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Research Article

Innovative Sustainable Processes in the Food and Beverage Sector: Driving Consumer Preferences and Building Brand Loyalty

Roshan Kumar Shiva, School of Business, SR University, Warangal, Telangana, India.roshanshiva1234@gmail.com, 2302C70023@sru.edu.in

https://orcid.org/0009-0007-9765-2054

Geetha Manoharan, Research Supervisor, School of Business, SR University, Warangal, Telangana, India, geethamanoharan1988@gmail.com, m.geetha@sru.edu.in

https://orcid.org/0000-0002-8644-8871,

Sanjeev Kumar, School of Hotel Management and Tourism, Lovely Professional University, Jalandhar, Phagwara, Punjab, India kumarsharma12360@gmail.com, sanjeev.sharma@lpu.co.in, https://orcid.org/0000-0002-7375-7341,

A. K Haghi, Centro de Química de Coimbra, Departamento de Química, Faculdade de Ciências e Tecnologia, Universidade de Coimbra, 3004-535 Coimbra, Portugal akhaghi@gmail.com, https://orcid.org/0000-0002-7259-6718,

Abstract:

As the green and ethical movement expands, this study examines how innovative sustainability processes are changing the face of the food and beverage (F&B) industry. Few academic studies directly address how green practices influence consumer preferences and brand loyalty. This study fills that gap by discussing sustainable processes such as ethical sourcing, eco-friendly packaging, digital storytelling, and environmentally driven loyalty programs. It presents qualitative analyses of industry cases and academic literature that demonstrate the effectiveness of these approaches. The results indicate that transparency, storytelling, and green branding have strong effects on consumer trust and loyalty in the food and beverage sector. Emotional engagement, health alignment and ethical positioning were the key drivers. It includes; minimize costs, green ecological activities new rules and regulatory compliance should examine. The study also examines the conventional sustainability and transformed into the sustainable innovative process. It connects in between “digital storytelling and eco-friendly production” with proper systematic manner and design the operational framework. The new

paradigm offers a quantitative and holistic model of sustainability along with operational, social and behavioral dimensions all together and do the improvement over the conventional marketing-based models.

Highlights

- Introduces an Integrative Sustainable Process Model for the F&B sector.
- Links ethical sourcing, eco- packaging and digital storytelling to brand loyalty.
- Defines sustainability as a continuous operational and behavioral process.
- Empirically demonstrates how trust and authenticity drive consumer loyalty.
- Provides a strategic framework connecting sustainability to competitive advantage

Keywords: consumer behavior, brand loyalty, ethical branding, food and beverage sector, eco-innovation, process integration, sustainability framework.

1. Introduction

The food & beverage industry focus on the sustainability and transformational theme driven in consumer values, environmental pressures and regulatory drivers [1]. It includes the Worldwide United Nations Sustainable Development Goals (SDGs) & the Environmental, Social and Governance (ESG) have created standards that have changed the paradigm of corporate responsibility. Sustainability more focused on the symbolical move with a competitive necessity that extends which includes; “environmental care and responsible sourcing for the community [2]. This study focusses on sustainability along with three different dimensional processes which includes; “environmental, ethical, and social dimensions” in each process of operation from production to the consumer [3]. Conceptualizes of sustainability not only a goal but as a sustainable process it creates a constant improvement, bring the improvement in the brand and resilience in the marketplace. The food & beverages industry it is a system and process where supply chain structure and high visibility for the consumer [4]. The usage of the advance technologies like; ‘AI-driven sustainability analytics, plant-based innovation and circular economy” models bring the changings in the brands and sustainability [5]. Most of the companies use the sustainable practices and integral their core strength and meet the basic standards and developing consumer demands [6]. The applications of sustainability implementation the practices which includes; “biodegradable packaging, purchasing ingredients ethically” and the digital stories on sustainability journeys and engaging customers campaigns values-based [7]. In the food and beverage industry customer are more

oriented towards the quality of food and where brand play an important role and improve the brand loyalty which leads to emotional attachment towards the products [8]. The new developing trends like; plant-based productions, analytics of sustainability using AI and climate action are changing the game and brings the quality in the competitive arena [9]. Fair-trade, carbon-neutral and organic labelling are on the rise as trust-building and consumer education technologies [10]. They too have their fair share of challenges to implement. These brands face challenges with regard to cost problems, green-washing accusations, and consumer mistrust [11]. However, with a sufficiently innovative adaptation of sustainability communication, these challenges could better be taken over. With sustainability no longer a trend, but an imperative, the demands from consumers and virtual responsibilities of corporations within the food and beverage industry are evolving [12]. It shall explore the dynamic nature of sustainability and suggest to the company's strategic frameworks such as ethical, environmental and values-based in which it shall build a long-term consumer loyalty toward its brands [13]. It focuses on innovative concepts such as eco-friendly packaging, digital storytelling, plant-based innovation, and climate-conscious branding as effective differentiation and trust-building points for the brand [14]. Finally, the threats of greenwashing, the costs of sustainability and the ultimate significance of transparency are explored [15]. This study shows the number of objectives focus on sustainability within the food and beverage industry. It also addresses the different impact of sustainability-driven processes and consumer attitudes and consumer behaviours which highlighting the sustainability practices which includes; "ethical sourcing, eco-packaging and digital storytelling". The research also explores that the transparency and value-based communication create long relationship in brand loyalty with consumers. The study also does the analysis on existing challenges and the implementation which includes; cost prohibitions and greater consumer understanding and the ever-present threat of green washing. Finally, it also investigates the future processes for sustainability focus on emerging trends and innovations which includes; plant-based products and circular economy activities.

1.1 Hypotheses of the Study

H1: Transparency & authenticity in sustainability practices show the positively influence on consumer trust in food and beverage brands.

H2: Consumer trust significantly enhances brand loyalty in sustainability-oriented brands.

H3: Sustainability-driven factors such as eco-packaging, ethical sourcing, and digital storytelling have a positive effect on consumers' willingness to pay a premium.

H4: Emotional engagement through sustainability mediates relationship between sustainable practices and brand loyalty.

2. Comprehensive Understanding of Sustainability in the Food and Beverage Sector

2.1 Defining Sustainability in the Context of Food and Beverage

The aspect of sustainability practices in food business operations which ensure environmental and human health [16]. It also expresses the intention to combine economic viability with ecological protection and social well-being which reflects the integrated practices of green innovation and ethical responsibility with consumers that turns into a business and brings improvement. "Resource efficiency, waste reduction, local communities", decision making contained the philosophy [17]. For example, sources can adopt sustainable sourcing that includes local or organic goods, which decreases travel emission and pesticide usage. Farm selection that applies crop rotation among other effective practices might help to conserve biodiversity, too. Also important in this business' sustainability is packaging. Using recyclable, biodegradable or reusable materials can minimize waste and appeal to customers who care more about plastic pollution [18]. In this industry, sustainability refers to the production of foods and beverages that promote economic justice, are healthy for people, and the environment. Being, therefore, in compliance with attitudes of numerous modern customers, sustainability is no longer a morally complying decision, but rather a commercially wise one.

2.2 Consumer demand for sustainable products

Consumer interest in eco-friendly products is increasing rapidly. Consumers are rapidly becoming aware of the impacts their choices create for communities, wildlife, and the environment at large. Consumers' attention towards food origin, its manufacture and compatibility with their values has been above any earlier statistics [19]. Today, consumers no longer look for brands that exploit sustainability as a marketing tool, but for companies that can openly declare their conduct of business and genuinely are concerned for the environment. Informationally surrounded Gen Z and Millennials' want more than anything. Most of such customers who make a purchase accord ethics, health, and the environment precedence over all in their purchase decisions. Such a significant shift in the consumer market is because consumers will pay that little premium for a product that shares their values-be it organic farming, fair labour practices, or less carbon impact [20].

Another major motivator for the growing demand for sustainable products is health. Most people opt for sustainably produced food because they believe that such food will be healthier in addition to being of better quality. The reason for consumers' engagement in their purchases is that they feel more responsible to socially and environmentally responsible behaviours if they are aware that they are contributing towards the same [21]. These concerns have also increased with the epidemic, since many consumers are aware of their health, vigilant about their well-being, and sensitive about the impact their choices have on the environment.

2.3 The Role of Corporate Responsibility

Corporate responsibility is a firm's desire to do the right thing: It means profit generation does not just go with the positive impact on society and the environment but also. Within the food and beverage sector, corporate responsibility is often synonymous with sustainability [22]. A firm can engage in fair trade by ensuring that there is adequate reward for farmers such that the worker's conditions are also safe. On the other hand, they are highlighting the ways to make carbon footprints lower, renewable energy sources and sustainable packaging. Consumers who support companies with corporate responsibility increase the purchase of goods through their purchasing policy; they gain more confidence and loyalty in purchase. It can be stated that consumers, due to their involvement, have developed an emotional relationship with brands that work for social causes moving beyond the horizon of profit maximization [23]. Effective action in place of promises - a brand is welcome to demonstrate its commitment to sustainability through effective action; they are more value-based in the eyes of its customers. This trust has transparency as its foundation. The disclosure of good, bad or any sustainability practice found in products helps a brand acquire a more positive reputation [24]. On their websites, many companies dedicate considerable amounts of space to explaining their suppliers, environmental impacts, and community initiatives. Such openness leaves customers with fewer doubts that the company means what it says and is doing its best for sustainability and is not trying to express meaningless words [25]. The other side of corporate responsibility is societal issues like equal remuneration, workplace diversity, and inclusion. In the modern business world, most companies have realized that properly treating workers is just as essential as well treating nature well. Consumers in this century of business expect that corporations would take a position on issues of society, and companies that take a position are generally supported by faithful stakeholders [26].

3. Reviewed literature: Summary of Prior Work

Table 1 below summarizes important studies within our understanding of the effect of sustainable marketing on consumer behavior and brand performance in the food and beverage industry. Studies gave light on topics of subjects ranging from ethical sourcing to plant-based innovations, digital storytelling and eco-packaging to data-backed decision making. Altogether, these studies clearly indicate that a paradigm shift toward values-based marketing exists in both academia and industry, where environmental and social responsibility is a contributing factor for consumers' preferences. Of the many findings, a significant focus on forming trust and transparency and authenticity as requirements for true brand loyalty still remains. Authenticity is key to many young consumers, and is often based on whether or not a brand lives by its sustainability mantra in a tangible way; for instance, it's possible to claim to be sustainable through the use of recyclable packaging, or sourcing fairly traded ingredients. Digital capabilities and analytics are also proving to be an effective way to increase engagement through personalization and more targeted communication channels. Such findings are particularly important in terms of reinforcing the urgent need for F&B companies to integrate sustainability into their core, rather than just satisfying the ethics demands of their consumers.

Table 1. Key studies addressing sustainability marketing in the F&B sector

S. No.	Author(s) & Year	Focus area	Methodology
1	Sharma et al. (2024) [54]	Plant-based beverages and consumer preferences	Qualitative review
2	Babatunde et al. (2024) [9]	Brand marketing and economic development	Case study
3	Cheng et al. (2024) [11]	Operational performance in the F&B industry	Quantitative surveys-based
4	Suvattanadilok (2024) [17]	Consumer behavior toward coffee sustainability	Survey
5	Gunawan et al. (2024) [14]	Sustainability-labelled packaging preferences	Interview and survey

6	Srivastava et al. (2024) [51]	Sustainability and brand positioning	Review article
7	Ko & Jeon (2024) [41]	Green practices in coffee shops	Empirical analysis
8	Lee et al. (2023) [30]	Eco packaging in F&B and customer behavior	Correlational study
9	Magdy (2024) [15]	Creative Food Experiences and Brand Equity	Tourism case analysis
10	Akgunduz et al. (2023) [34]	Customer citizenship behavior and sustainability	Case-based research
11	Socaciu et al. (2022) [39]	Biopolymer films for food packaging	Consumer preference survey
12	Amoako et al. (2021) [44]	Green marketing and corporate social responsibility	Empirical Model
13	Nuseir&Elrefae (2022) [56]	Social media marketing and brand equity of sustainability	Online survey
14	Liu et al. (2022) [47]	Value Co-creation and Green Shopping Behavior	Quantitative study
15	Tchanturia & Dalakishvili (2024) [35]	Data Analytics in Sustainable Marketing Innovation	Review of the literature

4. Theoretical Framework:

4.1 Core Elements of sustainability marketing in food and beverages

4.1.1 Sustainable Product Development

Sustainability and the ethical aspects of product development result in not only ethical and ecologically-sustainable food and beverage products, but also healthy organic crops. It removes the synthetic pesticides and chemicals from crops. In companies choose local sourcing and plant-based products to get away from the issues of transportation emissions and animal agriculture. It covers all stages, from manufacturing energy reduction to water use [27]. This is appreciated by customers who care for the environmental responsibility and want companies to minimize their green footprint. Combining upstream input with product innovation and downstream engagement, the Integrative Sustainable Process Model (Figure 1) places sustainable product development in a constantly flow system between sourcing, eco-design, energy and water efficiency and transparent traceability and consumer-facing communication and loyalty mechanisms. The model explains how these operational choices function by engaging with the vital mediators - authenticity, transparency believe, and value congruence - which would then generate tangible results - such as trust, satisfaction, and loyalty - which would be measured by KPIs of NPS, repeat purchase rate, and willingness to pay premium.

Table 2. Practices-to-Outcomes Process Map for F&B Sustainability

Practice (F&B)	Example implementation	Primary mediator(s)	Expected outcome(s)	Core KPIs
Ethical sourcing and fair trade	Certified supplier share; farmer premium policies	Authenticity; value congruence	Higher trust; repeat purchase	Trust index; repurchase rate
Eco-friendly packaging	Recycled content; refill/return programs	Perceived quality/health; environmental belief	WTP premium; advocacy	WTP %; referral rate
Supply-chain transparency	Traceability coverage; blockchain disclosures	Transparency belief; authenticity	Lower scepticisms; brand equity	Transparency score; brand equity index
Digital storytelling	Process narratives across web/social	Emotional engagement; authenticity	Satisfaction; loyalty	Dwell time; NPS
NGO/community partnerships	Co-branded initiatives; local sourcing	Value congruence; social proof	Trust; advocacy	Partnership count; UGC volume
Influencer marketing (sustainable)	Expert advocates; lifestyle alignment	Social proof; emotional engagement	Trial; repeat purchase	Influencer ER; conversion rate
AI-enabled personalization	Green recommendations; waste-aware offers	Relevance; perceived value	Satisfaction; retention	CTR; retention rate
Climate/energy actions	RE share; emissions disclosure	Authenticity; value congruence	Brand equity; loyalty	RE %; emission intensity

This table 2 operationalizes the integrative sustainable process by linking concrete practices (e.g., ethical sourcing, eco-packaging, transparency, storytelling, partnerships, influencers, AI, climate action) to psychological mediators (authenticity, transparency belief, value congruence) and measurable outcomes (trust, satisfaction, loyalty), specifying practical KPIs for empirical testing and managerial evaluation.

4.1.2 Ethical Sourcing and Fair Trade

Our desire is to get ingredients from places that will benefit workers, communities and advocacy for fair labour. The suppliers we partner with are those whose employees have the rights to their employees, who pay employees reasonable wages, ensure that safety measures are in place at the workplace, those farmers and producers who use environmentally friendly activities in farming and production of foods. Most food and beverage companies can chop and change their suppliers that are certified by Fair Trade or an equivalent body to ensure customers that unrefined materials are sourced sustainably [28]. Some of the ethical considerations include Respect to local people and the physical world. Ethical sourcing for the furnishing industry may well be considered as being a process that enables firms to become socially acceptable, and customers who wish to acquire their products may do so with a certain amount of sensibility.

4.1.3 Transparent Supply Chain Practices

Today, food and drink customers demand greater transparency in the food and drink industry. Customers want to know how food is processed and its journey from the farm to the fork. Part of supply chain practices, which reveal openly about sources, manufacturing processes, working conditions, and environmental standards, form what defines transparency [29]. For instance, some companies employ technological devices like blockchain, which guarantees a proper tracking record with high precision, thereby giving the customers clear details on the source of their purchases. In general, customers have more faith and confidence in companies that are transparent and honest about their supplier networks. Therefore, this factor is crucial in developing trust and eliminating green washing, by which firms pretend to implement more extensive sustainability measures than they do with no noticeable change in their operations.

4.1.4 Eco-Friendly Packaging and Waste Reduction

The greatest challenge facing the food and beverage sector is waste originating from packaging since single-use plastics are also producers of litter. Alternative solutions are biodegradable,

compostable, or recyclable and ensure that they have minimal contributions to the destructive effects on the environment. The company can make some customers come to collect containers to be refilled as it transitions into reusable or minimal packaging [30]. Other ways food waste can be reduced are "imperfect" vegetables or extras given at food. Brands can attract environmentally conscious customers who are bothered by plastic pollution in the environment by making a focused effort to reduce waste through eco-friendly packaging. It may reduce the cost of the packing material and be more in line with the ideals of the customers.

4.1.5 Health and Wellness in Sustainable Marketing

Health and wellness go hand in hand with sustainable marketing. Based on their knowledge, customers associate sustainable products with better health, fresher ingredients, and better quality. Hence, health-conscious consumers might be attracted to organic, non-GMO and additive-free products. Organizations sell gluten-free, vegan and plant-based products as healthier and greener [31]. Companies appeal to environmentally conscious and health-sensitive consumers by integrating health and wellness into sustainable marketing. This is an element that could increase a brand's reach and enhance its wellness image.

4.1.6 Community Engagement and Social Responsibility

Community involvement and corporate social responsibility dealt with social issues and, therefore, involved giving back to local communities. It could be in the form of helping local farmers, creating employment in poor areas, or financing community initiatives. Socially responsible companies take on charitable causes, sponsor local events, and contribute a percentage of their profits to environmental or social causes [32]. Brands earn credibility and customer loyalty when they truly care about people and their communities. In the approach of sustainable marketing, community involvement is one of the strongest tools as it reveals the brand's concern for more than just selling products.

4.2 Research Methodology and Data Collection

To validate the Integrative Sustainable Process Model, this study utilized a primary survey involving 90 participants, ensuring a balanced gender distribution of 50% male and 50% female. The methodology employed a convenience sampling approach focused on digitally native and environmentally conscious demographics, specifically targeting Gen Z (40%), Millennials (33.3%), and Gen X (26.7%) consumers. Data was gathered through a structured questionnaire designed to evaluate trust, loyalty, and perceptions of sustainability practices. Participation was strictly voluntary, with informed consent obtained from all individuals to

ensure ethical compliance for this non-clinical academic survey. The resulting data were analyzed using descriptive statistics and Pearson's correlation to quantify the relationship between brand trust and consumer loyalty.

5. Results

A total of 90 respondents participated in the survey, with 50% male and 50% female respondents. Age group breakdown was heavily weighted on younger consumers with 40% being Gen Z (ages 18-24), 33.3% Millennials (ages 25-40), and 26.7% Gen X (ages 41-56) consumers. Therefore, this survey represents a very good coverage of the young generation, as well as the environmentally conscious and digital native's generations, especially Millennials and Gen Z. This helps create the necessary context to understand the behavior trends in terms of trust, loyalty and engagement with initiatives of sustainable branding.

Table 3. Demographic Distribution of Survey Respondents (N = 90)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Age Group	Gen Z	36	40.00%
	Millennial	30	33.30%
	Gen X	24	26.70%
	Total	90	100.00%
Gender	Female	45	50.00%
	Male	45	50.00%
	Total	90	100.00%

Table 3 provide the information on distribution of our sample (N = 90) and we can see that the dispensing to the young consumers value-oriented, since Generation Z (40%) and Millennials (33.3%) prevail among the respondents. In contrast, Gen X accounts for 26.7% of the respondents with different perspectives than younger marketers. The gender mix is even and, as such, 50% males and 50% females will offer more insights in both segments. These demographics also support findings of this study as they are the main target market in the food and beverage sector for sustainability strategies. Age and gender are very good ways to ensure that findings are well-balanced and representative of current consumer behaviour trends.

Table 4. Sustainability Factors and Consumer Response analysis (N = 90)

Variable	Category/Range	No. of Consumers	Avg. Trust Score (1–5)	Avg. Loyalty Score (1–5)	Avg. Authenticity Score (1–5)	Avg. Storytelling Engagement (1–5)	Key Insight
Eco-Label Awareness	Yes	72	4.6	4.6	4.7	4.5	Strong driver of trust and loyalty

	No	18	2.1	2.2	2.1	1.9	Lack of awareness weakens brand connection
Storytelling Engagement	High (4–5)	65	4.7	4.6	4.8	4.9	High storytelling boosts authenticity & trust
	Low (1–2)	15	2	2.2	2.1	1.8	Low engagement yields poor perception
Age Group	Gen Z	36	4.8	4.7	4.8	4.9	Most loyal and sustainability-aware demographic
	Millennial	30	4.4	4.5	4.5	4.3	Strong support for ethical and wellness values
	Gen X	24	1.9	2.1	2	1.8	Least responsive to sustainability marketing
Purchases Sustainable Brands	Yes	75	4.6	4.6	4.7	4.6	Indicates alignment between values and loyalty
	No	15	1.8	2	1.9	1.7	Reflects trust gap and perception issues
Top Purchase Driver Mentioned	Ethics/Values	49	4.8	4.7	4.8	4.7	Most influential purchase motivation
	Health/Wellness	40	4.6	4.5	4.6	4.4	Strong association with sustainable product loyalty
	Eco-Friendly Packaging	38	4.5	4.4	4.5	4.3	Strong packaging impact on loyalty
	Price-Driven	25	2.1	2.2	2.1	2	Price-sensitive group less influenced by values
	Peer Influence	20	4.3	4.4	4.3	4.5	Strong effect in Gen Z; amplifies sustainability
Brand Loyalty by Trust Level	High Trust (4–5)	68	—	4.7	—	—	High trust leads to high loyalty
	Low Trust (1–2)	22	—	2.1	—	—	Trust is crucial for repeat purchase

Table 4 is the cross-tabulation, showing the association between key sustainability marketing variables and consumer responses. It is one of the other key findings that the trust, loyalty, and authenticity scores of consumers who are aware of the Eco-label are much-much higher as compared to the consumers who would remain ignorant of the Eco-label. The results obtained clearly show the effectiveness of storytelling; people with high level of engagement experience an increase in trust (4.7) and feeling of authenticity (4.8) and this confirms the strength of narrated marketing. The most receptive group to all dimensions is (not surprisingly) Gen Z, with higher scores around the board; while Gen X is quite barely receptive. Consumers conscious of ethics, health, and eco-friendly packaging appear to be the most loyal, while price-

sensitive shoppers exhibit the least emotional engagement with sustainable brands. Stronger evidence is the correlation between trust and loyalty- consumers with high trust variables rate average loyalty at 4.7, suggesting that gaining trust through sustainability initiatives is of paramount importance to achieving long-term brand commitment.

Table 5: Correlation Analysis of Brand Trust and Brand Loyalty

Correlation Matrix			
		Brand Trust	**Brand Loyalty**
Brand Trust	**Pearson's r**	—	
	df	—	
	p-value	—	
Brand Loyalty	**Pearson's r**	0.918	—
	df	88	—
	p-value	<0.001	—

In Table 5, Correlation analysis shows a strong positive correlation between brand trust and brand loyalty with a Pearson correlation coefficient of ($r = 0.918$). It implies that the more the consumers tend to trust a brand, the more their loyalty will increase. With a high value close to one, this indicates an almost perfect linear relationship. The results obtained were statistically significant, yielding a p-value of less than ($p < 0.001$), implying that the correlation is unlikely to have occurred by chance. The degrees of freedom ($df = 88$) correspond to the sample size of 90 respondents used in the analysis ($df = N - 2$). Overall, it suggests that trust-building in a brand is probably a key determinant of customer loyalty. If companies are interested in driving loyalty, they should start working on trust enhancement strategies because these two factors are closely related and significantly correlated in the sample studied. This strong dependency further indicates that efforts to build trust are very relevant for long-term customer retention.

6. Discussion:

6.1. Implications for Sustainable Process Design

Food and beverage companies are coming up with novel ways to communicate social and environmental responsibility to sustain the consumer's urgency for sustainability. Consumers in today's market require real stories, evidence of moral actions, and interactive forms of

engaging with the business. Businesses have now started to employ these innovative strategies to introduce variations in their sustainability programs, as illustrated in Figure 1.

6.1.1 Digital Storytelling and Transparency

Digital storytelling allows organizations to present their sustainability story in an engaging way. Organizations can tell the stories of their products through social networks, blogs, movies, and brand websites, explaining the process of sourcing materials, manufacturing, and how their operations effect the environment and societies [33]. A brand can develop a documentary series that takes its audience to farmers, production sites, and sustainability work. These stories educate and emotionally connect people to a company that has the same ideologies. Consumers want to see real human faces behind a company, and digital storytelling can reveal people with their points of view.

A good and bad report on sustainability achievements and challenges enhances consumer confidence [34]. Companies must create brand relevance and show appreciation for climate through their sustainability story revealed through digital storytelling.

6.1.2. Leveraging Certifications and Eco-Labelling

Certifications and eco-labels such as Fair Trade, USDA Organic, and Rainforest Alliance allow customers to identify products that meet established environmental or ethical standards, increasing trust and reducing greenwashing [35]. It helps customers make decisions about sustainable products by simply showing them and does not require any comprehensive investigation. In addition, most companies design their own sustainability labels or work with national certification bodies and disclose their adherence to existing standards along with developing new ones. Publicly showing eco-labels helps firms to attract environmentally concerned customers who wish to have clear markers of sustainability.

6.1.3. Collaboration with environmental organizations

Organizations such as the World Wildlife Fund or Ocean Conservancy serve as environmental partnerships that increase the legitimacy of sustainability of the brand. Collaborations indicate that beyond the company's profitability, there are financial gifts and environmental programs such as garbage removal and tree planting [36]. Those consumers who think that companies

should engage in environmental issues support these activities, indicating the truth behind corporate brand messages above the call of marketing.

6.1.4. Sustainable Influencer Marketing

Today, the food and beverage industry use the influencer marketing platform to promote sustainability. Here, brands partner with influential personalities who are environmental caretakers. The sustainable practice of brands will then be communicated to their followers, hence gaining confidence and trust [37]. To do this effectively, one should consider finding influencers who believe in sustainability. This is because their audience should resemble and believe in the values of the brand. In this case, an organic snack brand manufacturer can work with a dietitian or activist that highlights the ways that using this item is compatible with the eco way of life, and that active followers should make sustainable choices. This allows companies to reach new demographics and increase their dedication to sustainability.

6.1.5. Interactive Content can Engage Consumers

Interactive content like virtual tours, online quizzes, social media contests, etc. can be used effectively by a brand to engage with customers and teach them about sustainability initiatives. It is argued that this approach makes sustainability memorable and intimate in that it gives us a closer connection [38]. For instance, a coffee company will provide a quiz on how the environmental choice of coffee affects the surrounding environment or take their customers on virtual field tours to showcase a particular sustainable farming technique. By building immersive experiences, brands can make sustainability promises and know how to strengthen their bond with customers.

6.1.6. Sustainability Focused Loyalty Programs

Pro-environmental behaviour and brand loyalty are achieved by loyalty programs that encourage sustainable behaviours. Brands are using rewards such as rewards for consumers that promote recycling packaging to compensate, by using green delivery options, or even simply purchasing green instead of simply purchasing regular [39]. Customers are able to redeem their points by bringing back their packaging or for buying green products for the returns of sustainability, such as a discount, a contribution for the ecological programs or a tour of an agriculturist experience. This is a tactical approach that, while boosting sales, also reinforces the brand's commitment to the environment and strengthens the relationship with the customers by making a value-based distinction.

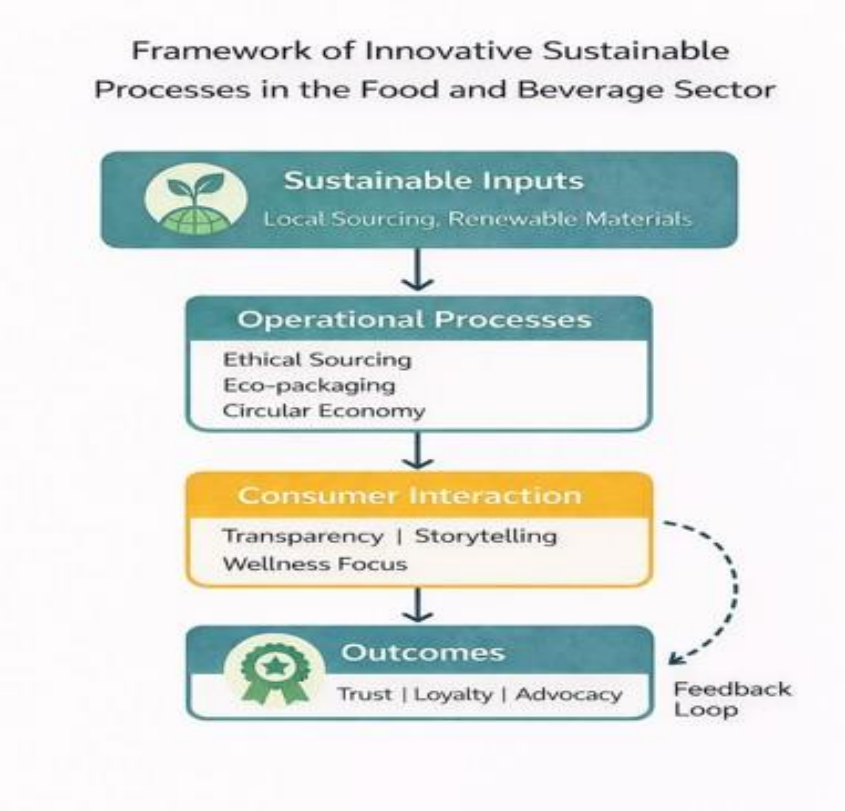

Figure 1.Framework of Innovative Sustainable Processes

As highlighted in the figure above, the food and beverage industry brands identified the establishment of continuous integration of ethical sourcing, eco-packaging, digital transparency, and consumer engagement which led to brand allegiance.

Table 6. Comprehensive Sustainability Marketing Components in the Food and Beverage Sector

No.	Sustainability Marketing Component	Description	Examples / Practices	Expected Consumer Impact
1	**Ethical Sourcing**	Fair labour, humane practices, and environmentally responsible procurement.	Partnering with Fair Trade or Rainforest Alliance certified suppliers.	Builds ethical trust; appeals to socially responsible buyers.
2	**Eco-Friendly Packaging**	Use of biodegradable, recyclable or reusable packaging.	Compostable cups, reusable jars, minimalist labelling.	Reduces environmental guilt; improves brand perception.

3	**Digital Storytelling**	Sharing the sustainability journey through narrative-driven content.	Instagram videos and blogs showing supply chain transparency.	Creates emotional resonance; increases brand authenticity.
4	**Transparency in Supply Chain**	Clear disclosure of sourcing, labour, and production methods.	Blockchain traceability, origin labelling.	Increase consumer confidence; combats greenwashing.
5	**Sustainability-Focused Loyalty Programs**	Rewarding environmentally friendly customer behaviours.	Points for recycling, discounts for green purchases.	Drives loyalty; promotes repeating sustainable actions.
6	**Health and Wellness Alignment**	Positioning sustainable products as healthier choices.	Organic, gluten-free, non-GMO, additive-free foods.	Attracts health-conscious consumers; increases product desirability.
7	**Community Engagement**	Support local producers and social causes.	Donations, farmer partnerships, local hiring.	Build emotional connection; promote brand loyalty.
8	**Influencer and Social Media Campaigns**	Partnering with sustainability advocates to promote values.	Collaborations with eco-bloggers and chefs.	Expands brand reach; enhances credibility through social proof.
9	**Green Certifications and Eco-Labeling**	Third-party validation of sustainable efforts.	USDA Organic, Carbon Neutral, Fair Trade Certified labels.	Build trust; helps consumers make informed choices.
10	**Circular Economy Practices**	Resource reuse, recycling, and waste minimization.	Returnable bottles, upcycled ingredients, zero waste policies.	Strengthens brand responsibility image; attracts eco-aware consumers.
11	**Plant-Based Product Innovation**	Developing environmentally low-impact, animal-free alternatives.	Vegan snacks, dairy-free beverages, plant protein-based meals.	It aligns with environmental and ethical food choices.
12	**AI and Data-Driven Sustainability**	Using data analytics to optimize sustainable operations.	Demand forecasting, waste reduction, personalized green marketing.	Enhances operational efficiency and personalization.
13	**Climate Action Commitments**	Public commitment to carbon neutrality or reduction.	Carbon offset programs, renewable energy sourcing.	Differentiates the brand as environmentally responsible.
14	**Sustainable Innovation and R&D**	Investment in eco-product and process innovations.	New biodegradable materials and water-saving processes.	Establishes leadership; appeals to early adopters.
15	**Customer Education Campaigns**	Information to consumers about the sustainability impacts of their choices.	Infographics, social media tips, and product footprint disclosures.	Empowers conscious consumption; strengthens customer-brand alignment.

The fifteen elements referred to in table 6 above are the core pillars of sustainability marketing that are being steadily gaining traction in the food and beverages industry. These factors call

for a shift in the traditional notion of how product advertising can assume the nature of value-based strategies which would emphasize crucial concerns such as the celebration of ethics, environmental awareness, health awareness, consumer empowerment, etc. As well as the impacts that this can have on the consumer; improved trust, perceived authenticity, and loyalty, on the basis of which marketing effort is based, can legitimately be described as a behaviourally sustainable practice. Together these options offer a very flexible yet potent toolkit for brands to adapt to consumer expectations as they continue to evolve, whilst at the same time further establish themselves as responsible and future facing leaders in the market place.

6.2. Influence of sustainability marketing on buying behavior

Consumer preferences: How sustainability marketing affects consumer preferences

Sustainability marketing is directly connected to the customer's preference via the merger of brand value and the ones that are sustainable. It restores the perceived image of a company by reassuring consumers that brand is aware of its ethical and environmental issues. Of equal path-breaking importance, it also appeals to all consumers which are environmental-aware and develop enduring consumer-consumer relationships. In order to empirically evaluate the influence of sustainability marketing on consumer preferences, the proposed measurement blueprint identifies constructs, validated scales/operational proxies, exemplar items and potential data sources. It turns the proposed mechanisms, namely authenticity, belief in transparency, congruence value, perceived quality and emotional engagement, into measured variables and relate them to behavioral outcomes such as trust, satisfaction, loyalty, advocacy, repeat purchase, and willingness-to-pay premium. This structure enables comparable studies and managerial dashboards aligned with the model.

Table 7. Measurement Blueprint for Validating the Sustainable Process Model

Construct	Definition	Recommended scale/metric	Example item or metric	Suggested data source
Transparency belief	Degree to which disclosures are perceived as clear and credible	5- or 7-point Likert multi-item	"This brand is open about its sourcing."	Consumer survey; website audit
Perceived authenticity	Perception that sustainability is genuine and embedded	Validated brand authenticity items	"This brand's sustainability is sincere."	Consumer survey
Value congruence	Alignment between brand values and consumer values	Value congruence scale	"This brand reflects my environmental values."	Consumer survey

Emotional engagement	Affective connection prompted by storytelling	Narrative engagement scale	"I felt connected to the brand's sustainability story."	Consumer survey; social analytics
Trust	Willingness to rely on the brand's integrity	Brand trust scale	"I trust this brand to do what is right."	Consumer survey
Satisfaction	Overall evaluation of brand experiences	CSAT index	"Overall, I am satisfied with this brand."	Consumer survey; CRM
Loyalty	Intention and behavior to repurchase/recommend	Behavioral + attitudinal	Repeat rate; "I intend to buy again."	Sales/CRM; survey
Advocacy	Willingness to recommend and defend	NPS; referral rate; UGC	NPS score; referral conversions	CRM; social analytics
WTP premium	Price premium attributable to sustainability	% premium vs. baseline	"Max price willing to pay with eco-packaging"	Conjoint/A/B test
Transparency coverage	Scope of traceable suppliers/products	% SKUs traceable	Share of SKUs with traceability codes	Internal audit
Eco-packaging intensity	Extent of sustainable packaging adoption	% recycled/compostable content	Average recycled content per SKU	Packaging specs
Emission intensity	Operational climate impact	tCO2e per unit revenue/volume	Scope 1–2 intensity; RE %	Sustainability reports

This table 7 defines each construct, recommends validated scales or operational metrics, and lists example items and data sources. It enables rigorous, replicable measurement of mediators (e.g., authenticity, transparency belief), outcomes (trust, satisfaction, loyalty), and operational indicators (traceability, recycled content, emissions), supporting hypothesis testing and managerial performance tracking.

6.2.1. Factors Influencing Consumer Purchase Behaviour

Sustainability identified the one of the factors where consumers choose each product in the food and beverage market. The impact of sustainability factors creates the impact on consumer purchase behaviour most significant and increasingly prioritize ethical alignment, transparency, and environmental responsibility on food & beverage brands. The sustainability-driven marketing approaches which includes; "digital storytelling, eco-labelling, AI-based personalization, and climate-action branding" have some advantages. These techniques will improve the perceived "authenticity, enhance emotional engagement, and long-term loyalty among the consumers. The new directions and integration bring the real time footprints and the

advancement of AI-enabled technology, hyper-personalized sustainability and circular economy practices such as; reusable packaging systems and product take-back programs [40].

Several factors push the demand for sustainable products up. These include individual values, social effects, and increasing awareness of global challenges such as waste pollution and climate change.

6.2.1.1. Personal Values and Ethics

Most consumers consider that the various things they buy hold their values, such as animal welfare, fair labour, or environmental protection. The differences made in such purchases will be considered when a consumer buys from a business that shares these values [41]. Environmental activists, for example, can look for companies that use sustainable packaging on its products or reduce waste. Customers and companies whose values intersect develop stronger bonds because of such an ethical agreement.

6.2.1.2. Social Influence and Community Norms

Friends, family, and information shared through networks on the Internet play a big role in the kind of products consumer's purchase. The purchase of sustainable items by other people motivates buyers to join a good cause. Reviewers use Twitter to advertise the adoption of environmentally friendly products, thus increasing demand for green products [42]. Over time, there is pressure to embrace sustainable practice and make what are regarded as 'reasonable choices', as others do.

6.2.1.3. Perceived quality and health benefits

Usually, consumers link sustainable products to good quality and health benefits. For the consumer, "organic" and "plant-based" are a guarantee of quality and safety. People believe that plant-based or eco-friendly products do not harm nature or humans, and they believe that sustainable products comprise harmful chemical-free products or pesticides [43]. With this thinking, consumers should choose sustainable products since they are somewhat cheaper.

6.2.1.4. Trust in Brand Transparency

Transparency is very important in the marketing of sustainability. Customers are likely to trust firms that are transparent about manufacturing, sourcing, and third-party certifications. When organizations are transparent about their progress and challenges, they give customers the assurance that they take authenticity and not mere marketing seriously [44]. On the other hand, vague or misleading claims (which sometimes appear as "greenwashing") are a threat to

consumer trust and lead them to search for other organizations they perceive as actually being sustainable.

6.2.1.5. Convenience and accessibility

Consumers also care more about the convenience they need or want regardless of the value system. Thus, products that are sustainable, easily available in retail stores, are properly and prominently labelled and are not very costly seem to be much more attractive. Manufacturers who offer green goods with less concern and effort to consumers prompt responsible customers with convenience [45]. Due to this, the larger population is more engaged in sustainable practices and factors influence Sustainable consumer behavior, as shown in Figure 2.

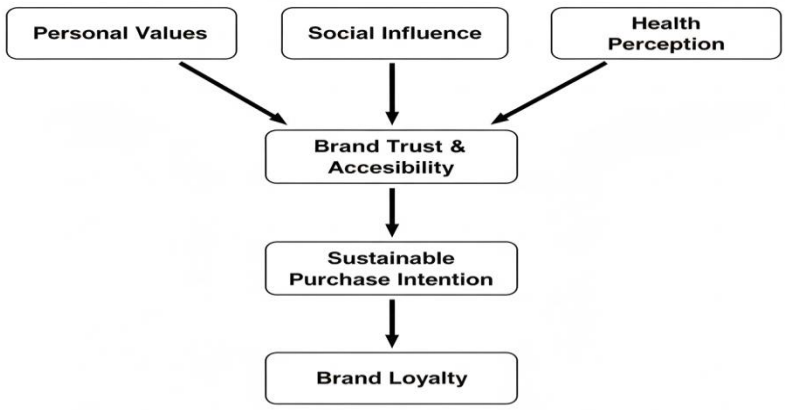

Figure 2. Conceptual Model of Factors Influencing Sustainable Consumer Behaviour

Conceptual model illustrating how personal, social, and perception factors influence sustainable purchase intention and ultimately lead of brand loyalty in the food and beverage sectors.

6.2.2. Case studies of successful brands

Several food and beverage companies have employed a sustainable marketing strategy to impact the target market. Such companies market themselves among value-conscious customers based on their environmental and social issues. This beautiful cup of coffee is founded on fair beans and ethical employment practices. The transparency of the brand and its direct connection with farmers have made it a preferred brand among customers concerned

with fair trade and sustainability [46]. It makes it appealing, really, with customer connection to the brand's narrative and to its commitment to ethical sourcing.

6.2.3. Consumer Perceptions of Authenticity in Sustainability Claims

Authenticity is extremely important in sustainable marketing because consumers are generally able to tell between a company that is truly vested in the cause and one that is just green washing-that is making big statements without actually doing anything [47].

6.2.4. The Role of Brand Loyalty in the Food and Beverage Sector

The food & beverage industries focus consumer brand loyalty and repeat purchase with the help of word of mouth [48]. Today consumers aware on the brands with principles which includes; “environmental and social responsibility” [49]. The use of sustainability marketing consumer is aware on purchasing and their choices which create a positive impact on society and emphatically targets customers [50].

6.2.5. Strategies to Foster Loyalty through Sustainability

Companies employ many different tactics that are relevant to sustainability to create identification of culturally appealing options while maintaining customer relationships. As shown in Figure 3, here are a few effective strategies to consider:

- **Sustainable loyalty programs:** Many businesses have established loyalty schemes to incentivize customers to adopt sustainable practices. The customer can convert the various other points gained for discounts, rewards that promote environmental activism, or donations to environmental groups. Such programs reinforce sustainable practices and give customers an extra reason to continue patronizing the business [51].
- **Emotional Connections through Purpose:** Strong brand loyalty has been realized whenever customers perceive their purchase as assisting a larger cause [52]. An example is a business that plants a tree every time a purchase is made; thus, customers perceive a contribution to the environment. This sense of purpose thus deepens relationships and converts consumers into brand ambassadors.
- **Exclusive access to eco-friendly products:** Several companies create brand loyalty by offering limited-edition eco-friendly products or exclusive access to the company's own sustainable product lines. For example, members could be offered exclusive discounts on green goods through a loyalty program or even early access to newly developed and

added sustainable products. This creates sustainable solutions but returns faithful clients by letting them feel appreciated and part of an exclusive group.

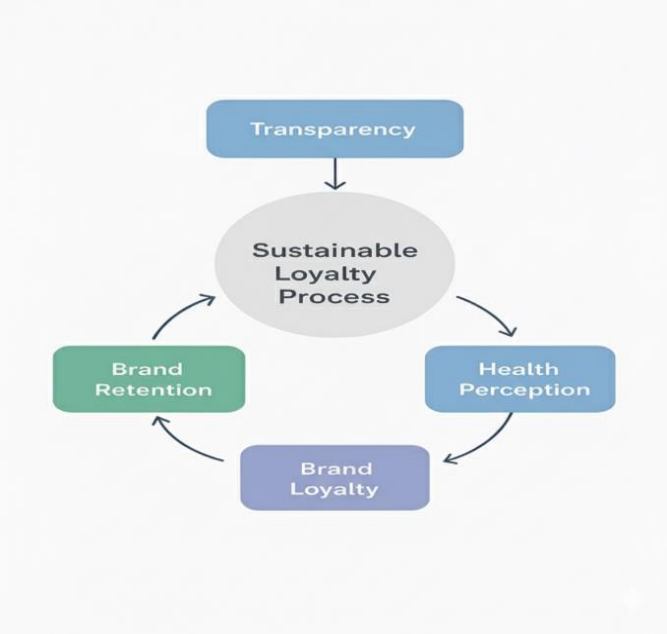

Figure 3: Circular feedback model of strategies for sustainable customer loyalty.

6.2.6. Emotional Connection and Brand Advocacy

Sustainability marketing can turn loyal customers into brand champions, those who are not only loyal to the organization but become advocates of the organization that promotes it to others. If consumers are emotionally connected to a brand, they are likely to express its purpose to their friends and family [53]. Brand advocacy is therefore more effective than traditional marketing because word of mouth through personal recommendation is more powerful and convincing than even advertising or any other marketing activity. Brand advocacy has also gained more ground through social media because dedicated consumers are able to publicly share their support for a company [54]. The brand will attract more customers when a consumer, for instance, shares nice experience with an eco-friendly product or blogs about what the company is doing to be sustainable. Brands easily promote this advocacy and give consumers the opportunity to share the message with others by using easy hashtags or social media challenges that publicize their sustainability efforts.

6.2.7. Measurement of brand loyalty in sustainability initiatives

In this case, brands must employ suitable indices to describe customer contact and their level of satisfaction with the purpose of mirroring the impact of sustainability marketing on reputation loyalty. The following are key metrics to measure brand loyalty:

- **Repeat Purchase Rate**

If repeat sales from eco-conscious clients increase, firms should experience more repeat-purchase rates. Metrics that reflect how often customers make repeat purchases reflect the firm's performance in maintaining loyal customers.

- **Customer Feedback and Surveys**

Companies usually collect information from consumers about what they value the most in the company. This includes feedback on sustainability projects that the company is running. In this regard, brands may determine customer happiness by asking consumers how important the company's sustainability initiatives are to their loyalty based on a survey.

- **Social Media Engagement**

Activities such as social media shares, comments, and mentions can reveal the extent to which customers will be advocates for their brand. Many times, when customers are interacting with the sustainability postings frequently, then it will be possible to infer that these customers are happy with the green activities being conducted by the company.

- **Net Promoter Score (NPS)**

NPS calculates the probability of a customer spreading the word of a brand. The chance of customers promoting and talking positively about a brand is high if they believe that a particular brand is good for the environment. This improves the brand's NPS score.

7. Challenges in Implementing Sustainability Marketing

Although sustainable marketing has the merits outlined above, food and beverage companies still face the challenge of making such strategies believable and effective. Brands are challenged from keeping costs in balance to maintaining open communication. It involves deep thinking and innovation in planning.

7.1 Balance of profitability with sustainable practices

The greatest conflict between profitability and sustainable practices is in the cases of sustainable sourcing, eco-friendly packaging, and energy-efficient production, where there are

more costs involved. These can be difficult for small brands to incur or even recover from their customers, making their products less competitive in the marketplace [55]. Cost efficiency in line with sustainability goals is the only key to long-term success.

The sustainable practices often focus on forthright costs and eco-friendly materials such as; “renewable energy systems and ethical sourcing schemes”. On the other hand, industry faces the different challenge which may be like; cut down the cost, short-term profitability and create pricing disadvantages in competitive markets. The study analysis on the different factors of financial performance improves when sustainability initiatives build customer trust and brand loyalty, ultimately increasing willingness to pay premium prices (Sharma et al., 2024).

7.2 Overcoming Green washing Accusations

Consumer Trust: Green washing one of the processes where exaggerating sustainability practices deceiving - has an erosive effect on consumer trust [56]. The success of communication & failure fosters the consumer trust and commitment. Green in sustainability marketing where consumers become more skilled. Therefore, consistent disclosure of progress, challenges, and factual metrics is essential for overcoming scepticism and strengthening brand integrity.

7.3 Educating and Engaging Consumers

The carbon footprint and ethical sourcing become familiar in the customers. It can make teaching a customer about sustainability and the practices if the food service industry [57]. Brands play an important role in the consumer life and also explain the importance and accessible manner through real examples. The usage of small clips of videos in the social media in graphics information may engage customers and help them better understand their choices and the implications. Consumers understanding of concepts of carbon footprint, circular economy and supply chain ethics, which reduces their ability to judge sustainability claims. Now a day’s consumer likening the QR-based traceability techniques in assessing the menu and for online payment [58].

7.4 Adapting to changing regulations

The governments and regulatory bodies have different rules & regulations which focus on sustainability which includes; carbon emissions and bans on plastics. Brands, meanwhile, must react quickly in the face of changing laws, and operational changes can often be quite costly [59]. The regulatory changes in financial and administrative pressure on companies, requiring them to redesign operations, modify packaging, and update compliance protocols.

8. Future Trends in Sustainable Marketing in the Food and Beverage Sector

This paper will unveil the expectations of consumers, changes in technology, and increased emphasis on ethical issues in the marketing of sustainable foods and drinks. The following are the most significant trends that cause this shift.

8.1 Advances in Sustainable Food Technology

New advances in food production related to emerging technologies in lab-grown meat, plant-derived proteins, and precise fermentation are gaining momentum today. Such new alternatives provide sustainable solutions with lower resource requirement and emissions [60]. Lab-grown meat requires much less water and land than traditional cattle, while plant-based diets provide nutritional alternatives with a lower environmental impact. Therefore, companies can highlight these advances in their sustainable marketing efforts as alternatives gain momentum.

8.2 AI and Data Analytics for Sustainable Optimization

Companies can advance sustainability by streamlining supply chain hassle, reducing waste levels, and personalizing customer experiences through AI and data analytics. Through AI-driven demand forecasting, companies reduce enterprise overproduction, as well as food waste. Through data analytics, companies can be transparent about environmental impacts [61]. AI and data can ensure that marketers personalize messages and explain to customers how every purchase affects the environment, thus building trust and engagement.

8.3 Climate action and carbon neutrality

With the increasing adoption of aggressive carbon neutral or carbon negative goals by more companies, climate action is becoming an activity well sought after for sustainability marketing. Carbon neutrality, as coined by [62], is defined as the activities pursued that would eliminate emissions by investments in renewable energy or reforestation; carbon negativity seeks to remove more carbon it emits. Sustainability marketing and buying are strongly drawn to brands using tangible means to achieve these goals. Explicit labelling, such as "carbon neutral product," allows customers to make informed choices; therefore, it increases brand loyalty.

8.4 Circular Economy Initiatives

The recovery, reuse, and rejuvenation of resources and products is known as the circular economy, which is becoming more employed. Variable weight packaging, returnable containers, and recycling take-back programs are some of the circular strategies most firms are

employing. Businesses commit themselves long-term to the sustainable management of resources and reducing produced waste through acting in the circular economy systems. The sale of such programs targets consumers who appreciate companies that utilize the closed-loop manufacturing system and those clients who wish to minimize waste.

8.5 Local Sourcing and Shorter Supply Chains

Customers are opting for firms that have sources for sourcing locally produced products to help develop local economies. Local sourcing ensures fresh food, reduces transportation-related emissions and helps the local economy. Furthermore, local supply chains involve more transparency that customers also value in searching for where their products come from [63]. Brands can attract customers who are concerned about sustainable, community-driven initiatives and develop legitimacy by having them show their sources as local in their marketing.

8.6 Social Responsibility and Fair Labor Practices

Besides environmental concerns, consumers care about social responsibility, for example, fair wages and healthy working conditions for the workers. Branding campaigns today are more focused on ethical sourcing, fair trading, and support for small-scale producers [64].

9. Novelty of the study

While there might have been similar studies in regards to green branding or ethical sourcing, this study is unique as it seeks to bring together all different types of sustainable marketing activities into one strategic umbrella ranging from digital storytelling, eco-packaging, to AI-analytics and climate action. In contrast to previous authors who have paid more attention to consumer behavior or corporate responsibility in general, we put specific importance on the bridging of emerging sustainability practices and long-term brand loyalty and consumer trust. The paper also throws light on sustainability-oriented loyalty programs, an underdeveloped literature in the F&B marketing body of knowledge.

In addition to combining theoretical discourse with real case studies and examples, performance mapping and implementable frameworks, this article can work as a practical guide for scholars and practitioners. Whereas tables and figures display the visual representation of sustainability strategies and their impact paths, this is an unconventional way of mapping that has not been done in previous reviews; such innovation adds uniqueness to this section of the review. In general, what is new is the more integrative, multi-disciplinary and future-looking

perspective of how sustainability marketing may develop in aftermarket technologies as well as in shifting towards consumer perceptions in a pandemic-influenced world.

10. Future Research Directions

Future studies could empirically validate the Integrative Sustainable Process Model using quantitative methods such as Structural Equation Modeling (SEM) to test the proposed hypotheses on sustainability-driven consumer behavior. The impact of AI-driven traceability, circular economy practices, and plant-based innovations on consumer loyalty, offering deeper insights into emerging sustainability strategies in the food and beverage industry.

11. Conclusions

This research paper explained how organizations could apply sustainable practices in the design of a product, creating ethics while sourcing, eco-friendly packaging, and transparency by engaging the customer to retain the brand. Firms can engage customers more deeply using techniques such as digital storytelling, eco-labelling, partnerships with environmental groups, influencer marketing, and sustainability-oriented loyalty programs. The crucial challenges a firm encounter in implementing sustainable marketing include "strategic, complexity in managing supply chains, keeping expenses under control, and away from greenwashing. “However, brands can easily overcome all these threats and express their efforts in creative strategies. The sector is also transforming due to future themes in sustainability, for instance, developing technology for food, artificial intelligence and data-driven insights, climate action, principles of circular economy, and local sourcing. As these trends are huge promises of ethically open business practices, sustainability will be vital for businesses that need to remain competitive. In fact, sustainability has become the best part of modern business and not an option in the food and drinks industry. Sustainability marketing's role in shaping a healthier and more sustainable future will certainly remain resourceful tool in the market evolution for businesses.

List of Abbreviations:

- USDA- United States Department of Agriculture
- F&B- Food and Beverage
- GMO- Genetically Modified Organism
- FMCG- Fast-Moving Consumer Goods
- AI- Artificial Intelligence

Availability of Data and Materials

The data in the research were obtained from authors through a questionnaire survey. All summarized data that support the conclusion of this work are presented in the article (Table 3 and 4). The additional dataset file can be obtained from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

This study was conducted in accordance with ethical principles for research involving human participants. As it was a non- clinical, academic survey involving adult participants, formal ethical approval was not required under the guidelines of SR University, Ananthasagar, Hasanparthy, Warangal- 506371, Telangana, India. A formal ethics approval protocol code was not applicable under institutional policy for non-clinical academic surveys.

Participation in the study was entirely voluntary, and Informed consent was obtained from all participants prior to data collection. Respondents were assured of anonymity, and their responses were used solely for academic purposes.

Author Contributions

Conceptualization, Methodology, Software, Investigation, Data Curation, Draft Writing: Roshan Kumar Shiva; Supervision, Project Administration, Validation: Geetha Manoharan; Validation, Formal Analysis, Resources, visualization: Sanjeev Kumar; Formatting, References, Review Editing: A. K Haghi. All authors have read and agreed to the published version of the manuscript.

Consent for publication

Not applicable

Conflicts of Interest

The authors state that they have nothing to indicate any conflict of interest regarding this manuscript.

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Figures 1-3 were created using the NAPKIN AI tool.

The authors confirm that no portion of the manuscript text was generated using any AI tool.

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