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A SEM-ANN analysis to examine the green consumption behavior of tourists in Vietnam

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Abstract

Environmental pollution has become a widespread issue across various sectors, necessitating effective solutions to enhance awareness and foster positive consumer attitudes towards eco-friendly products, particularly within the tourism industry. This study investigates the green consumption behavior of tourists in Vietnam using the Value-Attitude-Behavior (VAB) theoretical framework, focusing on key influencing factors and relationships. A hybrid SEM-ANN approach was applied, combining qualitative and quantitative methods. Data were collected from 526 tourists in Hanoi, Da Nang, and Ho Chi Minh City. Environmental consciousness and attitudes toward green advertising, environmental issues, and eco-social benefits significantly influence green consumption behavior. IPMA results show that environmental factors have the highest impact, followed by eco-social benefits, environmental issues, and green advertising. The analysis results also indicate the predictability of the ANN model compared with the SEM model, demonstrating the reasonableness of the SEM-ANN hybrid approach. The study also presents conclusions regarding its contributions to theoretical and practical aspects, as well as its limitations and directions for future research.

Keywords: Green consumption behavior, SEM-ANN model, Tourists, Value-Attitude-Behavior model.

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1. Introduction

Rapid infrastructural development and overexploitation of natural resources are the main contributors to environmental pollution, which has become a significant worldwide concern in recent years [1]. Sustainable consumption solutions are urgently needed due to problems such as resource depletion, air pollution, water pollution, climate change, the greenhouse effect, and soil contamination [2, 3]. As a result of environmental protection organizations raising consumer awareness, green consumption—defined as consumption practices that reduce adverse effects on the environment—has become a contemporary phenomenon [4].

With an upward trend in size and visitor numbers, Vietnam's tourism sector is expanding significantly [5]. However, the value-attitude-behavior (VAB) theory has not been thoroughly examined in the context of tourism, despite several studies on green consumption in Vietnam. Most of these studies use consumer behavior models or the theory of planned behavior (TPB). Personal values play a crucial role in the development of attitudes, which in turn influence specific behaviors, according to VAB theory [6]. This study examines the relationship between tourists' green consumption behaviors, attitudes toward environmental issues, and environmental awareness by applying the VAB model. The Vietnamese context has not adequately utilized this theory, despite its widespread application in the research of sustainable purchasing behavior internationally [7].

Utilizing the advantages of both analytical instruments is the ultimate objective of the SEM-ANN methodology chosen for this investigation. For examining the linear relationship between components of the VAB theoretical framework, such as the relationship between values, attitudes, and actions, SEM offers a solid theoretical basis. In the meantime, ANN strengthens the accuracy of forecasting travelers' green consumption behaviors while adding the capacity to model intricate non-linear interactions. Prior research has shown that SEM-ANN helps predict client loyalty in the service industry [8], project travel demand [9], and assess online buying behavior [10]. SEM-ANN assists in investigating the connection between environmental attitudes, perceptions, and green consumption practices in this research context and pinpoints the significant elements influencing tourists' decisions to engage in green consumption in Vietnam. The study examines how environmental attitudes and awareness affect Vietnamese travelers' green consumption behaviors. It analyzes how perceptions about green consumer behavior act as a mediator, putting forward ideas based on the study's findings to encourage tourists' green consumption in the travel sector. This study offers a theoretical and practical foundation for sustainable tourism development policies in conjunction with improving our understanding of Vietnamese tourists' green consumption behaviors.

2. Theoretical Background and Research Model

2.1. Green Consumption and Green Consumer Behavior in Tourism

Liu [11] and Ashraf, et al. [12]state that tourism encompasses behaviors across pre-purchase, during-purchase, and post-purchase stages, such as buying organic food, recycling, and using eco-friendly transportation. Early studies linked green consumption primarily to recycling and energy conservation in industries like automobiles and chemicals [13]. Environmental awareness has reshaped tourists' preferences for destinations that preserve natural landscapes and offer eco-conscious services [14]. Ghazvini, et al. [15] and Zhou, et al. [16] show that tourists are increasingly willing to pay premiums for sustainable options, driven by concerns about climate change and pollution. These trends align with growing environmental protection efforts and health benefits.

2.2. The Value - Attitude - Behavior (VAB) Model

The Value-Attitude-Behavior (VAB) theory, developed by Homer and Kahle [17], is a cognitive hierarchy model that illustrates the relationship between values, attitudes, and behaviors. According to the VAB model, attitude acts as a mediator, allowing consumer value to influence behavior indirectly. Specifically, value directly impacts attitudes and, through attitudes, indirectly influences behavior. This model has been widely applied in consumer behavior research, especially in contexts related to green consumer behavior [18-20]. The VAB model describes a hierarchical process of impact, from abstract perception (values) to intermediate perception (beliefs and attitudes) and ultimately to specific behavior [21]. In particular, value is the most basic and important factor, playing a role in guiding the decisions and actions of individuals. Values are understood as enduring beliefs, capable of forming specific attitudes and guiding behavior in various contexts [22]. The value-attitude-behavior process is particularly emphasized in the context of environmental behavior [6, 21]. This study proposes a model with factors including attitudes towards green advertising, environmental issues, social-ecological benefits, and green consumption-related behaviors of tourists to shed light on the role of these factors in promoting green consumption behavior.

2.3. Hypotheses Development

2.3.1. The Relationship Between Perceptions of Green Advertising and Environmental Consciousness

According to the VAB paradigm, attitudes are determined by personal values. In Cheung and Wai Ming [19], environmental consciousness is a value that represents a person's awareness of and dedication to environmental conservation. This knowledge aids in creating a favorable attitude toward commercials that encourage sustainable consumption in the context of green advertising [23, 24]. Travelers who are concerned about the environment are more susceptible to and appreciative of green advertising since they understand its contribution to environmental preservation.

H_1: Environmentally conscious tourists will have a more positive attitude toward green advertising.

2.3.2. The Relationship Between Environmental Consciousness and Attitudes towards Environmental Issues

Environmental values influence a positive attitude toward environmental protection concerns. Individuals with elevated environmental awareness frequently demonstrate considerable interest in ecological conservation and environmental protection initiatives [25, 26]. Regarding tourism, these tourists are not solely highly conscious of environmental concerns but are additionally eager to take action to reduce the adverse effects of travel [27-29].

H_2: Environmentally conscious tourists will have a more positive attitude towards environmental issues.

2.3.3. The Relationship Between Attitudes Toward Social-Ecological Advantages and Environmental Consciousness

According to the VAB model, environmental value promotes a positive attitude towards social-ecological benefits [1]. Environmentally conscious travelers often appreciate the long-term benefits of green consumption, including social and

ethical advantages [19, 30]. They believe that green consumption behavior protects the environment and contributes to the community's sustainable development [31].

H_3: Environmentally conscious tourists will have a more positive attitude towards social-ecological benefits.

2.3.4. The Relationship Between Green Consumer Behavior and Attitudes Toward Green Advertising

Attitude is an important mediator in the VAB model, connecting value to behavior. Positive attitudes toward green advertising drive the intention and behavior to purchase environmentally friendly products [32, 33]. In the tourism industry, green advertising increases visitors' awareness and directs them to choose sustainable products and services [34]. According to Zhuang, et al. [35], green advertising positively impacts shopping behavior related to eco-friendly products.

H_4: Tourists with a positive attitude towards green advertising will increase green consumer behavior.

2.3.5. The relationship between attitudes toward environmental issues and green consumer behavior

Jaiswal and Kant [36] demonstrated that consumer attitudes toward environmental issues positively influence their intention to purchase green products. Attitudes are emphasized as key predictors of both intention and behavior in green consumer research. According to Zaremohzzabieh, et al. [37], environmental consciousness positively influences consumer attitudes, affecting their green purchasing intentions and serving as a precursor to green purchases. Previous studies have shown that tourists with positive attitudes toward environmental issues are more likely to engage in environmentally responsible behavior, including a willingness to pay for hotels and restaurants that adopt environmentally friendly practices [2]. Tourists with positive attitudes toward environmental protection are more likely to engage in green consumption behaviors and utilize green services. Therefore, the following hypothesis is proposed:

H_5: Tourists with a positive attitude toward environmental issues will increase their green consumer behavior

2.3.6. The Relationship Between Attitudes Towards Social-Ecological Benefits and Green Consumer Behavior

According to studies by Cheung and Wai Ming [19] and Lin and Huang [38], travelers who understand the benefits of green consumerism for the environment and society are often willing to pay more for environmentally friendly goods and services.

H_6: Tourists with a positive attitude towards social-ecological benefits will increase green consumption behavior.

2.3.7. The relationship between environmental consciousness and green consumer behavior

Previous studies suggest that a motivational link with nature is important in encouraging environmentally friendly behaviors Richardson, et al. [39]. Holmgren and Coyne [40] demonstrated that environmental concerns influence the intention to purchase ecological products, with consumers willing to pay more for eco-friendly options.

In tourism, environmental consciousness encourages travelers' green consumption behavior, such as supporting sustainable enterprises, selecting green tourism services, and raising awareness of environmental challenges [41]. This study recognizes that environmental consciousness may significantly impact green consumer behavior, particularly for consumers with a strong sense of personal responsibility toward the environment, even though the VAB model suggests that attitudes play an important intermediary role between values and behaviors.

H_7: Environmentally conscious tourists directly and positively impact green consumer behavior, and attitudes' mediating role will strengthen them.

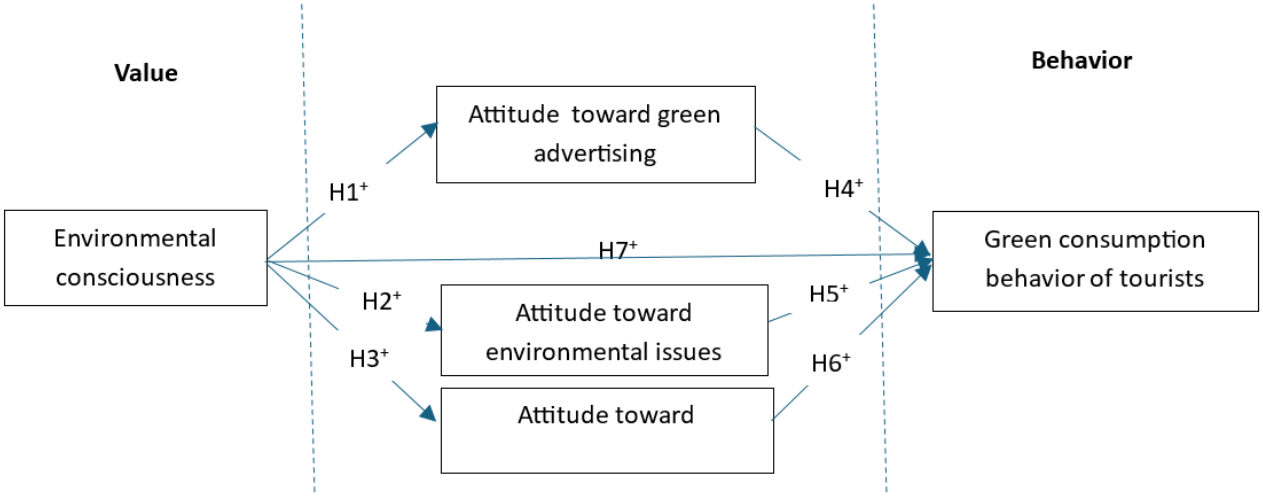

Figure 1.
Research model of green consumer behavior of tourists.

3 Research Method

3.1. Research Process

The study was conducted in three fundamental sections using a combination of conventional qualitative and quantitative approaches and sophisticated analytical tools.

Step 1: Initial qualitative research: Eleven prominent professionals were invited to participate in the interview, including three tourism specialists, three CEOs of major tourism businesses, two authorities on green consumer behavior, and three seasoned local government representatives. The views of experts are crucial in determining whether the study model on green consumer behavior in the travel industry is adequate and in assessing whether the variable scales are appropriate. The observed variables are then introduced to the theoretical model after modification.

Step 2: Preliminary quantitative research: Fifty visitors to Hanoi participated in a pilot investigation to evaluate the research model's dependability. The survey yielded very positive findings, demonstrating the scales' outstanding reliability, with the Cronbach Alpha coefficient reaching 0.70 and the correlation value of each corrective item exceeding 0.30.

Step 3: Official quantitative research: Combining both conventional and contemporary research techniques, official quantitative research is conducted in two steps:

- Structural Equation Modeling (SEM) analysis: The SEM method is used to test the linear relationships between variables in the theoretical model.
- Artificial Neural Network (ANN) Analysis: The ANN method is used to analyze nonlinear relationships and determine the level of improvement in the model's predictive ability.

Multi-Group Analysis (MGA): MGA was performed to examine the differences in the relationship between the elements of the theoretical model based on the visitors' educational background variable. Education platforms are classified into key groups (e.g., secondary, tertiary, postgraduate) to identify how groups with different levels of education perceive and respond to factors related to green consumption.

Importance-Performance Map Analysis (IPMA): This analysis clarifies the role of factors in green consumer behavior. It provides clear strategic guidance for tourism managers in prioritizing the factors that have the highest impact on tourists' green consumption behavior.

3.2. Scale Development

The scales used in this study were adapted from previous reputable research by Cheung and Wai Ming [19]; Činjarević and Tatić [7]; Jaiswal and Kant [36] and Kim, et al. [6]. They were further refined by the authors through qualitative research to ensure the scales' appropriateness and comprehensiveness. These modifications aimed to improve the relevance and accuracy of the measurement tools for the study. A questionnaire was built with 18 scales that were inherited and developed (Table 1).

Table 1.
Measurements of factors in the research model.

Variable Name	Code	Description of the Scale	Reference Source
Environmental consciousness	EC1	You are concerned about the future of the planet and your own health	Cheung and Wai Ming [19]
	EC2	You feel as though you are part of the environment	
	EC3	You have a consciousness of decreasing the amount of plastic waste and the usage of chemicals, water, and energy	
	EC4	You are conscious of using environmentally friendly tourism products	
Attitude toward green advertising	GA1	You like or dislike green ads in tourism	Činjarević and Tatić [7] Adapted through expert evaluation
	GA2	You react favorably/ unfavorably to the ads	
	GA3	You feel positive/negative toward the ads	
Attitude towards environmental issues	EI1	You have read newsletters or seen reports about environmental problems	Cheung and Wai Ming [19] Adapted through expert evaluation
	EI2	You volunteer or contribute financially to organizations and projects focusing on environmental concerns	
	EI3	If you know that a tourism business is harming the environment, you will stop purchasing its products or	

Variable Name	Code	Description of the Scale	Reference Source
		services.	
	EI4	You have a more favorable attitude toward tourism businesses with social responsibility	
Attitude towards eco-social benefits	EB1	By buying green products, you are contributing to society for the present and future	A Cheung and Wai Ming [19] Adapted through expert evaluation
	EB2	When buying green products instead of non-green products, you are acting morally	
	EB3	You will recommend green tourism options to your family and friends	
Green consumption behavior of tourists	GCB1	You choose to purchase environmentally friendly tourism products	Jaiswal and Kant [36] and Kim, et al. [6] Adapted through expert evaluation
	GCB2	You are willing to purchase green tourism products over non-green ones when their quality is similar.	
	GCB3	You are willing to pay more for green products	
	GCB4	You are willing to engage in green consumption in tourism to support sustainable tourism development	

3.3. Data Collection and Research Sample

This study used a convenience sampling method to survey international and domestic tourists in Hanoi, Da Nang, and Ho Chi Minh City from March to June 2024. Of the 650 distributed questionnaires, 526 valid responses were returned, yielding an 83% response rate. Most respondents were aged 25-44 (54.3%), with 23.8% under 25 and smaller proportions aged 45 and above. Males constituted 54.2%, while females made up 45.8%.

Income-wise, over 60% earned 10–18 million VND, reflecting a middle-income bracket. Higher-income groups (18 million VND and above) comprised 23.8% earning 18–32 million VND and 13.9% earning over 32 million VND. Respondents had diverse occupations: business professionals (35.6%), office workers (24.5%), freelancers (17.9%), and knowledge workers (12%). Educationally, 60.1% held undergraduate degrees, with 21.9% below and 18.1% above this level. Nationality distribution included 44.7% domestic Podsakoff respondents, 16.0% Europeans, and 14.3% Asians, reflecting a diverse sample.

3.4. Common Method Bias (CMB) Test

The study utilized the Multicollinearity Adoption Test (VIF) and Harman's Single-Factor Test to assess Common Method Bias (CMB). Exploratory factor analysis (EFA) without matrix rotation on ten observable variables identified three components, with a total variance of 31%, which is below the 50% threshold, indicating that no single factor dominated the data [42]. VIF testing further confirmed the absence of multicollinearity, as all VIF values were below 2, meeting accepted thresholds (<3: [43]; <5: [44]).

These results confirm the absence of CMB, ensuring the reliability of the collected data. The combined use of VIF and Harman's Single-Factor Test provides robust evidence that the data are unaffected by methodological bias, strengthening the validity of the analysis and conclusions.

4. Research Results

4.1. Evaluating Measurement Scales

The PLS-SEM method is employed to evaluate the measurement and structural model. The measurement model is evaluated through reliability, convergent, and discriminant validity. The results, which are robust and reliable, indicate that the outer loadings for all observed variables and Cronbach's Alpha and composite reliability (CR) values for all scales exceed the threshold of 0.7, meeting the reliability requirements (Table 2). Additionally, all constructs' average variance extracted (AVE) values go beyond 0.5, satisfying the requirement for convergent validity. The square root of the AVE for each scale was higher than the correlation coefficients of the latent variables in the Fornell-Larcker Criterion (Table 3). Furthermore, the Heterotrait-Monotrait ratio (HTMT) for each variable was below 0.85 (Table 4), ensuring the discriminant validity [45]. This illustrates that all constructs are unique in empirical aspects and have no issues with discriminant validity.

Table 2.
Test for reliability and convergent.

Constructs	Observed variable	Outer loading	Cronbach's alpha	Composite reliability (rho_c)	Average variance extracted (AVE)
EB	EB1	0.838	0.731	0.847	0.648
	EB2	0.815			
	EB3	0.760			
EC	EC1	0.773	0.780	0.857	0.600
	EC2	0.795			
	EC3	0.742			
	EC4	0.787			
EI	EI1	0.791	0.757	0.860	0.673
	EI2	0.852			
	EI3	0.816			
GA	GA1	0.835	0.706	0.836	0.630
	GA2	0.793			
	GA3	0.751			
GCB	GCB1	0.822	0.825	0.884	0.655
	GCB2	0.820			
	GCB3	0.787			
	GCB4	0.809			

Table 3.
Inter-construct correlations (Fornell-Larcker).

	EB	EC	EI	GA	GCB
EB	0.805				
EC	0.281	0.775			
EI	0.278	0.255	0.820		
GA	0.192	0.264	0.211	0.794	
GCB	0.499	0.524	0.462	0.375	0.810

Table 4.
Heterotrait-Monotrait ratio (HTMT).

	EB	EC	EI	GA	GCB
EB					
EC	0.365				
EI	0.366	0.322			
GA	0.276	0.350	0.295		
GCB	0.632	0.645	0.583	0.490	

4.2 Structure Model Analysis

The study evaluated the model's structure in the next step of analysis processing. Values such as the variance inflation index (VIF), the influence level (f^2), the out-of-sample predictive ability coefficient (Q^2), and the explanatory coefficient of independent variables on a dependent variable (R^2) were used. Notably, the results showed that the highest VIF value in the research model structure was 1.173, much lower than the recommended level of less than 3 by Hair, et al. [43], indicating no multicollinearity phenomenon. The bootstrapping method with 1,000 iterations was employed to evaluate the importance of the indicators and paths. The research results in Table 5 show that the f^2, R^2, and Q^2 values all meet the recommended values mentioned by Hair, et al. [43] and Götz, et al. [46].

Table 5.
Structural model evaluation.

Coefficient evaluation	Variables/ contructs	Testing values				Reference values
R^2		R^2		R^2 Adjusted		>=0.75: considerable =<0.5: Moderate =< 0.25: Weak Hair, et al. [43] and Liébana-Cabanillas, et al. [47]
	EB	0.079		0.077		
	EI	0.065		0.063		
	GA	0.070		0.068		
	GCB	0.508		0.504		
Effect Size(f^2)		EB	EI	GA	GCB	0.35=> Large effect 0.15 => Medium
	EB				0.161	
	EC	0.086	0.070	0.075	0.186	
	EI				0.117	

Coefficient evaluation	Variables/ contructs	Testing values				Reference values
	GA				0.057	0.02=> Small effect Hair, et al. [43] and Akour, et al. [48]
Collinearity(Inner VIF)	EB				1.153	VIF<5.0 Hair, et al. [43]
	EC	1.000	1.000	1.000	1.173	
	EI				1.144	
	GA				1.112	
Predictive Relevance(Q^2)	Q^2					Q^2 >0: Predictive relevance Götz, et al. [46]
	EB	0.050				
	EI	0.042				
	GA	0.043				
	GCB	0.328				

The bootstrapping method was applied to test the hypothesis. The β values, t-values, and p-values are used to evaluate the significance of the relationship. Table 6 and Figure 2 show the bootstrapping outcomes of this study. The findings demonstrate that all seven hypotheses are statistically significant.

The testing results indicate the significant impact of EC on GA (β = 0.264, p = 0.000, t = 6.249), EI (β = 0.255, p = 0.000, t = 5.748), and EB (β = 0.281, p = 0.000, t = 6.205), thus providing support for hypotheses H1, H2, and H3. This finding suggests that environmental consciousness positively influences tourist attitudes in this study's VAB model.

The next three hypotheses focus on tourist attitudes toward green consumption behavior. The results show that the paths of GA->GCB (β = 0.176, p = 0.000, t = 4.838), EI->GCB (β = 0.257, p = 0.000, t = 6.238), and EB->GCB (β = 0.302, p = 0.000, t = 7.629) are significant and positive; thus, hypotheses H4, H5, and H6 are supported.

Hypothesis H7 tests the impact of tourist environmental consciousness on green consumption behavior. The result from Table 6 shows that EC positively influences GCB (β = 0.524, p = 0.000, t = 11.946), indicating that hypothesis H7 is strongly supported.

Table 6.
Bootstrapping test results.

Hypothesis	Paths	Beta (β)	T – values	P -Values	Results
H1	EC -> GA	0.264	6.249	0.000	Supported
H2	EC -> EI	0.255	5.748	0.000	Supported
H3	EC -> EB	0.281	6.205	0.000	Supported
H4	GA -> GCB	0.176	4.838	0.000	Supported
H5	EI -> GCB	0.257	6.238	0.000	Supported
H6	EB -> GCB	0.302	7.629	0.000	Supported
H7	EC -> GCB	0.524	11.946	0.000	Supported

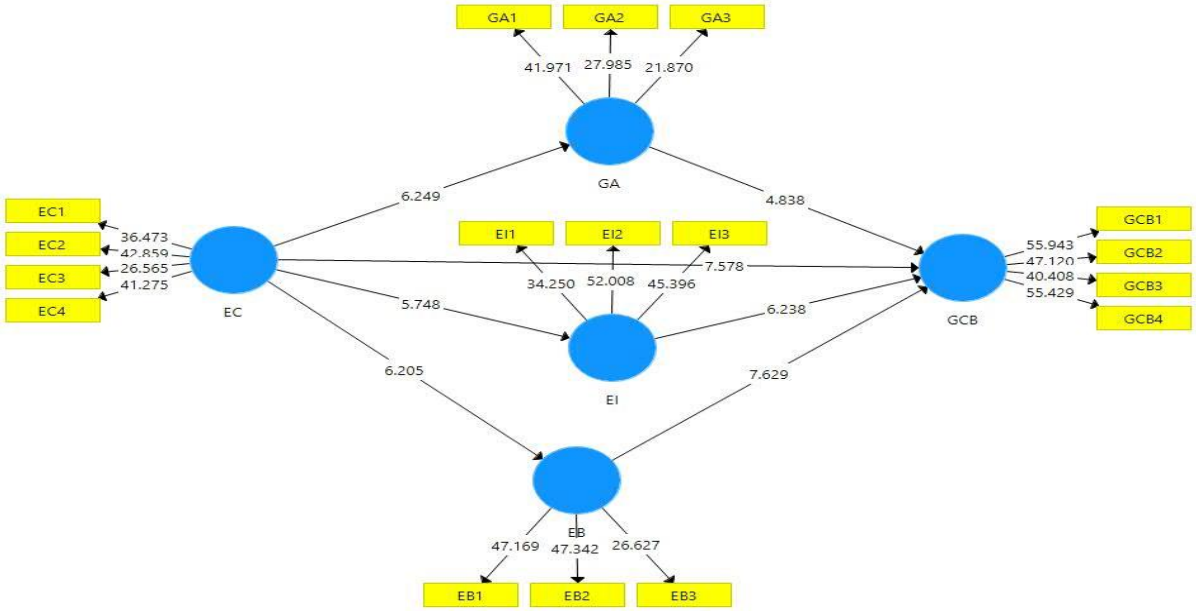

Figure 2.
Bootstrapping results.

The study also acknowledges the mediating role of GA, EI, and EB in the relationship between EC and GCB. Table 7 shows that the mediating relationships are statistically significant (p-value = 0.000). Among these, EC mediated by EB has the most substantial impact on GCB with β = 0.083 and t = 4657.

Table 7.
Mediating relationships results.

Paths	Beta (β)	Confidence intervals		T – values	P values
		2.5%	97.5%		
EC -> EI -> GCB	0.066	0.040	0.100	4.235	0.000
EC -> EB -> GCB	0.085	0.053	0.123	4.657	0.000
EC -> GA -> GCB	0.047	0.024	0.072	3.767	0.000

4.3. Multi - Group Analysis (MGA)

The study employed Multi-Group Analysis (MGA) to examine the relationship between environmental consciousness (EC) and green consumption behavior (GCB) among tourists' educational backgrounds. Results from Table 8 indicate that the influence of EC on GCB was strongest among postgraduates, significantly exceeding the effect observed in undergraduate or lower-educated groups. No significant difference was noted between the undergraduate and lower undergraduate groups. This highlights the importance of tailoring environmental strategies to demographic variations in promoting green consumption behavior.

Table 8.
MGA education analysis.

Path	Below undergraduate - Postgraduate		Below undergraduate- Undergraduate		Undergraduate- Postgraduate	
	Difference	P-value	Difference	P-value	Difference	P-value
EC ->GCB	-0.425	0.017	-0.022	0.849	0.403	0.013

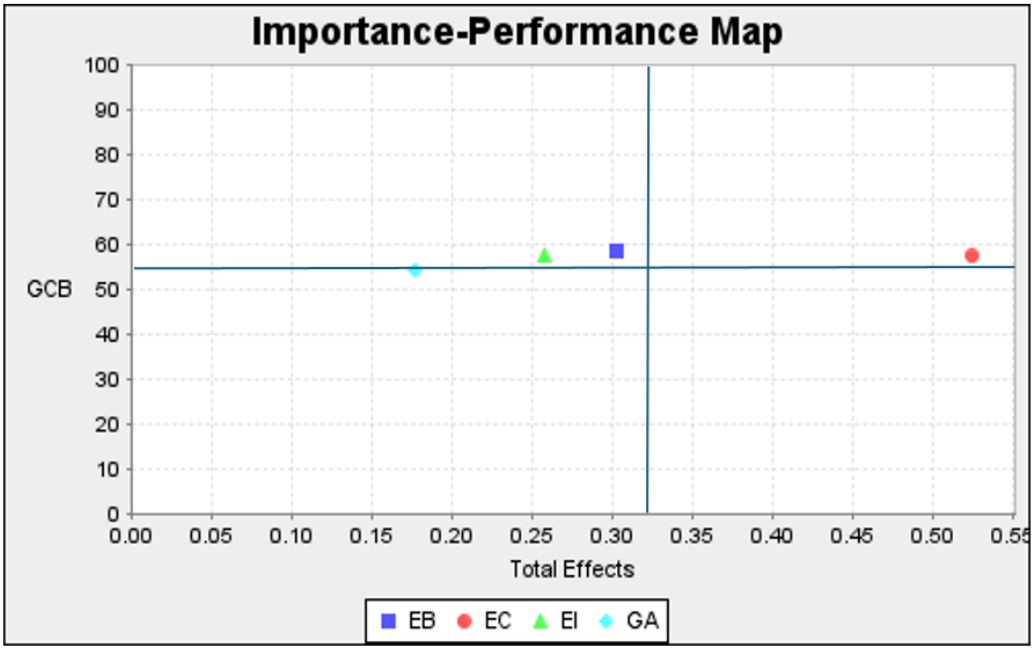

Figure 3.
IPMA results.

Figure 3 illustrates the importance and performance of four independent factors—EB, EC, EI, and GA—on GCB. EB has the highest importance (58.4) but demonstrates relatively low performance (0.302) on GCB. Conversely, while EC holds slightly lower importance (57.3), it exhibits the highest performance (0.52), making it the most effective factor influencing GCB.

EI ranks second in importance (57.58) but third in performance (0.25), highlighting its potential for future improvement and further research exploration. Lastly, GA ranks lowest in importance (54.32) and performance (0.176), indicating a limited impact on GCB compared to other variables. These findings underscore the need to prioritize EC for its high performance and to explore strategies to enhance EI and EB for greater effectiveness.

The study employed SPSS software to conduct Artificial Neural Network (ANN) analysis based on PLS-SEM findings. The ANN method, recognized for its precision in forecasting and output predictions, has been validated by prior studies [48]. In this analysis, EC, GA, EI, and EB served as input variables, while GCB was the output variable. A two-hidden-layer ANN

design was implemented, leveraging the sigmoid activation function for both hidden and output neurons to ensure reliability [47].

Input and output neuron values were normalized within the [1] range to optimize model performance. A rigorous ten-fold cross-validation process with an 80:20 training-to-testing data ratio was applied to validate the model's robustness. Prediction accuracy was assessed using the root mean square error (RMSE) for all ten ANN models. The influence of input neurons on the output was visualized through synaptic weights, with blue indicating a negative influence and gray indicating a positive influence. This comprehensive ANN approach enhanced the reliability and depth of the study's findings. Figure 4 shows the ANN model.

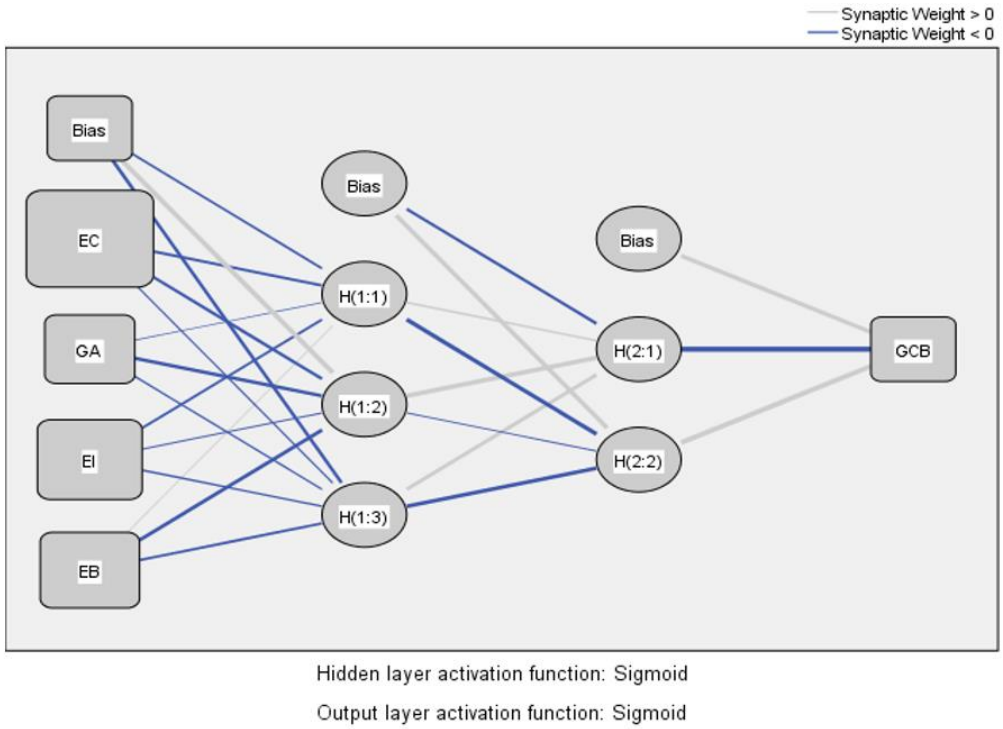

Figure 4.
The ANN model.

The ANN model emphasizes predictive accuracy, validated through RMSE values for training and testing across multiple iterations. Table 9 reports average RMSE values of 0.127 for training and 0.118 for testing over 10 runs, with standard deviation (SD) values of 0.005 and 0.006, respectively, indicating improved prediction accuracy [48].

To evaluate model effectiveness, the study utilized the R^2 formula $R^2 = 1 - RMSE/S^2$ proposed by Leong, et al. [8]. The ANN model achieved an R^2 value of 87.8%, significantly outperforming the PLS-SEM model (R^2 = 50.4%), demonstrating the predictive capability of the ANN approach.

Table 9.
RMSE of the neural network models.

ANNs	ANN-Model (R^2= 87.8%)					
	Training - Phase			Testing - Phase		
	N	SSE	RMSE	N	SSE	RMSE
ANN-1	426	6.592	0.124	100	1.499	0.122
ANN-2	418	6.823	0.128	108	1.706	0.126
ANN-3	407	6.777	0.129	119	1.622	0.117
ANN-4	412	7.627	0.136	114	1.37	0.110
ANN-5	413	6.275	0.123	113	1.628	0.120
ANN-6	416	7.294	0.132	110	1.219	0.105
ANN-7	419	5.794	0.118	107	1.691	0.126
ANN-8	413	6.399	0.124	113	1.581	0.118
ANN-9	423	7.022	0.129	103	1.282	0.112
ANN-10	416	6.236	0.122	110	1.712	0.125
Average		6.684	0.127	100	1.531	0.118
Std-Dev.		0.515	0.005	108	0.171	0.006

The results in Table 10 highlight the critical influence of the independent variables on the dependent variable. Environmental Consciousness (EC) holds the highest normalized importance at 94.64%, followed by Eco-Social Benefits

(EB) at 78.16%, Environmental Issues (EI) at 76.78%, and Green Advertising (GA) at 57.59%. This ranking closely aligns with the IPMA test results from the PLS-SEM model, providing strong validation for the significance of EC, EB, EI, and GA in influencing the dependent variable.

Table 10.
Normalized independent variable importance.

ANNs	EC	GA	EI	EB
ANN-1	0.269	0.206	0.288	0.237
ANN-2	0.315	0.143	0.329	0.214
ANN-3	0.247	0.226	0.325	0.201
ANN-4	0.429	0.072	0.271	0.229
ANN-5	0.279	0.186	0.246	0.289
ANN-6	0.331	0.278	0.149	0.243
ANN-7	0.276	0.169	0.244	0.312
ANN-8	0.301	0.182	0.203	0.313
ANN-9	0.341	0.195	0.226	0.238
ANN-10	0.337	0.19	0.22	0.253
Average relative importance	0.3125	0.1847	0.2501	0.2529
Normalized relative importance	94.64%	57.59%	76.78%	78.16%

5. Discussion and Conclusion

This study utilized a hybrid PLS-SEM and ANN model to analyze green consumption behavior in tourism, yielding statistically significant results. The PLS-SEM analysis validated the proposed hypotheses, while the ANN analysis demonstrated superior predictive power, with R^2 values of 87.8% compared to 50.4% from PLS-SEM. This highlights the effectiveness of the VAB model in explaining tourists' green consumption behavior.

Findings indicate that Environmental Consciousness (EC), mediated by attitudes toward Green Advertising (GA), Environmental Issues (EI), and Eco-Social Benefits (EB), positively influences Green Consumption Behavior (GCB). These results align with prior studies [4, 18, 19]. EC fosters positive attitudes toward GA, EI, and EB, enhancing GCB, as supported by earlier research [18, 25]. Additionally, EC directly impacts GCB, consistent with studies by Nekmahmud and Fekete-Farkas [49] and Zaremohzzabieh, et al. [37].

The MGA analysis revealed significant differences in EC's impact on GCB based on nationality and education, echoing earlier findings on the role of education and income in green purchasing behavior [28, 50]. ANN results ranked EC as the most important variable (94.64%), followed by EB (78.16%), EI (76.78%), and GA (57.59%), corroborating the PLS-SEM-IPMA test.

The hybrid SEM-ANN model demonstrated greater predictive power due to the ANN's ability to capture non-linear associations, validating its scientific robustness. These results affirm the ANN model's superior predictive capacity over PLS-SEM, consistent with prior studies [48, 51].

5.1. Theoretical Contributions

This study reinforces the importance of the VAB model and is one of the few that applies VAB in the tourism sector. It acknowledges the mediating role of attitudes toward green advertising, environmental issues, and eco-social benefits in the relationship between environmental consciousness and green consumption behavior among tourists. All three mediating relationships are statistically significant, with the most substantial effect observed in the relationship between environmental consciousness and green consumption behavior through attitudes toward eco-social benefits.

In the ANN model, EC, EB, EI, and GA are input neurons, while GCB is an output neuron. All nodes in an ANN model are interconnected and have an impact on each other. Using activation functions, EC sends information to EB, EI, and GA, and the result generated in the hidden layer is sent to GCB by firing output activation functions. The results demonstrate effectiveness in predicting the green consumption intention of tourists in Vietnam. This is a new point that differs from previous studies; the research results have positive significance in the context of tourism development in Vietnam.

A notable contribution of this research is validating the hypothesis that environmental consciousness exerts a direct, positive impact on green consumption behavior. Additionally, the multi-group analysis based on nationality and educational background revealed statistically significant differences. Specifically, the study shows that environmental consciousness has a more substantial impact on international tourists than domestic tourists, and that individuals with postgraduate education levels exhibit a more significant influence of environmental consciousness on green consumption behavior than those with undergraduate or lower education levels. This helps address a gap in the tourism literature, where demographic factors have often been overlooked.

5.2. Practical Implications

The empirical findings from the three tourism destinations—Hanoi, Da Nang, and Ho Chi Minh City—highlight attitudes toward green advertising, environmental issues, and eco-social benefits in the relationship between environmental consciousness and green consumption behavior among tourists. Thus, tourists' green consumption behavior is driven by their awareness and attitudes, particularly toward eco-social benefits. To enhance awareness, foster positive attitudes, and encourage green consumption behavior in tourism, tourism destinations, local authorities, tourism managers,

and businesses should actively promote responsible tourism and cultivate sustainable green tourism practices, prioritizing EC as the most influential factor, followed by EB, EI, and GA.

In addition, destination management organizations should implement green tourism, responsible tourism, and green consumption strategies and policies, including electronic word-of-mouth (eWOM) campaigns and green advertising on social media platforms, to raise awareness of green consumption in general and in the tourism industry. Efforts to diversify green tourism products, offer eco-friendly accommodations, and promote green shopping at tourism destinations will attract tourists, raise environmental consciousness, and encourage responsible tourism behavior, contributing to environmental protection and sustainable tourism development. Additionally, the findings derived from applying the model offer valuable insights for policymakers in designing initiatives and incentives to enhance green consumption practices. The awareness of the factors that influence green consumption behavior will assist tourism practitioners in promoting the potential of their country and attracting tourists more effectively. Understanding the impact of cultural differences on green consumption behavior could help segment markets, design promotional programs, and create green marketing strategies that cater to each cultural segment.

5.3. Limitations and New Research Directions

Despite its valuable contributions, this study has certain limitations. First, it focuses on environmental consciousness as a value factor, aligning with prior studies. However, future research could explore other value factors to examine their influence on tourists' attitudes and green consumption behavior. Second, the dataset consisted of academic articles written in English, excluding other publications or articles in different languages, which may have influenced the findings. Future studies should consider a broader range of publications to address this limitation.

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