Original Article

Validating PLS and Artificial Neural Network hybrid approach to Test Antecedents of Eco-Label Purchase Behaviour

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Abstract - There are great prospects attached to the growth of the future of the food industry as more and more consumers are aware of the environment since they are looking for eco-friendly food products. The current study attempts to gauge the factors determining the purchase of eco-labelled food products by millennials. Using Behavioural Reasoning Theory (BRT) as a base, this study developed hypothesized direct and moderating relationships between variables. The hypotheses were tested using sample data of Indian millennials (n = 411). The study was divided into two stages, wherein stage one involved Partial Least Square SEM (PLS-SEM) using R studio were used to analyze data. In the second stage, the study employed Artificial Neural Network (ANN) to reveal the influence of antecedents on behaviour. The findings indicate a significant role of perceived ecolabel credibility, green environmental knowledge and green communications in forming millennials' attitudes towards ecolabels. Study results also indicate a major role of attitude in shaping millennials' intentions which further impacts purchase behaviour. Research results would assist food marketers to channelize their efforts towards green marketing, green supply chain management and eco-friendly food products. Study implications would ease the dissemination of ecolabels which would reduce the ambiguity within consumers and would earn consumers' trust for a competitive advantage.

Keywords – Consumerism, Green marketing, Sustainability, Reward process, Trust.

1. Introduction

The topic of environmental protection and sustainable economic growth has gained significant importance in discussions among governments, businesses, and academicians in recent times. Global warming and climate change pose grave threats to the survival of humanity, and most of the environmental issues recognized consumption practices as chief contributors to this problem [1]. As a result, consumers are becoming more and more cognizant of their consumption pattern and its impact thereby instigating customers' predisposition towards sustainable purchases [2]. Over the past few decades, there has been a notable rise in consumers' awareness and concern regarding environmental issues [3]. The abrupt change in the environment coupled with rising awareness towards eco-friendly products has influenced food purchases, thereby triggering the market to adjust quickly [4]. Environmentally conscious individuals exhibit a strong inclination towards Sustainability and demonstrate a firm commitment to embracing sustainable consumption practices. These conscientious consumers actively seek sustainable and eco-friendly products and hence are a part of ever-growing green consumerism. The inclination towards responsible purchase practices poses a challenge to the business world, persuading marketers to reconsider their strategies. Studies in the past revealed the significance of green promotional strategies in convincing consumers [5]. To achieve sustainability goals, companies must undergo significant transformations focused on sustainability considerations as chief drivers of strategic planning [6]. This approach by specific brands aims to develop a constructive effect on the brand image to induce consumer purchases. Modern day consumers are consistently curious and cognizant about food choices, and product information has a significant impact on consumer decisions. From a marketer's perspective, it is imperative to balance all aspects of marketing to ensure profitability and transparency [7]. In this regard, labelling can be seen as a crucial aspect of green marketing practices, garnering significant attention in terms of promotion and logistics [8]. Labelling eco-friendly products ensures their ability to serve as a promotional appeal by projecting environment sensitization as a core. More recently, green marketing has seen some different competitive dynamics in the form of 'private' labelling [8]. Also known as "ecolabels", these symbols present reliable and accurate information linked to a product's social and environmental orientation. Labelling plays a central role in creating awareness by offering consumers information that promotes responsible behaviour [9].

To ensure the dissemination of information and actionable results, marketers can employ these green labels to provide consumers with relevant, accurate, and meaningful information [10]. Additionally, sustainability labels drive purchases by reducing perceived risk and ensuring the accuracy of the claim made by such labels [11], [12]. This empowers consumers to integrate considerations of their health and the environment into purchasing decisions. In the extensive dominion of the global food industry, there exists a wide range of eco-labels that confer environmental, ethical, and Sustainability attributes covering an extensive range of products.

The labelling is aimed to ensure the safety, efficiency and quality of consumer products [9]. Ecolabels generally appear on the product packaging as words, symbols, pictures, and badges and can either be privately declared ecolabels or third-party ones [13]. As discussed, certification adoption in its various forms is increasing worldwide, but the concept of the economic viability of these labels is often unproven and, therefore, opens up a wide question on consumers' willingness to purchase eco-labelled products [14]. Considering the existence of literature supporting the role of environment-friendly labels in determining purchase decisions [13], [15], [16] current study attempts to gauge the factors influencing the purchase of eco- labelled food products by millennials or Generation Y using PLS and Artificial Neural Network.

Generation Y, commonly recognized as millennials, is considered a significant group of consumers having the environment as a top concern [17]. Hence, Gen Y is the best sample for testing our model. Representing the future green consumers, Generation Y includes individuals born between the 1980s and early 2000 [18]. Millennials are focused on environment-friendly consumer behaviour and are socially conscious. They prioritize Sustainability and ethical production, which further translates into their buying habits [19]. Notably, millennials are known to pay a premium for green products, services, and brands [20]. Earlier research on millennials revealed their tendency to balance the environmental and social impacts of their purchase decisions [21], [22].

Additionally, millennials who are self-motivated and conversant are the most sensitized consumer group. To add on, India holds the largest millennial population in the world which is well above the global average [17]. Hence, it is reasonable to select millennials as the unit of analysis for the current study. The present research has overlooked the Gen Y and Gen X consumer segments in the context of ecolabel communication by brands and its influence thereof on the purchase intentions of these segments. Secondly, it is clear from previous research that consumer behaviour is influenced by the communication of various attributes. Therefore, it becomes imperative to gauge the role of labelling in purchase decisions, as they are considered to promote responsible behaviour through awareness and accurate information about food products [8] [9], [10]. Notably, there also exist counterclaims on these eco-labels as not being the only determinant of sustainable purchase

decisions [23]. Research also claims that the presence of multiple labels leads to confusion among consumers [24]. Recent research on millennials' food purchase choices found a significant impact on education [25]. Therefore, it becomes imperative that millennials should be seen as a group of smaller sub-segments that vary in terms of levels of cognizance and motives [26]. With a huge number and a high potential to disrupt the market, no doubt understanding millennials' purchase behaviour holds the key for marketing practitioners, scholars and policymakers. This study shall make theoretical contributions to the contemporary research on green branding and sustainable consumption.

The study also substantiates the two-stage methodological approach of determining and validating antecedents of consumer behaviour.

Stage 1: Partial Least Squares Structural Equation Modelling (PLS-SEM) was used to test the relationships between Perceived Credibility, Green Environmental Knowledge, Green Communication, Attitude towards Ecolabel Purchase Intention and Purchase Behaviour. This first stage helps us understand the overall impact of these factors.

Stage 2: Neural Network Modelling (NNM) was used to rank the key factors influencing purchase behaviour and validate the findings from PLS-SEM. This stage leverages the strength of ANNs in capturing both linear and non-linear relationships, providing a more nuanced view.

2. Literature Review and Model Development

Behavioural Reasoning Theory (BRT) by Westaby [27] is based on the basic underlying assumption to elucidate the complicated associations between reasons, beliefs, motives, and intentions. The BRT can be linked with pivotal literature based on behavioural theories. As per the scholarly work of Westaby [27], most of the modern-day behavioural intention theories find their origin in two prominent theories: TRA and TPB [28], [29]. The grounded principles of BRT include the addition of reasons for and reasons against a behaviour, the role of values and the ability to fit into specific contexts. Due to these reasons, BRT is considered a modern and more effective theory for determining the human decision-making process. The available scholarly literature in the area of social psychology validates the claim that there are other variables and contexts which has an impact on consumer decisions [27]. Therefore, applying BRT into the specific context of eco- labelled food purchases seems more appropriate as compared to other behavioural theories.

The BRT finds its application in understanding the adoption of new innovations [30], [31] m-banking adoption [32], IOT adoption [33], and shopping behaviour [34], [35]. The scholarly literature on sustainable practices employing BRT further strengthens the appropriateness of the model [36], [37], [38]. Specifically, a recent study on organic food purchase decisions[39] confirms the ability of the model to explain consumer behaviour towards sustainable food

choices. Previous research on consumers revealed about their sceptical nature towards green products [40]. These studies further assert that there is a significant level of awareness about green products amongst Indian consumers, but sometimes these consumers find themselves either confused or less informed due to the variety of ecolabels and claims of firms. This study is an effort to fill the existing gap by gaining insights into consumer attitudes towards eco-labels and their impact on behaviour. Authors further found that most of the empirical studies in eco-friendly purchase contexts rely on customers' self-reported attitudes and practices instead of actual behaviours [41]. This study is an attempt to validate the empirical findings through Artificial Neural Networks to enhance the existing understanding of the purchase behaviour of eco-labelled food products.

2.1. Perceived Ecolabel Credibility

The Ecolabel credibility is the degree to which an ecolabel is perceived to be authentic, proficient, and trustworthy. Ecolabel credibility substantially influences the process of product evaluation [42]. Existing literature suggests a positive role of the credibility of ecolabels in affecting their adoption. Scholars have argued that the degree of credibility of an eco-label influences green purchases. Ecolabel's credibility is further known to establish the firm's reputation in the market [43]. The study results have been reinforced by previous research and have supported the role of eco-labels in green purchases [42]. It is also argued that ecolabels increase sales and improve the product image provided; consumers should identify them as trustworthy [44]. Hence, the literature has enough evidence to support that suffices the role of eco-label credibility in green purchases. Therefore, this variable is proposed in the context of food purchases as the perceived risk is much higher, and consumers may react differently to issues linked with food safety [43]. Therefore, the variable was added to the model to highlight its role in eco-labelled food product purchases. Based on the arguments, the study proposes that:
H1: Food ecolabel credibility positively influences attitude towards eco-labelled food purchase.

2.2. Green Environmental Knowledge

Green knowledge is a person's ability to comprehend and appraise environmental issues and their impact on society [45]. Green knowledge is usually linked with awareness towards green products [46]. Researchers have attempted to link the concept of green knowledge with false claims by firms (also known as greenwashing) and have also revealed the impact of consumers' knowledge on environment-related issues. It has been established that the level of greenwashing depends on the level of consumer's information and knowledge [47]. As the literature already suggested, consumers are less informed, therefore, consumers' knowledge of green products and their labelling holds importance. Results from the research of Wijekoon and Sabri [41] revealed that environmental knowledge is one of the major drivers of green products' purchase. Green environmental knowledge is believed to be impacted by consumers' responses [48], eco-labelling [49], green

learning [50] and attitude [51], [52]. Due to the role of green environment knowledge in green product purchases, this factor was included in determining the impact of green knowledge in eco-labelled food product purchases, as it is assumed that consumers' awareness regarding the impact of their food choices on the environment is a key determinant. Hence, it was hypothesized as:
H2: Green environmental knowledge positively influences attitude towards eco-labelled food purchases.

2.3. Green Communications

An increase in green claims by marketers has led to the development of a new segment of well-informed green consumers who exert pressure on marketers with criticism about the type of communication [53]. Modern-day communication strategies emphasize heavily on generating trust and belief in a brand's promise. For example, User Generated Content or UGC is seen as a more accurate and alternative source of communication for green brands [54]. Hence, the focus has shifted towards maintaining a healthy line of communication with potential consumers. Currently, companies are experiencing a rapid increase in the demand for sustainable products and, therefore, are more engrossed in green practices that include green communication to maintain competitive advantage [55]. Literature shows that firms emphasizing green practices are able to maintain their reputation in the industry [56]. Furthermore, previous studies on green marketing depict that consumers are hesitant to buy green products because green claims on green products are sometimes unclear and unreliable. Nevertheless, studies have also indicated that green advertising and green marketing do wield influence over consumer attitudes and intentions [57]. As communication between a brand and consumer is considered important, this study will attempt to test the impact of Green Communications on attitudes towards eco-labelled food purchases. Therefore, the hypothesis:
H3: Green communications positively influence attitudes towards eco-labelled food purchases.

2.4. Attitude

Attitude is considered the strongest factor that fundamentally affects an individual's behavioural intention towards green purchases [58]. Based on robust underlying research on consumer attitudes, further attempts by scholars uncovered the positive role of attitude in determining pro-environmental purchases [59], [60]. Recent studies [61], [62] emphasized that customers' environmental-related attitudes act as mediators and moderators that further impetuses green purchase intention. Also, similar attempts have been made by researchers to determine the role of attitude in green purchases [41], [42]. Hence, it can be inferred that attitude is a strong determinant of green product purchase intentions [63]. Similarly, consumers' attitudes towards a specific ecolabel can play an instrumental role in the execution of a purchase decision. Therefore, this study proposes to measure the impact of consumers' attitudes towards eco labelled food products on their intentions. Based on conceptual understanding, the study proposes:
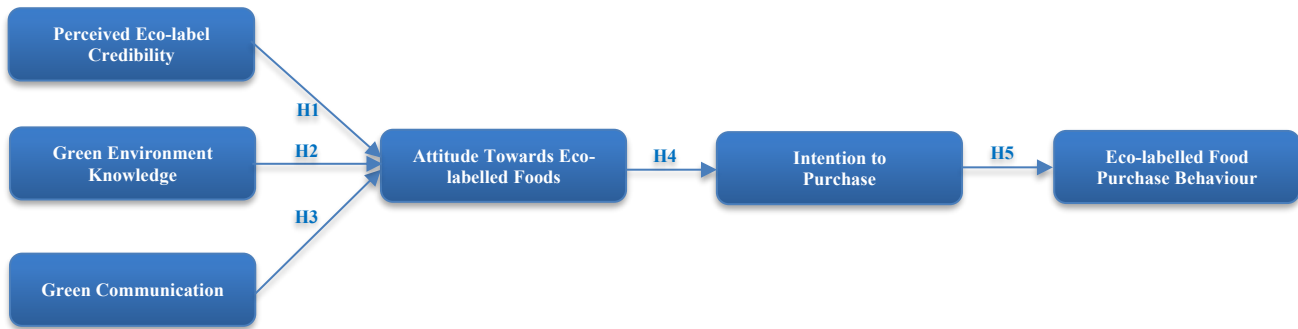
Fig. 1 Research framework (Adapted from Westaby, 2005)

H4: Attitude towards eco-labelled products positively influence consumers' intentions.

2.5. Intention and Behaviour

Consumers' inclination towards sustainable brands is increasing. This can be witnessed through the research depicting an increase in the popularity of products with environment-friendly claims [64]. Consumer behaviour involving green purchases revolves around the purchase of products which are designed for recyclability and, at the same time avoiding products which cause harm to the environment [65]. Research on consumers' intention towards green purchases highlights a significant impact of individual factors [66], [67]. Furthermore, scholarly studies also indicate that consumer's intentions can serve as a strong indicator of their inclination to purchase sustainable products or services [68], [69]. Also, previous research found a disconnect between consumers expressing environmental concern and their actual sustainability actions [70]. Within the realm of sustainability research, a continuous challenge is the "intention-behavior gap", which explains an inconsistency between what consumers think about the environment and what they actually do [71], [72][73], [74]. Therefore, it becomes utmost essential to understand the process of intention development for decisions involving green purchases. Hence, based on the existing understanding of consumers' intentions, it is rational to affirm that consumers' intentions towards eco-labelled food purchases can serve as a reliable predictor of their actual purchase. Therefore, the following hypothesis is proposed:

H5: Purchase intentions towards eco-labelled food products positively influence consumers' purchase decisions.

3. Methodology

The research followed a descriptive and quantitative design to conduct the survey considering recommendations [75]. The population included males and females within the millennial age group (Gen Y) who are aware of ecolabels and green food products from the states of Punjab, Haryana and Delhi NCR in North India.

3.1. Area

The main reason to choose Punjab is due to its performance in the SDG India Index 2021. As the state has performed well in the selected parameters related to Sustainability and clean energy goals [76], It is therefore expected that it stands better in terms of its outreach in establishing communication with the people regarding green practices. The reason to add Haryana and Delhi NCR is attributed to the shift in Indian urban consumers' willingness towards more socially responsible and sustainable consumption [77].

Specifically, Haryana has urban population living in cities is higher than the national average [78]. Data were collected from selected urban areas falling in these two states, as consumption of green products is higher in urban areas as compared to rural areas. Data were collected online and offline. The advantages of an online questionnaire survey are low cost, fast feedback, wide coverage, and a lack of time and space restrictions. In addition, online questionnaire surveys allow researchers to use less time and effort to reach target groups [79]. The offline questionnaire survey has a high response rate. In offline data collection, the information obtained is relatively complete, but the cost of obtaining data is relatively high. Hence, this study used both methods.

3.2. Samples

The data were collected using a stratified sampling technique. As per the suggestions, a sample size of 384 is sufficient for a population of 1 million or more [80]. For this reason, the current study considered a sample size of 384. Keeping an upper limit for the sampling, researchers decided to collect 125 samples each from Punjab, Haryana and Delhi NCR, thereby totalling the number to 375. Keeping an upper limit, researchers reached out to 761 potential respondents.

Out of 761 individuals, researchers got responses from 602 and out of these, 411 responses were found accurate. Initially, respondents were approached at the sales outlets/point of sales to fill out a questionnaire. In addition, the online method of approaching respondents was considered using keywords on social media platforms like LinkedIn and Facebook.

The reason for adopting the online method can be attributed to the consideration of the internet as the "natural habitat" of millennials, and it is suitable to interact with them through social media [81]. The only restriction was the age, to fit within the millennial age range. This requirement was controlled via a screening question. Identical responses with repeat values were discarded.

4. Results

The statistical analysis of the proposed research is assessed by employing the partial least squares structural equation modelling (PLS-SEM) method. This approach has an advantage over the covariance-based structural equation modelling (CB-SEM), as it can analyze more complex models [82] having a small sample and also does not involve normality [83]. This approach is also considered effective for analyzing moderation [84]. Suggestions provided by the scholarly works [85], [86], [87] were considered as the base to select PLS-SEM as method of analysis. For the computation purpose, researchers employed R, an open-source software environment for statistical computing and graphics (https://www.r-project.org/), using the SEMinR package as suggested [88], [89].

4.1. Measurement and Structural Model (Stage -1)
4.1.1. Data Pre-Processing

Data pre-processing is a vital step in Structural Equation Modeling (SEM). It involves preparing the data for analysis to ensure the accuracy and reliability of SEM results. The study employed *Full-Information Maximum Likelihood (FIML)* as the estimation approach for missing data before assessing measurement and structural models. FIML estimates missing data and also works well for all potential data points during data analysis [90]. Before building the model, the quality of data was also assessed to ensure it accurately reflects the concepts and produces consistent results. The study assessed reliability, convergent and discriminant validity to examine the measurement model [86]. Results revealed the outer loadings of all items with Cronbach's alpha, the composite reliability and the average variance extracted. The λ value and Cronbach's alpha for all constructs were above 0.7, whereas CR and AVE (Table 1) were well above the threshold value of 0.5, indicating that the construct explains no less than 50 per cent of the variance, thus establishing the construct reliability and convergent validity [86]. Furthermore, to assess the discriminant validity, researchers used two methods: The Heterotrait-Monotrait (HTMT) ratio of the correlations and the Fornell and Larcker criterion to strengthen the claim on discriminant validity. High HTMT values lead to discriminant validity issues and therefore suggested a threshold value of 0.90 [82]. The HTMT values were found to be below 0.90 (Table 2a), thus establishing the discriminant validity of all the variables [91]. Overall, the HTMT ratio table suggests that each construct is sufficiently distinct from the others. Findings further indicate that square roots of the AVE for all the constructs are greater than the inter-construct correlations, thus establishing discriminant validity [92] (Table 2b). These findings suggest that each construct within the model has a distinct conceptual and empirical role and hence holds significance for the validity and interpretability of the structural equation modelling results.

4.1.2. PLS-Path Modelling

Structural model assessment was carried out using R-square values. The model established the variance as 51.8 %, which suffices the minimum value benchmarks [93]. An assessment of R2 values of ATE and PI was found to be 0.471 and 0.426. In order to establish predictive relevance, the study considered Q2 values by using the C-SEM package in R studio. Values more than 0 advocate the predictive relevance of the model. Q2 values for the endogenous constructs (ATE=0.319; PI=0.278; PB=0.340) were over 0.00. Hence, predictive validity was established.

4.1.3. Hypotheses Testing Results

The interpretation of path coefficients and hypothesis testing through Structural Equation Modelling (SEM) provides insight into the relationships among theoretical constructs (Figure 2). As evident in Table 3, hypothesis testing was carried out conducted by examining the beta coefficients, T statistics, and P values to determine the statistical significance of the hypothesized paths. The relationship between PC and ATE was found to be strong and statistically significant with a beta coefficient (β = 0.392; T =7.283, p <0.01). The hypothesis that the perceived credibility of food eco-labels positively influences the attitude is supported. GEK was found to be significantly associated with ATE (β = 0.295; T=3.933, p <0.01), thus indicating a significant positive relationship.

Hence, the hypothesis that Green Environment Knowledge impacts consumers' attitudes is supported. Furthermore, the analysis revealed that GC has a significant association with ATE (β = 0.250; T =4.07, p <0.01), thereby supporting the hypothesis that Green Communication also influences ATE. Also, the relationship between AT and PI was significant and positive (β = 0.412; T =8.307, p <0.01). Hence, there is strong support for the hypothesis that a positive attitude leads to strong purchase intentions. The hypothesized path between PI and PB was also found significant (β = 0.329; T=6.318, p <0.01), thus depicting that stronger purchase intentions lead to actual purchase behaviour. The model focused on purchase behaviour towards eco-labels based on five factors: Perceived eco-label credibility, Green Environment Knowledge, Green Communication, Attitude towards Eco-labelled food products and Purchase Intention (Figure 2). The minimal difference between training and testing RMSE (Mean=0.218, SD=0.017) indicated a reliable model based on recommendations of previous research findings [94], [95].

4.2. Neural Network Results (Stage 2)

Artificial Neural Networks (ANNs) are a powerful machine-learning tool used across various research domains. ANN is "an immensely parallel distributed processor that consists of simple processing units to store experimental information and make it available for use [96]. ANNs imitate the human brain's work and learn by uncovering hidden patterns in data through a process called "training" and then demonstrate their knowledge through "testing." A key advantage of ANNs is their ability to handle complex relationships without any requirement of assumptions about data distribution. This makes them superior to traditional methods like Structural Equation Modelling, which can only analyze linear relationships [94].

Table 1. Factor loadings, Cronbach alpha, CR and AVE

Factors	Cronbach's Alpha	Composite reliability	Average variance Extracted (AVE)
Perceived Eco-label Credibility	0.793	0.858	0.550
Green Environment Knowledge	0.738	0.849	0.653
Green Communication	0.823	0.882	0.652
Attitude Towards Eco-Labelled Food	0.798	0.867	0.620
Intention to Purchase	0.827	0.897	0.744
Eco-labelled Food Purchase Behavior	0.755	0.859	0.670

Table 2a. Discriminant Validity assessment using HTMT Ratio

	R^2	ATE	GC	GEK	PB	PC	PI
ATE	0.471						
GC		0.634					
GEK		0.583	0.502				
PB	0.518	0.240	0.283	0.242			
PC		0.536	0.451	0.498	0.286		
PI	0.426	0.414	0.443	0.390	0.588	0.406	

Table 2b. Discriminant validity assessment using Fornell-Larcker criterion

	ATE	GC	GEK	PB	PC	PI
ATE	**0.788**					
GC	0.439	**0.808**				
GEK	0.378	0.461	**0.808**			
PB	0.227	0.199	0.182	**0.819**		
PC	0.525	0.369	0.429	0.213	**0.742**	
PI	0.299	0.315	0.306	0.439	0.313	**0.862**

Table 3. Hypotheses testing

Hypothesized Paths	Beta	T statistics	P values	Result
PC -> ATE	0.392	7.283	0.00	Supported
GEK -> ATE	0.295	3.933	0.00	Supported
GC -> ATE	0.250	4.07	0.00	Supported
ATE -> PI	0.412	8.307	0.00	Supported
PI -> PB	0.329	6.318	0.00	Supported

4.2.1. Neural Networks Validation

This study built an Artificial Neural Network (ANN) model using SPSS v.24 (Figure 3). The training accuracy revealed the model's performance on the training data as the number of epochs increased. In this case, it was higher initially but then steadily decreased to around 0.2, which indicates a high training accuracy. Additionally, the testing accuracy also revealed the model's performance. In this case, it was observed to reach 1.5, which is also a determinant of high testing accuracy.

Overall, both the training accuracy and testing accuracy are high, which further suggests that the ANN model is effective at learning the patterns in the data. The model implemented the most commonly used approach: a feed-forward backpropagation algorithm with a hyperbolic tangent activation function [94], [97]. To prevent overfitting, a 10-fold cross-validation technique was adopted. Determining the best network structure often relies on trial and error since there's no clear guide [94], [97]. In this case, the model's accuracy was measured using Root Mean Square Error (RMSE), a well-established metric [98]. 80% of the data was used for training, and the remaining 20% for testing [95].

As seen in Figure 4, the training accuracy is high, along with the testing accuracy. This implies that the model is able to accurately predict the target variable on both the data it was trained on and unseen data as well.

Table 4. Neural network performance validation results

Networks	Training	Testing
ANN01	0.632	0.617
ANN02	0.614	0.683
ANN03	0.598	0.702
ANN04	0.608	0.648
ANN05	0.631	0.619
ANN06	0.621	0.647
ANN07	0.625	0.601
ANN08	0.673	0.598
ANN09	0.619	0.627
ANN10	0.607	0.704
Sum	6.228	6.446
Average	0.622	0.644
Standard Deviation	0.019	0.037
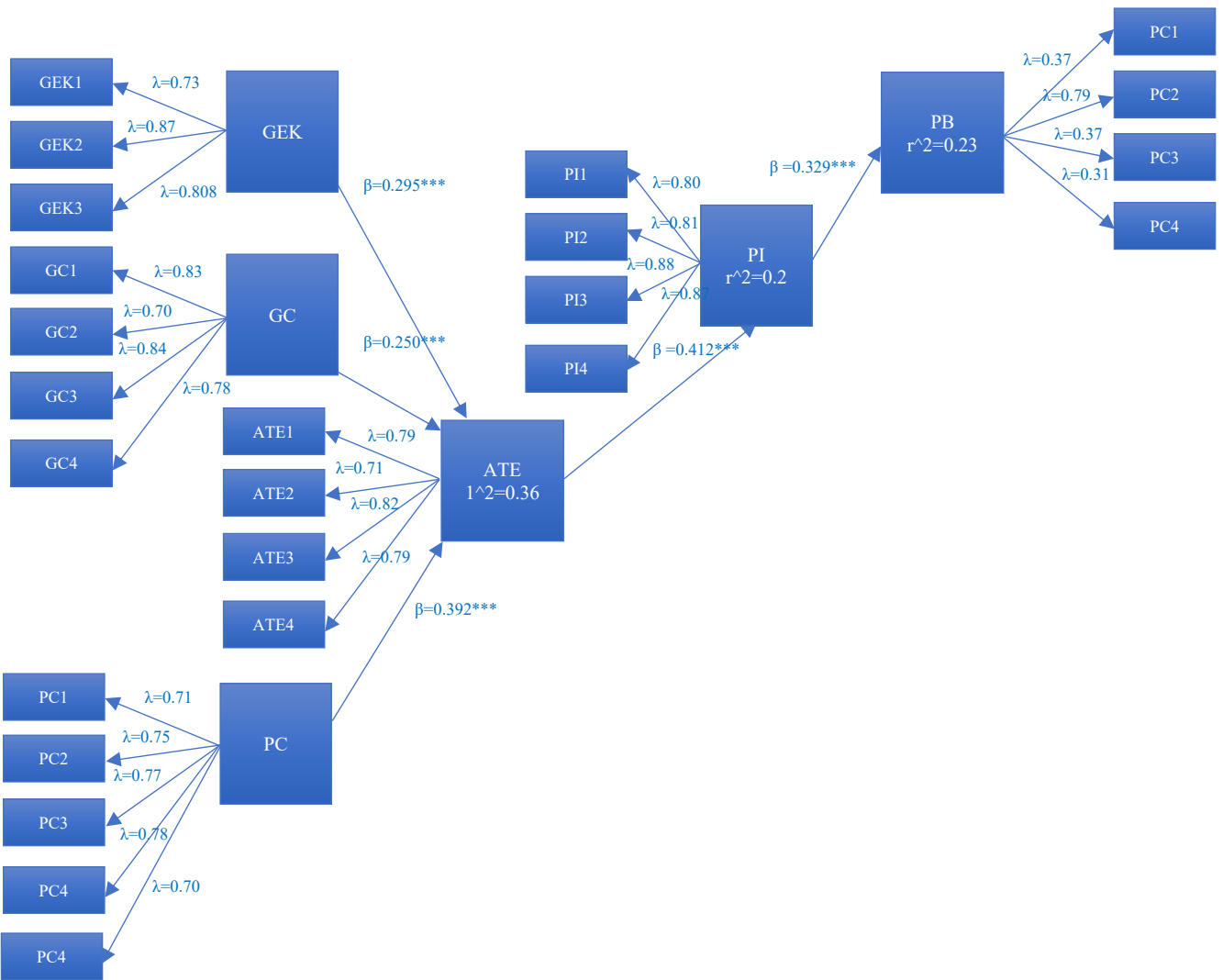
Note: ATE=Attitude towards Eco-labelled food Products; GC=Green Communication;
GEK = Green Environment Knowledge; PB= Eco-labelled Food Purchase Behaviour
PC= Perceived Credibility of Eco-labels: PI=Purchase Intention
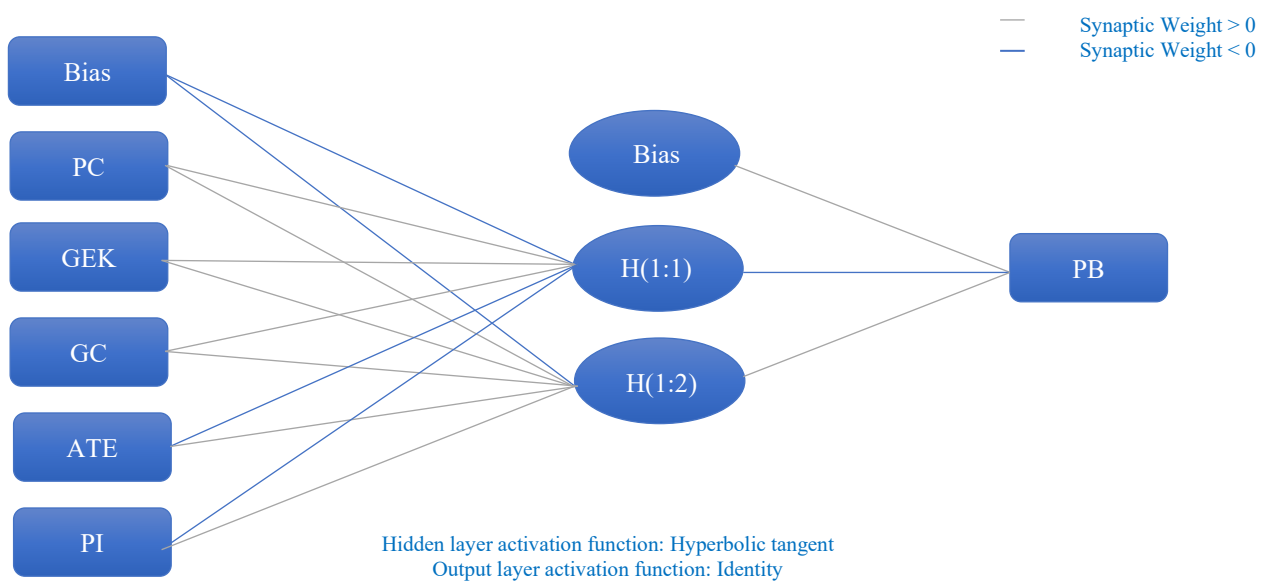
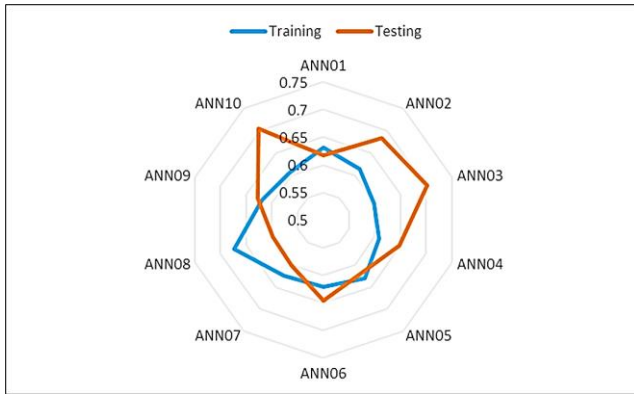**Fig. 2 PLS-SEM path results**

Fig. 3 ANN Model

Fig. 4 Neural Network Validation

Table 5. Importance of constructs

Network	PC	GEK	GC	ATE	PI
ANN01	0.014	0.084	0.053	0.115	0.734
ANN02	0.042	0.049	0.045	0.215	.650
ANN03	0.058	0.023	0.073	0.215	0.63
ANN04	0.047	0.107	0.067	0.131	0.648
ANN05	0.055	0.1	0.086	0.145	0.615
ANN06	0.053	0.101	0.077	0.162	0.608
ANN07	0.048	0.11	0.035	0.121	0.687
ANN08	0.055	0.075	0.031	0.149	0.689
ANN09	0.014	0.078	0.109	0.14	0.659
ANN10	0.07	0.05	0.043	0.155	0.683
Average Importance	0.045	0.077	0.061	0.154	0.660
Normalized Importance	69.6	117.9	95.3	236.4	100

4.2.2. Sensitivity Analysis

To ensure that specific assumptions or data features did not overly influence findings, a sensitivity analysis of the findings obtained in stage 1 was performed. This analysis assessed the robustness of the conclusions. In simpler terms, this analysis evaluated how much the importance of each factor affecting purchase behaviour changed under small variations. The process involved averaging the importance scores of Perceived Credibility, Green Environmental Knowledge, Green Communication, Attitude towards Ecolabel, and Purchase Intention in predicting purchase behaviour. The detailed results are presented in Table 4.

The sensitivity analysis revealed that attitude towards ecolabels emerged as the most influential factor affecting purchase behaviour within the ANN model. Its normalized importance ratio, a measure of relative influence, was found to be 236.4%. This was followed by Green Environmental Knowledge (117.9%), Purchase Intention (100%), Green Communication (95.3%), and Perceived Credibility (69.6%). These findings suggest that a consumer's attitude towards eco-labels plays the most significant role in predicting their purchase behaviour.

5. Discussion

This study examined the factors that impact millennials' eco labelled food purchases. The research is one of its kind as no previous attempt has focused on the variables that affect intention and behaviour towards eco-labelled products. The current study advances the behavioural reasoning theory by using constructs: perceived ecolabel credibility, green environment knowledge and green communication as significant predictors of attitude.

Study results revealed that perceived eco-label credibility, green environmental knowledge and green communication act as pivotal predictors of attitude. These findings are well in line with the scholarly studies covering the pro-environment milieu. The significance of ecolabel's credibility offers evidence that trustworthy eco-labels augment positive attitudes. ANN further established attitude as the most significant factor in predicting green purchase behaviour.

5.1. Key findings

The research contributes to the theoretical understanding by empirically proving the direct influence of these factors on the attitudes and purchase intentions of millennials. In addition, the theoretical model provides firm evidence that attitude is pivotal in shaping consumer intentions towards eco-labelled products. Therefore, current research extends the domain of consumer behaviour by integrating cognitive and affective factors. The statistical analysis through R studio adds a quantitative dimension to the understanding of green purchasing behaviour, offering a methodological approach which can be replicated in future research.

5.2. Comparison with Existing Studies

Results are consistent with the findings that depict the role pro- environmental variables linked with ecolabels in attitude development [42]. Furthermore, a significant role of green environmental knowledge and green communication portrays that a brand's outreach involving Sustainability tends to create economic and social impact, thereby affecting the attitude [57].

Notably, findings representing the positive impact of green environmental knowledge on attitude resemble previous scholarly findings [52], thereby further corroborating the claims of this study. Attitude is known to impact intention as it can be assessed from existing literature [99]. In line with previous findings, current research confirms that people with positive attitudes towards ecolabels value environmental protection and carry a tendency to act on it. Since attitude is the strongest variable that influences behaviour, this means people with more positive attitudes are more likely to buy eco-labels. Interestingly, the current model further indicates that changes in attitudes will lead to a change in purchase

behaviour. This insight draws corroboration from well-validated scholarly studies [58], [59], [60].

5.3. Model Implications

The findings provide crucial insights that can assist marketers in developing targeted strategies for millennials. Especially, the model revealed a substantial contribution of perceived ecolabel credibility, green environmental knowledge, and green communication to influence attitudes toward eco-labelled food products. This holds significant relevance for practitioners looking to endorse the pro-environmental aspects of their offerings to individuals having a proactive approach towards green purchases. This research applied a hybrid modelling approach to the purchase of food eco-labels. This context demonstrates how SEM and neural networks (ANNs) can be combined effectively to capture complex, non-linear relationships between variables. This study revealed that using SEM results to guide the development of an ANN model significantly improves its prediction accuracy compared to a standard neural network. The results obtained by using this approach are particularly valuable when dealing with increasingly intricate models across various research domains.

The study uncovered that by employing two-step SEM-ANN approach, complex relationships in consumer behaviour can be assessed effectively. Also, analysis of the current model proved the strength of this modelling technique beyond consumer preference analysis. Based on the significant relationships found in the SEM analysis, the most important variables were chosen as inputs for the ANN model. The novelty of this study lies in the utilization of the ANN model for eco-label purchase behaviour because of its generalizability.

Unlike traditional static models, the ANN can adapt and improve over time. As new data on consumerism becomes available, the model can be retrained to make further modifications in the future. This allows the ANN to remain relevant and familiarize with evolving trends, providing more accurate predictions. Furthermore, the advantages of ANN lie in its balance between adaptability and stability to handle new cases effectively and react appropriately to changing consumer behaviour. It is important to note that, to our understanding, this ANN model is the first dedicated model specifically designed to predict eco-label purchase behaviour within the field of green consumerism.

5.4. Limitations

This study is a novel attempt to gauge millennials' green purchase behaviour in India with reference to eco-labelled foods. As with each research, this research too has some limitations. Firstly, the study's emphasis on millennials may not capture the purchasing behaviours of other consumer groups. Hence, the findings may not be generalizable across different age groups or demographics. Secondly, the study's static nature does not depict the change in consumer attitudes and behaviours over time. As such, it may not reflect the long-term effectiveness of eco-labels and related green marketing strategies. Third, the study did not test the effectiveness of specific behavioural interventions, which could have provided practical insights to guide consumers toward environment-friendly purchase decisions.

6. Conclusion and Future Work

This study attempted to draft a substantial piece of research covering the importance of eco-labelled food purchase behaviour of millennials. The current study has contributed significantly to the theoretical frameworks that serve environmental marketing. Study results lead to a strong and statistically significant model in the context of millennials who possess strong buying power.

Therefore, this research holds importance for marketers, researchers and policy makers in addressing the concerns linked with environment-friendly food purchases. Study results established the crucial role of eco-label credibility, environmental knowledge, and green communication. The inferences drawn from the research further reinforce the imperative for marketers to align their strategies with the values and cognitive processes of millennials. Further, the significant role of attitude also delivers actionable insights for marketers to develop future strategies that are not only focused but also direct millennials in processing information towards eco-labels, making decisions, and taking action based on these discernments. To overcome the limitations of the study future research could use longitudinal study designs to measure change in attitudes and behaviours of millennials over time.

In addition, scholars can undertake a comparative study considering different cultures and regions to offer insights into the specificity of the findings. To strengthen the generalizability of findings, current research could be expanded to include other demographic groups beyond Millennials. Thus, it can be stated that this study adds to the current understanding of scholars and practitioners to deliberate critically about the measures in engaging millennials towards eco-friendly food purchases as environmental concerns are increasingly persuasive on the global agenda.

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Author's Contribution Statement

Deeksha Sharma: Conceptualization, Data collection, Draft Writing. Pawan Kumar: Editing and Data Analysis, Avinash Rana: Interpretation of results, Monoo John: Proofreading and Vishal Soodan: Final Supervision

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