high loadings from 0.643 to 0.904, indicating the urgency with which passengers view environmental issues.

Factor 3, Connectedness to Nature, included five items reflecting participants' emotional ties to nature, with significant loadings between 0.662 and 0.931, suggesting that passengers who feel a connection to nature are more likely to advocate for environmental conservation activities.

Factor 4, known as Subjective Norms, featured six variables that highlighted the influence of social circles on passengers' decisions regarding carbon compensation. Statements such as "People around me support carbon offsets" and "My family and friends frequently discuss carbon compensation" had loadings ranging from 0.650 to 0.792, illustrating the impact of peer influence in environmental decision-making.

Factor 5, Perceived Behavior Control, was derived from nine items, indicating how confident passengers feel about their ability to participate in carbon compensation schemes. Loadings ranged from 0.737 to 0.939, reinforcing the idea that when passengers feel capable and informed about carbon offsetting, they are more likely to engage in such behaviors.

Factor 6, titled Attitude, consisted of ten variables reflecting passengers' positive attitudes toward carbon compensation. High loadings between 0.651 and 0.743 indicated that positive beliefs about carbon offsets directly influence the likelihood of passengers choosing environmentally responsible options when traveling.

Lastly, Factor 7, "Willingness to pay for Carbon," includes seven items that assess passengers' readiness to incur additional costs to support environmental initiatives. Items such as "I am willing to pay extra to support environmental projects" and "I would consider services that include carbon offsetting when choosing an airline" exhibited loadings ranging from 0.726 to 0.797, indicating a strong tendency among travelers to prioritize sustainability in their decision-making.

This study found that passengers are willing to pay approximately 170 THB per person for international flights.

In the results, 94.5% of international travelers expressed willingness to pay in this context. This finding aligns with prior research by Hui et al. [63], where 86% of long-haul passengers in Hong Kong indicated a willingness to pay for carbon offsets. This consistency suggests a growing global trend among travelers to support sustainable aviation practices. The high percentage observed in this study highlights a significant opportunity for airlines to leverage passenger support especially for long-haul routes where environmental concerns are often more pronounced. This insight offers a novel cross-cultural perspective, demonstrating that the inclination to pay for carbon offsets is strong across different regions and travel contexts, and further reinforces the potential for implementing integrated carbon offset schemes for international flights.

Together, these factors elucidate the complex interplay between environmental awareness, personal beliefs, and social influences on passengers' willingness to engage in behaviors that support carbon neutrality in the aviation industry. The results underscore the importance of fostering awareness and understanding among travelers to promote sustainable practices and contribute to global efforts to mitigate climate change.

4. RESULTS

The results of this study underscore the critical importance of environmental awareness in shaping passengers' willingness to pay for carbon credits in the aviation sector. Exploratory factor analysis identified seven key elements: environmental knowledge, environmental concern, connectedness to nature, subjective norms, perceived behavioral control, attitude, and willingness to pay. These factors collectively influence pro-environmental actions among travelers.

While ambitious global emission reduction targets such as those in the Paris Agreement have been established, achieving these goals requires not only technological advances but also significant shifts in consumer behavior. Passengers' choices, including selecting sustainable airlines, supporting carbon offset initiatives, or paying premiums for eco-friendly services, can directly influence industry practices and corporate policies. As sustainability becomes a greater priority for travelers, their collective actions encourage airlines to adopt greener operations, invest in innovative emission-reduction strategies, and align with international climate commitments.

To further promote sustainable behavior, airlines should develop targeted campaigns to raise passenger awareness about the environmental impacts of flying, utilizing online media and engagement activities to support carbon offset programs. In addition, airlines should provide clear and accessible information about their carbon offset projects and make participation easy, thereby enhancing passenger confidence and willingness to contribute to climate mitigation.

Factor 1, Environmental Knowledge, shows passengers' strong basis of knowledge on climate change and its consequences for aviation. The large loadings connected with this element suggest that educated travelers are more likely to participate in pro-environmental activities and make wise decisions considering the effect of their travel on the surroundings.

Factor 2 shows environmental concern a growing fear among passengers about climate change and the effects of air travel on the surroundings. This increased knowledge results

in expectations for airlines to implement sustainable practices, so the sector has to properly answer these issues.

Factor 3, Connectedness to Nature, was included in the extended TPB model to address the affective and emotional dimensions of environmental behavior, which are not fully captured by traditional TPB constructs. Theoretical and empirical evidence indicates that individuals who feel a strong emotional bond with nature are more likely to engage in pro-environmental behaviors, such as participating in conservation projects or supporting sustainability initiatives. This suggests that airlines could foster such emotional connections by organizing activities and communications that promote environmental knowledge and encourage interaction with the natural environment.

Factor 4, subjective norms, show that passengers view social support from their circles in selecting greener choices. This emphasizes the need of community influence on personal decisions since friends and relatives greatly affect opinions on carbon compensation.

Factor 5, Perceived Behavior Control, emphasizes the need of confidence and skill in participating in carbon offset projects. Carbon credits are more likely to be chosen by passengers who feel empowered to make sustainable decisions; so, airlines should offer pertinent tools and information to raise passenger confidence in these methods.

Regarding Factor 6 carbon compensation passengers exhibit a favorable predisposition toward lessening environmental impact. This optimistic view suggests that customers will find great resonance in marketing campaigns stressing the advantages of carbon offsets, therefore inspiring them to choose ecologically friendly travel options.

Finally, Factor 7, the Willingness to pay for Carbon, shows that customers are obviously ready to pay extra for environmental projects. For the airline industry, this eagerness is encouraging since it implies that customized initiatives like integrated carbon offsetting included into ticket prices could efficiently raise passenger participation in environmental initiatives. Moreover, the study finds that passengers are willing to pay approximately 170 THB per person for international flights, with 94.5% of travelers expressing a readiness to pay for environmental initiatives.

This concept can be encapsulated in Figure 3, which illustrates the impact of the seven factors mentioned.

Figure 3. Summary of guidelines for creating carbon credit policies

Finally, the interaction of environmental knowledge, concern, closeness to nature, subjective norms, perceived behavior control, attitudes, and readiness to pay shows a whole picture of passenger environmental behavior. Promoting sustainable practices and raising environmental awareness will be crucial for the aviation sector to match customer expectations and handle worldwide climate strategies as it comes under more attention about its environmental impact. Future rules should concentrate on improving education, easing information flow, and supporting carbon offset initiatives to foster a sustainable aviation culture.

5. DISCUSSION

This study provides important insights into how environmental awareness shapes aviation consumers' willingness to pay for carbon credits, revealing that decision-making among airline passengers is influenced not only by cognitive understanding but also by emotional and social dimensions. The findings on Environmental Knowledge (Factor 1) highlight the need to strengthen passenger awareness of climate change, carbon emissions, and their impacts. High knowledge levels, consistent with previous

studies emphasizing the role of education in promoting pro-environmental behavior [64], suggest that informed passengers are more likely to demand transparency from airlines regarding their sustainability initiatives. By openly sharing practices such as the use of Sustainable Aviation Fuels (SAF) and carbon offset programs, airlines can cultivate a more environmentally sensitive customer base, while targeted educational campaigns can reinforce responsibility and encourage sustainable actions.

The results on Environmental Concern (Factor 2) indicate that passengers, particularly in the aviation context, exhibit strong worry about the consequences of climate change, consistent with the growing global recognition of environmental risks [65]. This concern supports preference for airlines that prioritize sustainability, underscoring the importance of aligning operational strategies with customer expectations. Messaging that frames carbon offsets as both a collective responsibility and a necessary action for the benefit of future generations can further enhance passenger engagement.

In terms of Connectedness to Nature (Factor 3), the inclusion of CTN within the Theory of Planned Behavior significantly improved model fit (CFI increasing from 0.89 to 0.94; RMSEA decreasing from 0.07 to 0.05), demonstrating its added explanatory power. This reinforces the value of integrating both cognitive and affective factors when predicting sustainable passenger behaviors. Promoting eco-friendly destinations and sustainable tourism can deepen passengers' connection to nature, thereby encouraging them to adopt carbon offsetting as a natural part of their travel choices.

The role of Subjective Norms (Factor 4) emphasizes that social influence significantly shapes environmental behavior; when passengers observe peers valuing carbon offsetting, they are more likely to follow suit. This social dimension aligns with research on sustainability-related peer influence [66]. Airlines can leverage this by incorporating social proof into marketing campaigns, such as testimonials or case studies showcasing community-driven offset initiatives.

Findings on Perceived Behavioral Control (Factor 5) reveal that participation in carbon offsetting is strongly linked to passengers' confidence in their ability to contribute, consistent with the Theory of Planned Behavior's assertion that perceived capability influences action. Integrating offsetting options directly into booking processes, coupled with transparent reporting on their impacts, can reduce uncertainty and encourage involvement. Similarly, favorable attitudes toward carbon compensation (Factor 6) present opportunities for airlines to strengthen participation through clear communication of tangible environmental benefits and alignment with passenger values.

Finally, Willingness to pay (Factor 7) results show a positive trend toward prioritizing sustainability in travel decisions, suggesting a viable market for carbon offset services. Airlines that adopt proactive strategies—either incorporating offset fees into ticket prices or offering them as optional add-ons—can maximize this willingness, provided they ensure passengers understand how their contributions directly support climate change mitigation.

6. POLICY RECOMMENDATION

Enhance Passenger Environmental Awareness: Implement campaigns to educate passengers on climate change, aviation's carbon footprint, and mitigation strategies, while transparently sharing initiatives such as Sustainable Aviation Fuels (SAF) use and carbon offset programs.

Promote Engagement Through Effective Communication and Social Influence: Frame carbon offsetting as a shared responsibility and essential action for future generations, leveraging social proof and community-based examples to normalize sustainable travel behaviors.

Facilitate and Incentivize Carbon Offsetting Participation: Integrate offset options into ticket booking processes with clear, transparent impact reporting, and design programs aligned with passenger values to encourage willingness to pay for climate mitigation.

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AUTHOUR CONTRIBUTION

CRediT: Jakkawat Laphet: conceptualization, methodology, software, validation, formal analysis, writing - original draft preparation, writing - review and editing, project administration, and summarize results; Duangrat Tandamrong: supervision, methodology, software, validation, formal analysis, writing - original draft preparation, summarize results, funding acquisition and investigation. All authors have read and agreed to the published version of the manuscript.

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