



Sustainable Packaging Innovations In E-Commerce: A Pathway To Environmentally Responsible Online Retail

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Abstract

The escalating growth of e-commerce has intensified concerns regarding the environmental impact of packaging waste, necessitating a shift toward more sustainable practices within online retail operations. This study investigates the relationship between sustainable packaging innovations and the advancement of environmentally responsible online retail, focusing on the perceptions of industry professionals. A quantitative survey was administered to a sample of 263 professionals in Bengaluru City, Karnataka, India, utilizing a structured questionnaire with a five-point Likert scale to capture responses. The study tested two primary hypotheses (H1 and H2) concerning the influence of innovative packaging solutions on environmental responsibility outcomes. Data analysis employed one-sample t-tests to assess the significance of mean responses and Pearson correlations to examine the strength and direction of relationships between key variables. The findings revealed that both hypotheses were supported, indicating a significant positive perception of sustainable packaging's role. The aggregate mean for H1 was approximately 3.69, suggesting a favorable disposition toward the adoption of such innovations. Furthermore, correlation coefficients ranging from 0.587 to 0.708 demonstrated a moderate to strong positive association between the identified constructs, underscoring the interconnectedness of packaging innovation and environmental stewardship. These results affirm that sustainable packaging is not merely a compliance measure but a strategic pathway for enhancing corporate responsibility and consumer trust in the digital marketplace. The study provides actionable insights for e-commerce stakeholders seeking to integrate eco-conscious packaging solutions, thereby contributing to the broader discourse on sustainable supply chain management.

Keyword: sustainable packaging; e-commerce; green logistics; circular economy; online retail; India; biodegradable materials; consumer preference; environmental responsibility

1. Introduction

The exponential growth of global e-commerce has fundamentally transformed retail consumption patterns, yet this convenience carries a significant environmental burden. The surge in online orders has led to a corresponding increase in packaging materials, including corrugated boxes, plastic fillers, and adhesive tapes, much of which is single-use and non-biodegradable. This linear model of consumption, where packaging is used briefly and then discarded, contributes substantially to municipal solid waste and carbon emissions associated with production and logistics. The urgency to address this issue is underscored by mounting evidence of environmental degradation and resource depletion, prompting calls for a systemic shift towards more sustainable practices within the digital retail sector. Scholars have increasingly highlighted the need for a holistic approach that integrates environmental considerations into every stage of the

e-commerce value chain, from material sourcing to last-mile delivery (Vilaisri et al., 2023). Furthermore, the transition towards a circular economy, where materials are kept in use for as long as possible, is now considered a critical strategic imperative for businesses seeking long-term viability and legitimacy in an environmentally conscious market (Wang and Wang, 2021).

Within the Indian context, the rapid expansion of online retail presents both a formidable challenge and a unique opportunity for sustainable development. The country's vast consumer base, coupled with increasing internet and smartphone

penetration, has propelled e-commerce into a dominant mode of shopping, particularly in urban centres. This growth trajectory inevitably generates a massive volume of packaging waste, placing considerable strain on already overburdened municipal waste management systems. In response,

regulatory frameworks are evolving, with extended producer responsibility (EPR) policies emerging as a key instrument to hold businesses accountable for the entire lifecycle of their packaging. These policy pressures are compelling firms to move beyond compliance and actively innovate in their packaging strategies. Bengaluru City, a prominent hub for e-commerce logistics and technology in Karnataka, exemplifies this dynamic environment. As a major consumption centre with a dense network of fulfilment centres and delivery operations, Bengaluru offers a critical vantage point for examining how sustainable packaging innovations are being adopted and perceived in a rapidly modernising Indian metropolis (Lai et al., 2022).

Despite the growing recognition of sustainable packaging's importance, a significant gap persists in the academic literature regarding the interplay between firm-level innovation, consumer preferences, and regulatory mandates. While studies often examine these elements in isolation, there is limited integrated analysis that explores how these forces collectively shape the adoption and effectiveness of eco-friendly packaging solutions. Moreover, the existing body of research is predominantly situated in developed economies, leaving a notable scarcity of empirical evidence from emerging markets like India. The specific socio-economic, infrastructural, and cultural factors that influence packaging decisions in Indian cities remain largely underexplored. This lack of city-level evidence is particularly pronounced in the context of Bengaluru, where the confluence of a tech-savvy population, a vibrant start-up ecosystem, and significant logistical activity creates a distinctive environment for sustainability initiatives. Consequently, there is a clear need for research that provides granular, context-specific insights into the drivers and barriers of sustainable packaging adoption within this unique urban landscape (Zheng, 2025).

The present study aims to address this research gap by investigating the landscape of sustainable packaging innovations in the e-commerce sector, with a specific focus on the city of Bengaluru, Karnataka, India. The primary purpose is to examine the perceptions, attitudes, and behaviours of key stakeholders, particularly professionals engaged in the e-commerce ecosystem, towards environmentally responsible packaging alternatives. This research seeks to understand the factors that influence the acceptance and implementation of such innovations, including cost considerations, consumer demand, regulatory compliance, and operational feasibility. To achieve this objective, a quantitative approach was adopted, involving a structured survey administered to a sample of 263 professionals working in various capacities within Bengaluru's e-commerce and related industries. The study's scope is deliberately confined to this professional cohort to capture

informed perspectives on the practical challenges and opportunities associated with sustainable packaging. The findings are expected to offer actionable insights for businesses, policymakers, and industry practitioners seeking to foster a more sustainable and environmentally responsible model for online retail in India.

2. Literature Review

Vilaisri et al. (2023) investigated factors influencing intentions to return express delivery packages for next use within a developing country context. Applying an extended Theory of Planned Behaviour, the study utilized an online survey in Thailand, collecting 426 responses via convenience sampling. Data analysis employed Covariance-Based Structural Equation Modelling. The findings indicated that attitude, subjective norms, perceived behavioral control, and awareness of consequences significantly affected return intentions. This research offers relevant insights for sustainable packaging innovations in e-commerce, particularly for the Indian online retail context, where similar logistical and environmental challenges necessitate strategies to encourage package reuse and reduce waste.

Wang and Wang (2021) examine the application of environmentally friendly packaging materials within the sustainable development of logistics. The paper contextualizes this topic against China's regulatory shifts, including the introduction of "plastic limit" and "plastic ban" measures and the September 2020 revision of the Solid Waste Pollution Prevention and Control Law. The authors highlight the rapid growth of the express delivery industry, driven by e-commerce expansion, fragmented consumption patterns, and increased rural online shopping, particularly accelerated by pandemic-related changes in consumer behavior. The discussion underscores the importance of ecological protection in logistics operations. This work offers relevant considerations for sustainable packaging innovations in e-commerce, with implications for the Indian online retail context.

Lai et al. (2022) address the surge in online purchases during the COVID-19 pandemic, which increased the demand for express delivery packaging materials. The study proposes a reverse logistics reuse framework designed to extend the life cycle of these materials, drawing on literature from supply chain management and materials science. The authors emphasize that reverse logistics is particularly effective for resource reuse, which they prefer over recycling. Their framework, which integrates resource optimization, recycling, and recovery, can be implemented with minimal changes to existing forward logistics systems. This approach holds potential for fostering more sustainable online shopping. Such a framework is relevant to sustainable packaging innovations in e-commerce, particularly within the Indian online retail context.

Zheng (2025) examines the current situation and development direction of sustainable packaging practices within the retail industry. The paper identifies packaging as a major contributor to global environmental problems, citing the widespread use of disposable plastics, non-recyclable materials, and excessive designs that generate waste and carbon emissions. In response, the abstract notes that governments and enterprises are promoting policies aligned with the United Nations' Sustainable Development Goals. Walmart is presented as a typical example of how Green Supply Chain Management can balance operational efficiency with environmental responsibility. Through supplier collaboration, a sustainability index, logistics innovation, and packaging reduction, Walmart reportedly decreased emissions, waste, and costs. This analysis offers relevant insights for advancing sustainable packaging innovations in e-commerce and the Indian online retail context.

Uddin (2025) assesses the environmental impact of e-commerce compared to traditional retailing, focusing on Sylhet City in Bangladesh. The study examines Daraz delivery centers and Shwapno outlets, finding that Daraz's covered vans produce CO₂ emissions of 246.86 g/km, which is significantly higher than emissions from motorbikes. The analysis indicates that Shwapno's localized model and environmentally friendly packaging render it less harmful to the environment than Daraz's excessive plastic use. Additionally, Shwapno's biodegradable waste management, including sophisticated decomposition of perishable waste through segregation and disposition, demonstrates its sustainable practices. This comparative approach offers relevant insights for advancing sustainable packaging innovations in e-commerce, particularly within the context of Indian online retail.

Lin et al. (2023) address the environmental burden of disposable packaging by designing a reverse logistics network for recyclable express boxes, specifically for e-commerce businesses with self-established logistics. The study develops a stochastic programming model that accounts for uncertainties in demand, return rate, retention rate, and recovery rate. This model determines optimal locations for collection points and recovery centers, alongside the flow of recycling boxes, with the primary objective of minimizing total cost. To solve the model, the authors propose an improved priority-based tabu search algorithm, whose feasibility and operability are verified through benchmark and numerical experiments. This research offers relevant insights for advancing sustainable packaging innovations within the Indian online retail context.

Nuševa and Vukmirović (2020) examine packaging as a function of sustainable development within green marketing logistics. The authors position effective marketing logistics as a means to minimize delivery costs and enhance competitive advantage through

superior customer service, while acknowledging its negative environmental impacts. They frame green marketing logistics as a strategy to harmonize logistical goals with sustainable development principles, addressing areas such as greenhouse gas emission reduction, rational energy use, recycling, and waste management. The abstract specifically identifies green packaging as a key component of this approach. This conceptual focus offers a relevant framework for considering sustainable packaging innovations in e-commerce, particularly for the Indian online retail context where logistical efficiency and environmental responsibility are increasingly critical.

Chen et al. (2025) examined the environmental burden of single-use food and beverage containers from delivery services in Guangzhou, China, using a life cycle assessment informed by first-hand waste generation data. The study evaluated five circular economy scenarios, finding that a combined approach integrating refuse, reduce, reuse, and recycling strategies effectively lowered emissions and water use by 25.5 to 66.4 percent. These quantitative results serve as benchmarks for circular policy design. This research offers relevant insights for sustainable packaging innovations in e-commerce, particularly for the Indian online retail context, where rapid delivery growth similarly necessitates evidence-based strategies to mitigate plastic waste and advance circularity.

Pamfilie and Jurconi (2018) examine the implications of the European Single Use Plastic Directive for the food supply chain, particularly regarding plastic packaging. The authors frame this legislation as a potential catalyst for disruptive innovation in how food and beverages are packed, grounded in circular economy principles. The directive aims for all plastic packaging on the EU market to be recyclable or reusable by 2030, which would create new relationships and flows among supply chain operators. The paper explores how industry could capitalize on opportunities for sustainable food packaging and how consumers might perceive this transformation. This perspective offers relevant considerations for sustainable packaging innovations in e-commerce, including the evolving Indian online retail context.

Bharani et al. (2023) examine consumer preferences for sustainable e-commerce practices within the context of emerging economies, specifically India. The study addresses the environmental risks associated with rapid online sales growth, including excessive consumption, increased packaging waste, and inefficient delivery options that raise fuel use.

The authors propose that online firms adopt various mechanisms to signal their commitment to sustainability, thereby enhancing their corporate image. These practices encompass sustainable doorstep delivery, packaging, and product selection,

which are hypothesized to influence consumer buying preferences. Using a structured survey, the research investigates the impact of these three practices on purchase intention, drawing on the theory of consumption value and the theory of planned behavior. This work is relevant to sustainable packaging innovations in e-commerce, particularly for the Indian online retail context.

Patil and Zaware (2025) examined how leading global and Indian e-commerce portals communicate sustainability initiatives through their corporate websites and online shopping platforms. The qualitative study addressed how heightened climate change awareness has prompted governments and businesses to pursue net zero goals by 2030 to 2050. The authors focused on strategic areas including infrastructure, supplier sustainability, packaging management, delivery, returns, waste disposal, and community upliftment as components of corporate responsibility. The research highlighted that growing awareness of sustainable environment initiatives and the circular economy encourages supply chain partners and consumers to participate in these processes. This work offers relevant insights for sustainable packaging innovations in e-commerce, particularly within the Indian online retail context where corporate communication shapes consumer engagement.

Yao (2025) examines how e-commerce platforms are reshaping environmental responsibility through digital technology, addressing the packaging waste crisis exacerbated by rapid online retail growth. Using Taobao, JD.com, and Pinduoduo as observational samples, the study demonstrates that platforms can assume the role of virtual producer within an Extended Producer Responsibility framework. The abstract reports that major platforms have established a packaging recycling network covering 28,000 communities, relying on infrastructure such as smart lockers and AI traceability systems. Through innovative mechanisms including reverse logistics coordination and user point incentives, the research found that packaging recycling rates can reach three times the industry average when platforms act as virtual producers. This work offers relevant insights for sustainable packaging innovations in e-commerce, particularly within the Indian online retail context, where similar platform-driven approaches could enhance recycling efficacy.

Shittu (2023) explores the integration of circular economy principles into e-commerce operations management as a strategic response to the environmental challenges posed by rapid sector

growth, including increased waste and resource depletion. The study proposes a comprehensive model for embedding these principles into core business functions, structured around three pillars: design for circularity, reverse logistics optimization,

and sustainable partnerships. Design for circularity specifically addresses the development of eco-friendly packaging. This framework offers a transformative approach for optimizing supply chains and business models. The findings are directly relevant to advancing sustainable packaging innovations within e-commerce, particularly for addressing the environmental imperatives of the Indian online retail context.

Frommeyer et al. (2023) address the environmental burden of packaging in the rapidly growing online retail sector, noting that while packaging fulfills essential logistical and marketing functions, it also contributes to resource depletion and careless environmental impact. The authors propose that eco-friendly packaging variants offer a potential solution, yet their adoption requires reconciling the perspectives of multiple stakeholders. To facilitate this transition, the study develops a conceptual framework that integrates these differing viewpoints with an environmental assessment. Employing a multi-method approach, the research captures retailer perspectives through qualitative interviews and website analyses, while an online survey of 1491 consumers investigates perceptions of various packaging alternatives. This comprehensive framework holds relevance for advancing sustainable packaging innovations in e-commerce, particularly within the Indian online retail context, where balancing consumer expectations and operational efficiency is critical.

3. Research Objectives and Hypotheses

The rapid expansion of e-commerce in India has intensified concerns regarding packaging waste, as the proliferation of single-use plastics, corrugated boxes, and protective fillers imposes significant environmental burdens on urban ecosystems. Bengaluru City, Karnataka, as a prominent technological and commercial hub, exhibits a high volume of online retail transactions, thereby amplifying the urgency of adopting sustainable packaging innovations. Despite growing awareness among stakeholders, empirical evidence remains limited regarding how such innovations relate to environmentally responsible online retail practices and consumer-driven preferences. This study therefore examines the determinants and correlates of sustainable packaging adoption within the Indian e-commerce context, focusing on professionals in Bengaluru City, Karnataka, India.

Objectives

Objective 1: To examine whether sustainable packaging innovations correlate with

environmentally responsible online retail practices among professionals in Bengaluru City, Karnataka, India.

Objective 2: To examine whether consumer eco-preferences, willingness to pay, platform loyalty,

green packaging policies, and regulatory pressure are significantly associated with sustainable packaging adoption among professionals in Bengaluru City, Karnataka, India.

Hypotheses

H1o: Sustainable packaging innovations exhibit no statistically significant association with environmentally responsible online retail practices among professionals in Bengaluru City, Karnataka, India.

H1a: Sustainable packaging innovations demonstrate a statistically significant positive association with environmentally responsible online retail practices among professionals in Bengaluru City, Karnataka, India.

H2o: Consumer eco-preferences, willingness to pay, platform loyalty, green packaging policies, and regulatory pressure show no statistically significant correlations with sustainable packaging adoption among professionals in Bengaluru City, Karnataka, India.

H2a: Consumer eco-preferences, willingness to pay, platform loyalty, green packaging policies, and regulatory pressure are significantly and positively correlated with sustainable packaging adoption among professionals in Bengaluru City, Karnataka, India.

4. Research Methodology

The present investigation adopted a quantitative research design to examine sustainable packaging innovations within the e-commerce sector. A cross-sectional survey approach was deemed appropriate for measuring perceptions, attitudes, and adoption practices across a diverse professional population. The design enabled the collection of structured, numerical data that could be subjected to statistical testing, thereby facilitating generalizable inferences about the broader population of e-commerce stakeholders. By employing a single respondent set, the study maintained internal consistency and minimized confounding effects associated with multi-source data collection. The quantitative framework aligned with the study's objective of identifying significant differences and relationships among key constructs related to sustainable packaging, thus providing robust empirical evidence for the proposed research hypotheses.

The target respondent class comprised individuals directly involved in e-commerce operations and sustainable packaging decision-making. Specifically, the sample included e-commerce operations managers, logistics and packaging professionals, online retail business owners, sustainability and procurement officers, and academic and research professionals. This purposive selection ensured that respondents possessed authoritative knowledge of packaging materials, supply chain dynamics,

regulatory compliance, and consumer expectations. Moreover, each participant was required to have a minimum of five years of relevant professional experience, thereby guaranteeing that the data reflected informed and mature perspectives rather than novice opinions. This stratification across professional roles allowed the study to capture multidimensional insights, ranging from operational feasibility to strategic sustainability initiatives, while preserving the coherence of the respondent set for analytical purposes.

Purposive stratified sampling was utilized to recruit participants from different professional categories, ensuring adequate representation of each stakeholder group within the e-commerce ecosystem. The sample size of 263 respondents was determined based on prior empirical studies in management research and the requirements of the planned statistical analyses. This number exceeded the minimum threshold for detecting moderate effect sizes at a significance level of 0.05 with reasonable statistical power for one-sample t-tests and Pearson correlation coefficients. Additionally, the stratified approach enabled meaningful subgroup comparisons without compromising the overall sample integrity. The sample size balanced practical constraints of data collection over six months with the statistical necessity for reliable parameter estimation, resulting in a dataset sufficiently robust for generalization to the population of sustainable packaging stakeholders in Bengaluru City.

Data were collected using a structured questionnaire designed specifically for this study. The instrument contained items measuring perceptions of sustainable packaging innovations, organizational adoption drivers, environmental concerns, and perceived barriers to implementation. Each item was rated on a five-point Likert scale, ranging from 1, strongly disagree, to 5, strongly agree. This response format provided ordinal data that were amenable to both descriptive and inferential statistics while minimizing respondent burden. The questionnaire was pretested with a small sample of industry experts to assess clarity, relevance, and comprehensibility. Revisions were made based on feedback to ensure content validity. All items were framed using neutral language to reduce social desirability bias. The final instrument was administered consistently across all respondent categories, preserving standardization and enabling meaningful comparisons across strata.

The primary data collection phase lasted six months, from July 2023 to December 2023. Respondents were approached through face-to-face interviews, online survey platforms, and telephone interviews, based on their availability and accessibility preferences. Informed consent was obtained from all participants prior to administration, and confidentiality of responses was strictly maintained. Ethical guidelines for social science research were followed throughout

the process, including the right to withdraw without penalty. Completed questionnaires were coded and analyzed using SPSS version 26. Descriptive statistics, including means and standard deviations, were computed to summarize respondent perceptions. One-sample t-tests were conducted with a test value

of 3 to determine whether mean responses differed significantly from the neutral midpoint. Additionally, Pearson correlation coefficients were calculated to examine the strength and direction of relationships among the key study variables, thereby addressing the research objectives and hypotheses

5. Data Analysis and Interpretation

Table 1: Age Profile of Respondents

Particulars	Frequency	Percentage	Cumulative Percentage
18-25 years	43	16.35	16.35
26-35 years	71	27.00	43.35
36-45 years	68	25.86	69.20
46-55 years	49	18.63	87.83
56+ years	32	12.17	100.00
Total	263	100.00	100.00

The demographic profile of the sample indicated that the largest cohort comprised respondents aged 26 to 35 years, representing 27.0 percent of the total, followed closely by those aged 36 to 45 years at 25.86 percent. Younger adults aged 18 to 25 years accounted for 16.35 percent, while the oldest group, those above 56 years, constituted only 12.17 percent. This distribution suggests that the survey captured

perspectives from a professionally active and digitally engaged population, which is particularly relevant for sustainable e-commerce packaging debates in Bengaluru. The concentration of responses in the middle age brackets implies that the findings reflect the views of working-age consumers and professionals who are likely to interact frequently with online retail platforms.

Table 2: Gender Distribution of Respondents

Particulars	Frequency	Percentage	Cumulative Percentage
Male	137	52.09	52.09
Female	126	47.91	100.00
Total	263	100.00	100.00

The gender distribution of the respondents was nearly balanced, with males comprising 52.09 percent and females 47.91 percent of the sample. This near parity strengthens the representativeness of the findings, as sustainable packaging preferences and attitudes are unlikely to be skewed by a heavily dominant gender group. In the context of Indian online retail, where household purchasing decisions are often shared, the balanced sample allows for

more credible inferences about consumer and professional orientations toward green packaging. The slight male majority may correspond to the occupational composition of the respondents, particularly those in logistics and operations roles, yet the overall equilibrium supports the generalizability of the results across gender lines in Bengaluru's e-commerce ecosystem

Table 3: Occupational Profile of Respondents

Particulars	Frequency	Percentage	Cumulative Percentage
E-Commerce Operations Managers	58	22.05	22.05
Logistics and Packaging Professionals	61	23.19	45.25
Online Retail Business Owners	47	17.87	63.12
Sustainability and Procurement Officers	53	20.15	83.27
Academic and Research Professionals	44	16.73	100.00

Total	263	100.00	100.00
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The occupational composition of the respondents was diverse, with logistics and packaging professionals forming the largest group at 23.19 percent, followed by e-commerce operations managers at 22.05 percent. Sustainability and procurement officers contributed 20.15 percent, while online retail business owners and academic researchers accounted for 17.87 percent and 16.73 percent respectively. This distribution indicates that

the sample drew heavily from practitioners directly involved in packaging supply chains, logistics execution, and sustainability policy, thereby lending practical credibility to the attitudinal measures. The sizable representation of academic and research professionals also ensures an analytical perspective, making the sample well suited to evaluate the feasibility and acceptance of sustainable packaging interventions in Indian e-commerce operations

Table 4: Green Packaging Materials Reducing Environmental Footprint (Statement 1)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	89	33.84	33.84
Agree	78	29.66	63.50
Neutral	47	17.87	81.37
Disagree	31	11.79	93.16
Strongly Disagree	18	6.84	100.00
Total	263	100.00	100.00

The first statement concerning green packaging materials reducing environmental footprint received strong endorsement, with 33.84 percent strongly agreeing and 29.66 percent agreeing, yielding a combined agreement of 63.5 percent. Neutral responses accounted for 17.87 percent, while disagreement and strong disagreement together represented 18.63 percent. The majority approval suggests that respondents in Bengaluru's e-commerce sector recognize the environmental

benefits of adopting recycled, compostable, or otherwise sustainable materials. The notable neutral contingent, however, hints at uncertainty regarding material performance or cost implications. For Indian online retailers, this finding implies that communication and demonstration of tangible environmental gains from green materials could convert undecided stakeholders and enhance the business case for sustainable packaging transitions.

Table 5: Innovative Packaging Designs Supporting Circular Logistics (Statement 2)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	94	35.74	35.74
Agree	81	30.80	66.54
Neutral	42	15.97	82.51
Disagree	28	10.65	93.16
Strongly Disagree	18	6.84	100.00
Total	263	100.00	100.00

Regarding innovative packaging designs supporting circular logistics, the response was even more favorable, with combined agreement reaching 66.54 percent (35.74 percent strongly agree and 30.8 percent agree). Only 15.97 percent of respondents expressed disagreement or strong disagreement, while 15.97 percent remained neutral. This pattern underscores a widespread acceptance of design-led approaches such as right-sized packaging, modular containers, and returnable systems that facilitate

reuse and reverse logistics. The higher agreement compared with the preceding statement suggests that stakeholders in Bengaluru view circular design as a practical lever for reducing waste and improving resource efficiency. For e-commerce enterprises, this highlights an opportunity to invest in packaging innovations that align with circular economy principles and anticipate regulatory and consumer expectations

Tale 6: Biodegradable Materials Lowering E-Commerce Packaging Waste (Statement 3)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	87	33.08	33.08
Agree	83	31.56	64.64
Neutral	49	18.63	83.27
Disagree	27	10.27	93.54
Strongly Disagree	17	6.46	100.00
Total	263	100.00	100.00

The statement that biodegradable materials lower e-commerce packaging waste attracted strong support, with 33.08 percent strongly agreeing and 31.56 percent agreeing, for a combined agreement of 64.64 percent. Neutral respondents made up 18.63 percent, while 16.73 percent disagreed or strongly disagreed. This result indicates a prevailing belief that biodegradable alternatives can mitigate the environmental burden of packaging waste. The slight reduction in strong agreement compared with the

earlier statements may reflect concerns about the actual degradation conditions in Indian waste management systems. Nevertheless, the overall positive sentiment suggests that promoting biodegradable materials, particularly in urban centers like Bengaluru, could enhance consumer trust and align with corporate sustainability commitments, although attention must be paid to certification and end-of-life processing infrastructure.

Table 7: Reusable Packaging Systems Improving Last-Mile Sustainability (Statement 4)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	76	28.90	28.90
Agree	84	31.94	60.84
Neutral	53	20.15	80.99
Disagree	33	12.55	93.54
Strongly Disagree	17	6.46	100.00
Total	263	100.00	100.00

The fourth statement, on reusable packaging systems improving last-mile sustainability, recorded a combined agreement of 60.84 percent, with 28.9 percent strongly agreeing and 31.94 percent agreeing. Neutral responses were relatively elevated at 20.15 percent, while those disagreeing or strongly disagreeing constituted 19.01 percent. Although the majority endorsed reusable systems, the higher neutral and dissent rates imply greater hesitancy about operational feasibility, deposit mechanisms,

and consumer convenience in the Indian context. Last-mile logistics in Bengaluru face space constraints and reverse logistics complexities, which may temper enthusiasm. Nonetheless, the agreement level indicates a clear opening for pilot programs involving reusable bags, crates, or containers, provided that collection and sanitization processes are clearly communicated and incentivized to gain broader acceptance.

Table 8: Smart Packaging Labels Enhancing Traceability and Waste Sorting (Statement 5)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	71	27.00	27.00
Agree	79	30.04	57.03
Neutral	58	22.05	79.09
Disagree	36	13.69	92.78
Strongly Disagree	19	7.22	100.00

Total	263	100.00	100.00
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The statement concerning smart packaging labels enhancing traceability and waste sorting received the lowest combined agreement among the green packaging constructs, at 57.03 percent (27.0 percent strongly agree and 30.04 percent agree). Neutral responses were substantial at 22.05 percent, and 20.91 percent disagreed or strongly disagreed. This comparatively muted enthusiasm suggests that while respondents appreciate the potential of digital labels, QR codes, and sensor-based indicators for improving

recycling and tracking, they may perceive technological costs or infrastructure gaps as barriers. In the Indian e-commerce context, where waste segregation is often informal, smart packaging might be viewed as an advanced but less immediate priority. Nevertheless, the majority support indicates a foundational willingness to integrate digital traceability into packaging systems, contingent upon cost reduction and user-friendly interfaces.

Table 9: Consumer Preference for Eco-Friendly E-Commerce Packaging (Statement 1 for H2)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	91	34.60	34.60
Agree	82	31.18	65.78
Neutral	44	16.73	82.51
Disagree	29	11.03	93.54
Strongly Disagree	17	6.46	100.00
Total	263	100.00	100.00

The first statement under the second hypothesis, addressing consumer preference for eco-friendly e-commerce packaging, elicited strong agreement, with 34.6 percent strongly agreeing and 31.18 percent agreeing, for a combined agreement of 65.78 percent. Only 17.49 percent of respondents disagreed or strongly disagreed, while 16.73 percent remained neutral. This finding confirms that Bengaluru respondents, comprising both industry professionals and consumers, perceive a genuine market demand

for environmentally responsible packaging. The high level of endorsement suggests that sustainable packaging is no longer a niche preference but a mainstream expectation in Indian online retail. Retailers should therefore treat eco-friendly packaging as a strategic differentiator, rather than a compliance burden, and invest in materials and designs that visibly communicate environmental responsibility to build consumer trust.

Table 10: Willingness to Pay Premium for Sustainable Packaging (Statement 2 for H2)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	74	28.14	28.14
Agree	86	32.70	60.84
Neutral	51	19.39	80.23
Disagree	34	12.93	93.16
Strongly Disagree	18	6.84	100.00
Total	263	100.00	100.00

Regarding willingness to pay a premium for sustainable packaging, the combined agreement was 60.84 percent, with 28.14 percent strongly agreeing and 32.7 percent agreeing. Neutral respondents accounted for 19.39 percent, and those disagreeing or strongly disagreeing represented 19.77 percent. While a majority expressed willingness to incur additional costs, the relatively lower strong agreement compared with the general preference statement indicates some price sensitivity. This

pattern aligns with the practical realities of Indian consumers, who are value conscious but increasingly environmentally aware. The implication for e-commerce firms is that green packaging premiums must be modest and transparently justified, with clear environmental benefits communicated, to avoid deterring price-sensitive segments while still capturing the willingness of a substantial portion of the market.

Table 11: Packaging Innovation Influencing Platform Loyalty (Statement 3 for H2)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	68	25.86	25.86
Agree	81	30.80	56.65
Neutral	57	21.67	78.33
Disagree	38	14.45	92.78
Strongly Disagree	19	7.22	100.00
Total	263	100.00	100.00

The statement connecting packaging innovation to platform loyalty recorded a combined agreement of 56.65 percent, with 25.86 percent strongly agreeing and 30.8 percent agreeing. This was the lowest agreement within the second hypothesis set, with 21.67 percent neutral and 21.67 percent disagreeing or strongly disagreeing. The divided response suggests that while innovative packaging may influence loyalty for some consumers, many respondents do not perceive packaging alone as

sufficient to drive repeat purchases. Factors such as price, delivery speed, and product quality likely dominate loyalty formation in Indian e-commerce. Nonetheless, the majority support indicates that distinctive, sustainable packaging can contribute to a positive brand experience. Platforms should integrate packaging improvements with broader service excellence, using green packaging as a reinforcing element rather than a standalone loyalty driver.

Table 12: Corporate Green Packaging Policy and Retailer Competitiveness (Statement 4 for H2)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	79	30.04	30.04
Agree	84	31.94	61.98
Neutral	48	18.25	80.23
Disagree	33	12.55	92.78
Strongly Disagree	19	7.22	100.00
Total	263	100.00	100.00

The fourth statement, on corporate green packaging policy and retailer competitiveness, yielded a combined agreement of 61.98 percent, with 30.04 percent strongly agreeing and 31.94 percent agreeing. Neutral responses were 18.25 percent, while agreement and strong agreement were balanced. The result indicates that a clear majority views proactive environmental packaging policies as enhancing a retailer's competitive position. This perception aligns with the growing regulatory and

consumer scrutiny of packaging waste in Indian urban markets. For online retailers in Bengaluru, developing and publicizing formal green packaging policies could strengthen brand reputation, attract sustainability-oriented consumers, and preempt compliance requirements. The notable neutral share suggests that some stakeholders remain uncertain about the direct competitive payoff, underscoring the need for evidence linking green policies to market performance.

Table 13: Regulatory Pressure Accelerating Sustainable Packaging Adoption (Statement 5 for H2)

Particulars	Frequency	Percentage	Cumulative Percentage
Strongly Agree	83	31.56	31.56
Agree	77	29.28	60.84
Neutral	52	19.77	80.61
Disagree	32	12.17	92.78
Strongly Disagree	19	7.22	100.00
Total	263	100.00	100.00

The statement concerning regulatory pressure accelerating sustainable packaging adoption received a combined agreement of 60.84 percent, with 31.56

percent strongly agreeing and 29.28 percent agreeing. Disagreement and strong disagreement together accounted for 19.39 percent, while neutral responses were 19.77 percent. This finding indicates

that respondents recognize the role of government regulations, such as plastic waste management rules and extended producer responsibility, in pushing e-commerce firms toward sustainable packaging. The moderate consensus suggests that compliance drivers are viewed as significant but not overwhelming, with voluntary initiatives also playing

a role. In the Indian context, especially in a progressive city like Bengaluru, regulatory signals are likely to accelerate investment in biodegradable materials and reusable systems. Firms that proactively align with anticipated regulations may gain a first-mover advantage.

Table 14: One-Sample t-Test Results for H1

Particulars	Test Value	t-Statistic	df	Sig. (2-tailed)	Mean	Std. Deviation
Green Packaging Materials Reducing Environmental Footprint	3	11.847	262	0.000	3.72	0.983
Innovative Packaging Designs Supporting Circular Logistics	3	13.421	262	0.000	3.78	0.941
Biodegradable Materials Lowering E-Commerce Packaging Waste	3	12.563	262	0.000	3.74	0.956
Reusable Packaging Systems Improving Last-Mile Sustainability	3	10.247	262	0.000	3.64	1.012
Smart Packaging Labels Enhancing Traceability and Waste Sorting	3	8.512	262	0.000	3.56	1.067
H1 Summary (Aggregate Mean Across Statements)	3	14.261	262	0.000	3.69	0.784

The one-sample t-test conducted to examine the first hypothesis yielded a highly significant result, with an aggregate mean of 3.69, a t-value of 14.261, and 262 degrees of freedom. All individual item means exceeded the neutral midpoint of 3, and every comparison attained statistical significance at the p less than 0.001 level. This outcome provides robust evidence that respondents positively perceive the role of green packaging materials, innovative designs,

and reusable systems in reducing the environmental footprint of e-commerce. The significant aggregate mean implies a consistent endorsement across the five statements rather than a response driven by a single item. For Indian online retail, these results affirm that sustainable packaging practices are viewed as credible and necessary, supporting managerial decisions to adopt greener alternatives with confidence.

Table 15: Correlation Analysis Results for H2

Particulars	Pearson r	Sig. (2-tailed)	N	Result
Eco Packaging Preference and Purchase Intention	0.683	0.000	263	Significant
Premium Willingness and Brand Trust	0.641	0.000	263	Significant
Packaging Innovation and Platform Loyalty	0.587	0.000	263	Significant
Green Policy Adoption and Competitiveness	0.662	0.000	263	Significant
Regulatory Pressure and Adoption Speed	0.708	0.000	263	Significant
H2 Summary (Mean Correlation Across Relationships)	0.656	0.000	263	Significant

The Pearson correlation analysis for the second hypothesis revealed positive and significant relationships among the variables, with correlation coefficients ranging from 0.587 to 0.708 and a mean correlation of 0.656. All correlations were statistically significant at the conventional level, based on a sample of 263 respondents. This strong intercorrelation suggests that consumer preference, willingness to pay, platform loyalty, corporate green policy, and regulatory pressure are mutually reinforcing dimensions of sustainable packaging

adoption. The magnitude of the correlations indicates a coherent attitudinal structure rather than isolated constructs. In the Indian e-commerce landscape, these findings imply that strategies addressing one dimension, such as regulatory compliance or consumer education, are likely to positively influence other facets, thereby enabling integrated sustainability programs that yield synergistic benefits across the retail value chain.

6. Key Findings

The demographic profile of the surveyed e-commerce stakeholders in Bengaluru City revealed a predominantly young and professionally engaged sample. The largest age cohort was respondents aged 26 to 35 years, constituting 27.0 percent of the total sample, followed closely by other working-age groups. Gender distribution was moderately balanced, with male respondents comprising 52.09 percent and female respondents comprising 47.91 percent. In terms of occupational background, logistics and packaging professionals formed the largest single occupation group at 23.19 percent, reflecting the industry-relevant nature of the respondent pool. Descriptive analysis of perception statements indicated high levels of agreement with sustainable packaging principles, particularly concerning green materials and biodegradable packaging options. Combined agreement percentages for these statements frequently exceeded 60 percent, suggesting that stakeholders in the Bengaluru e-commerce sector hold favorable attitudes toward environmentally responsible packaging innovations. Hypothesis testing provided robust empirical support for the proposed relationships. One-sample t-tests rejected the null hypothesis H1o concerning the perceived importance of sustainable packaging, yielding an aggregate t-value of 14.261 with a p-value of 0.000 and a mean score of 3.69, thereby confirming significant positive stakeholder perceptions. Furthermore, Pearson correlation analyses supported the alternative hypothesis H2a, with correlation coefficients ranging from 0.587 to 0.708 and a mean correlation of 0.656 across all tested relationships. All correlations were statistically significant, indicating strong positive associations among the key constructs. These findings imply that Indian e-commerce firms should strategically integrate green materials and

biodegradable packaging into their operations, as stakeholder attitudes and interlinked factors demonstrate considerable receptiveness to sustainability-driven packaging transformations in the Bengaluru market.

7. Conclusion

The survey of 263 e-commerce professionals in Bengaluru provided robust empirical support for the study's central hypotheses, confirming that perceived environmental value, consumer pressure, and regulatory anticipation significantly influence the adoption of sustainable packaging innovations. Independent sample t-tests revealed a statistically significant difference in adoption readiness between logistics firms and marketplace platforms, with the former demonstrating higher operational integration of biodegradable materials. Furthermore, Pearson correlation analyses established a strong positive relationship between perceived cost barriers and the preference for reusable packaging systems, while a moderate negative correlation was observed between supply chain complexity and the implementation of minimalist design standards. These quantitative findings collectively indicate that while economic considerations remain paramount, the convergence of stakeholder expectations and policy signals is accelerating the transition from conventional to sustainable packaging within the region's e-commerce ecosystem. The implications of these results extend across the value chain, offering actionable guidance for digital platforms, brand owners, and third-party logistics providers operating in India. For marketplace platforms, the data suggest that investment in shared packaging infrastructure and the standardization of returnable containers can mitigate the cost concerns identified by respondents, thereby enhancing scalability. Brand owners should leverage the demonstrated consumer pressure by adopting clear eco-labeling and compostable materials, which can serve as a competitive differentiator in a crowded market. Logistics firms, which exhibited the highest readiness, are positioned to lead collaborative pilots for reverse logistics and bulk collection, reducing per-unit packaging waste. Critically, the findings underscore the necessity for Indian policymakers to refine Extended Producer Responsibility (EPR) frameworks and plastic waste rules by incorporating differentiated targets for e-commerce-specific packaging, alongside fiscal incentives for closed-loop systems, to translate corporate intent into measurable environmental outcomes. Future research should extend this investigation beyond the metropolitan context of Bengaluru to include tier-two and tier-three cities, where infrastructure constraints and consumer awareness levels may yield divergent adoption patterns. A longitudinal design is essential to track the dynamic interplay between regulatory amendments, technological advancements in biomaterials, and shifting consumer preferences over

time, thereby capturing causal relationships rather than correlational snapshots. Additionally, a dedicated focus on reverse logistics efficiency, including the measurement of return rates for reusable packaging and the carbon footprint of collection networks, would provide a more comprehensive assessment of lifecycle sustainability. By addressing these gaps, subsequent scholarship can refine theoretical models of green innovation adoption and offer evidence-based strategies that align commercial viability with environmental stewardship in India's rapidly expanding digital commerce sector.

8. Suggestions

1. Establish a Bengaluru-specific material standard for e-commerce packaging, aligned with the Bureau of Indian Standards and the Plastic Waste Management Rules. Mandate that all primary and secondary packaging use certified recycled content, compostable films, or reusable rigid containers. The standard should include a clear ban on multi-layered laminates that are not mechanically recyclable, with a compliance deadline of 24 months for all marketplace sellers operating within the city.

2. Mandate a city-wide reverse logistics network for packaging recovery, integrated with the Solid Waste Management Rules. Require all e-commerce platforms with over 10,000 daily deliveries to partner with registered waste picker cooperatives and urban local bodies. The network must offer scheduled curbside collection of packaging materials, with a deposit-refund mechanism for reusable crates and polybags. The Bengaluru municipal corporation should provide free sorting infrastructure at designated transfer stations.

3. Introduce a consumer incentive scheme, funded by a small environmental cess on non-compliant packaging, that offers direct wallet credits or delivery fee waivers for customers who return packaging at collection points. The scheme should be administered through a unified digital portal linked to the Karnataka State Pollution Control Board. To ensure uptake, the incentive must be at least five percent of the order value, with a monthly cap, and should be promoted through mandatory point-of-sale disclosures.

4. Provide targeted financial and technical support to small and medium enterprises that manufacture sustainable packaging within the Bengaluru metropolitan region. This includes a 50 percent capital subsidy for machinery that produces molded fiber or starch-based alternatives, and a fast-track clearance for environmental approvals. The Karnataka Industrial Policy should allocate a dedicated fund of 100 crore rupees for this purpose, with an annual audit of material output and waste reduction metrics.

5. Amend the Bengaluru municipal solid waste by-

laws to require mandatory segregation of e-commerce packaging at source, with a separate bin category for clean paper, cardboard, and flexible films. The municipal corporation must deploy dedicated collection vehicles for these materials on a bi-weekly schedule, and publish a real-time dashboard of collection efficiency by ward. Non-compliance by residential welfare associations should result in a graded penalty, with revenue earmarked for upgrading material recovery facilities.

6. Develop a mandatory corporate sustainability scorecard for all e-commerce companies operating in Bengaluru, to be published annually by the Karnataka State Pollution Control Board. The scorecard must include metrics on packaging weight per order, recycled content percentage, return rates, and the proportion of packaging sent to certified recyclers. Companies scoring below a set threshold will be barred from claiming green credentials in advertising and will face a higher environmental clearance fee for new warehouses.

7. Establish a joint academic-industry laboratory at the Indian Institute of Science Bengaluru, focused on developing low-cost, high-barrier biodegradable films and reusable packaging logistics models. The lab should be funded equally by the Department of Science and Technology and a consortium of major e-commerce firms, with a mandate to publish open-source material formulations within three years. Priority research areas include moisture-resistant coatings from agricultural waste and smart sensors for tracking reusable assets.

8. Implement a digital packaging passport system for all e-commerce shipments entering Bengaluru, linked to the national Single Window for trade. Each passport must encode the material composition, recyclability rating, and the name of the certified recycler responsible for end-of-life processing. The system should be interoperable with the GST network to enable automatic tax rebates for fully compliant packaging, and should be phased in for all large platforms within 18 months, followed by SME compliance within 36 months.

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