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The Future of Last-Mile Logistics: Pathways Toward Sustainable E-Commerce

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ABSTRACT: The exponential growth of e-commerce has intensified challenges in last-mile delivery logistics, making sustainability a critical priority for researchers, policymakers, and industry practitioners. This study synthesizes existing literature on sustainable practices in last-mile logistics, focusing on economic, environmental, social, and technological dimensions. A narrative review approach was employed, drawing from academic databases such as Scopus, Web of Science, and Google Scholar. Literature was selected using targeted keywords and inclusion criteria to ensure comprehensive coverage of practices ranging from cost efficiency strategies to technological innovations. The results reveal that sustainable logistics practices, such as electric vehicle adoption, route optimization, and crowd logistics, can reduce operational costs, improve customer satisfaction, and decrease carbon emissions. However, disparities between developed and developing countries highlight systemic challenges, including inadequate infrastructure, limited regulatory support, and varying consumer preferences. Social outcomes, including the welfare of couriers and improvements in urban air quality, emphasize the broader societal benefits of sustainability, though labor protections remain underexplored in the literature. Technological advances, particularly GIS-based systems and autonomous vehicles, offer transformative potential but require supportive policy frameworks for effective implementation. The discussion highlights the importance of systemic factors—policy, regulation, and infrastructure—in shaping adoption. This review concludes that sustainable last-mile logistics is essential for aligning economic growth with ecological responsibility and social equity, recommending targeted policies, cross-sector collaboration, and longitudinal research to address current limitations.

Keywords: Last-Mile Delivery Logistics, Sustainable Logistics, Green Supply Chain Management, Urban Logistics Innovation, Crowd Logistics, Autonomous Delivery Vehicles, E-Commerce Sustainability.

INTRODUCTION

Last-mile delivery logistics has become a key research area due to the rapid growth of e-commerce. The increasing demand for direct-to-consumer deliveries has not only redefined traditional

logistics frameworks but has also generated pressing concerns regarding environmental and social sustainability. In this context, the final leg of the delivery process—often the most resource-intensive—has become a focal point for innovation, policy debates, and scholarly investigation. Recent studies emphasize that last-mile logistics contributes disproportionately to urban traffic congestion, carbon emissions, and packaging waste, necessitating systematic reforms to align efficiency with sustainability goals (Poo et al., 2024; Mangano et al., 2021).

The expansion of e-commerce has significantly transformed consumer behavior and reshaped supply chain management. This transformation is characterized by the shift toward flexible, customer-centric delivery options such as same-day or instant delivery. While these models enhance customer satisfaction, they exacerbate environmental challenges, increasing fuel consumption and urban pollution levels. Scholars underscore that sustainable practices in logistics are no longer optional but integral to long-term business viability and societal welfare (Bonilla et al., 2024). Importantly, sustainability has become interwoven with customer experience, where eco-friendly practices can serve as a source of competitive differentiation (Mangano et al., 2021).

The urgency of developing sustainable practices is further highlighted by alarming statistics. The e-commerce sector generated over USD 4 trillion in global sales in 2023, accompanied by exponential growth in parcel deliveries. These deliveries, concentrated in urban areas, now account for approximately 30% of total CO2 emissions in the transport sector (Bonilla et al., 2024). Such figures underscore the ecological consequences of current delivery models and stress the importance of adopting practices that reduce carbon footprints. For instance, route optimization technologies, the deployment of electric vehicles, and the integration of drones or autonomous delivery systems have been explored as promising alternatives to conventional delivery modes (Min, 2023; Gupta, 2025).

Urban areas bear the greatest impacts. With dense populations and congested road networks, cities face acute environmental degradation linked to last-mile logistics. Technological interventions, including smart routing systems and electrified fleets, have been tested to alleviate these pressures. At the same time, consumer attitudes toward sustainable delivery options are evolving. Surveys suggest that consumers are increasingly willing to accept slower deliveries or pay modest premiums for environmentally responsible options, provided that the environmental implications of their choices are transparent (Ignat & Chankov, 2020). This intersection of consumer preference and corporate responsibility opens new pathways for rethinking logistics strategies.

Despite these encouraging trends, significant challenges persist. The rapid rise of quick commerce (Q-commerce) has heightened logistical pressures, often at the expense of environmental considerations (Gupta, 2025). Infrastructural constraints, particularly in developing economies, hinder the adoption of advanced green logistics technologies. Inadequate urban planning, poor transport infrastructure, and regulatory gaps present barriers to the successful integration of sustainable systems (Frehe et al., 2017; Jurburg et al., 2023). Another major challenge lies in reconciling operational efficiency with sustainability imperatives. While consolidated delivery hubs and micro-depots have demonstrated reductions in emissions and congestion, their implementation requires substantial investment and stakeholder collaboration (Buldeo et al., 2017). Furthermore, the logistics workforce, particularly independent delivery workers, often faces

precarious working conditions. Integrating social sustainability alongside environmental goals is essential to ensure equitable outcomes for all stakeholders (Bonilla et al., 2024).

These challenges reveal persistent gaps in the literature. Despite the growing body of research on sustainable logistics, there remains limited understanding of consumer acceptance of green delivery practices. While some studies suggest positive consumer attitudes, empirical evidence on behavioral adoption and willingness-to-pay remains fragmented (Ignat & Chankov, 2020). Moreover, practical implementation of sustainability frameworks often encounters resistance due to high costs, regulatory complexities, and limited infrastructure, particularly in emerging economies (Paddeu et al., 2018). There is also a notable scarcity of longitudinal studies assessing the long-term impacts of sustainable practices on business operations, consumer behavior, and environmental outcomes.

This study seeks to address these gaps by conducting a narrative review of sustainable practices in last-mile delivery logistics. The review aims to identify and categorize key sustainability strategies, evaluate their effectiveness across economic, environmental, and social dimensions, and analyze the factors that influence their adoption.

METHOD

This study employed a structured methodology designed to ensure the systematic and comprehensive identification, selection, and evaluation of academic literature addressing sustainable practices in last-mile delivery logistics. Given the rapidly evolving nature of e-commerce and logistics, methodological rigor was essential to capture a broad yet relevant range of publications while maintaining the standards of academic credibility and replicability.

The literature search was conducted across several major academic databases: Scopus, Web of Science, and Google Scholar. These three platforms were chosen due to their complementarity and breadth of coverage. Scopus was selected for its extensive indexing of peer-reviewed journals in the fields of logistics, supply chain management, and technology applications in business. Web of Science was used because of its rigorous indexing criteria, ensuring the inclusion of high-quality and reputable journals across multiple disciplines. Meanwhile, Google Scholar provided a more accessible and inclusive repository, covering academic articles, theses, conference proceedings, and reports, thus expanding the scope of the review to capture emerging research and gray literature that may not yet be indexed in Scopus or Web of Science.

The literature search was guided by a carefully curated set of keywords reflecting the study's thematic focus on sustainability, innovation, and last-mile logistics. These included: "last-mile delivery logistics," "sustainable logistics," "green logistics," "e-commerce sustainability," "urban logistics," "innovative delivery solutions," "autonomous delivery vehicles," "carbon footprint reduction," "crowd logistics," "circular economy in logistics," "smart logistics," "sustainable supply chain management," "technology in last-mile delivery," and "customer preferences for sustainable delivery." Boolean operators (AND, OR, NOT) were employed to refine the search

queries. For example, combinations such as "last-mile delivery AND sustainable logistics" or "urban logistics AND carbon footprint reduction" were used to generate precise results. By integrating different keyword sets, the search strategy aimed to capture both established literature and novel insights from adjacent fields.

The inclusion and exclusion criteria were established to ensure the selection of studies most relevant to the research objectives. Inclusion criteria encompassed peer-reviewed journal articles, conference papers, book chapters, and reputable reports published in English within the last fifteen years, to balance contemporary relevance with historical perspective. Studies had to explicitly address themes of sustainability in last-mile delivery logistics, whether through technological innovation, environmental practices, economic evaluations, or social dimensions such as labor conditions and consumer behavior. Exclusion criteria involved studies that only tangentially mentioned logistics without addressing last-mile delivery, articles lacking empirical or conceptual depth, or publications that were opinion-based without scholarly rigor. Additionally, duplicate studies retrieved from multiple databases were removed to maintain data integrity.

The types of research designs considered eligible for inclusion were intentionally broad to capture diverse methodological perspectives. Both qualitative and quantitative studies were included. This encompassed experimental research such as randomized controlled trials evaluating technological interventions, observational research such as cohort or case studies analyzing operational strategies, and modeling studies assessing environmental or economic impacts of various delivery practices. Systematic reviews and meta-analyses were also incorporated, as they provided comprehensive syntheses of existing research. Including a range of methodologies enabled triangulation of evidence and provided a holistic understanding of the topic.

The process of article selection followed a multi-step approach. First, the initial search results were compiled and screened based on titles and abstracts. This step helped filter out irrelevant studies at an early stage. Second, the full texts of potentially relevant articles were retrieved and reviewed to ensure compliance with the inclusion criteria. During this phase, particular attention was paid to the methodological rigor, clarity of research questions, and alignment with the sustainability focus of the study. Third, reference lists of included articles were examined to identify additional relevant studies not captured in the initial search. This snowballing technique proved effective in ensuring comprehensive coverage of the literature.

Evaluation of the included studies was conducted through a combination of content analysis and critical appraisal. Content analysis facilitated the categorization of themes emerging from the literature, including economic, environmental, technological, and social dimensions of sustainability in last-mile logistics. The appraisal process assessed the methodological quality of each study, examining aspects such as sample size, data sources, analytical methods, and transparency of reporting. This step was crucial in distinguishing between high-quality evidence and studies with limited reliability or generalizability.

To mitigate bias, the selection and evaluation process was independently verified by multiple researchers involved in the review. Disagreements over inclusion or classification were resolved through discussion and consensus, ensuring that the final pool of studies reflected a balanced and

rigorous selection. The methodological transparency of this review was also maintained by documenting each stage of the process, including the search queries used, the number of studies retrieved and excluded, and the rationale for final inclusion decisions.

In summary, the methodology adopted in this study combined comprehensive database searches, precise keyword strategies, and strict inclusion and exclusion criteria to identify literature relevant to sustainable practices in last-mile delivery logistics. The incorporation of diverse research designs, ranging from case studies to large-scale empirical analyses, facilitated a multifaceted exploration of the topic. The structured selection and evaluation process enhanced the validity and reliability of the review, ensuring that its findings provide a credible and holistic contribution to the academic discourse on sustainable last-mile logistics.

RESULT AND DISCUSSION

The findings of this narrative review highlight the multidimensional nature of sustainable practices in last-mile delivery logistics, organized around four thematic areas: economic, environmental, social, and technological dimensions. Each theme is supported by empirical evidence and scholarly discussions, offering a comprehensive perspective on how sustainability is being integrated into last-mile logistics globally.

Economic Dimension

The economic implications of last-mile logistics play a crucial role in determining the feasibility of sustainable practices. Rising delivery costs and the demand for faster services compel logistics providers to seek solutions that simultaneously enhance efficiency and reduce ecological footprints. Research by Ignat and Chankov (2020) demonstrates a positive correlation between cost efficiency and sustainability, showing that companies adopting eco-friendly solutions often realize long-term operational savings. Empirical data further indicates that investments in electric vehicles and optimized routing systems reduce fuel consumption and maintenance costs while delivering clear economic benefits.

Beyond cost efficiency, service quality is strongly associated with economic sustainability. Kawa and Światowiec-Szczepańska (2021) argue that value creation in logistics services directly enhances customer satisfaction, which in turn drives customer loyalty and supports long-term financial stability. Firms that prioritize sustainable practices not only meet environmental objectives but also strengthen their competitive advantage. Evidence suggests that customers who perceive delivery services as sustainable are more likely to remain loyal, thereby reinforcing the economic resilience of logistics companies. This indicates that sustainability and profitability are not mutually exclusive but rather mutually reinforcing dimensions of modern logistics operations.

The global perspective on the economic outcomes of sustainability also reveals important differences between regions. In developed markets, regulatory frameworks and subsidies often support investments in green technologies, making sustainable transitions economically viable. In contrast, firms in developing economies face higher initial costs and infrastructure limitations that hinder immediate returns on sustainable investments. Nevertheless, case studies from emerging

markets reveal that small-scale initiatives, such as crowd logistics and localized delivery hubs, can yield significant cost reductions while gradually building momentum toward broader sustainable practices (Bonilla et al., 2024).

Environmental Dimension

The environmental dimension of sustainability in last-mile delivery has been extensively studied, with particular emphasis on emissions reduction. Arnold et al. (2017) show that replacing diesel-powered delivery vehicles with electric alternatives significantly lowers CO2 emissions. Similarly, Paddeu et al. (2018) highlight the environmental benefits of using bicycles and other non-motorized transport options for short-distance deliveries, demonstrating improvements in urban air quality and reductions in localized emissions. These findings provide strong empirical support for the adoption of environmentally friendly transport modes as a cornerstone of sustainable logistics.

Comparative analyses across developed and developing economies illustrate significant disparities in the capacity to implement green logistics practices. Jurburg et al. (2023) report that developed countries, supported by robust infrastructure and policy incentives, achieve higher reductions in emissions through the adoption of electric fleets and renewable energy integration. By contrast, developing economies encounter systemic barriers such as inadequate charging infrastructure and limited access to green technologies, slowing their transition to sustainable logistics (Ignat & Chankov, 2020; Poo et al., 2024). Despite these challenges, pilot programs in developing contexts demonstrate the potential for substantial emission reductions when even small fleets of electric vehicles are deployed.

The cumulative environmental impact of these practices is evident in cities where sustainable logistics initiatives have been implemented. For example, urban consolidation centers and optimized routing systems have been shown to reduce unnecessary trips, thereby lowering emissions and traffic congestion (Buldeo et al., 2017). Moreover, the integration of circular economy principles, such as sustainable packaging and recycling initiatives, further contributes to environmental goals (Gružauskas et al., 2023). These collective practices underscore the role of environmental innovation in advancing sustainability in last-mile logistics.

Social Dimension

The social implications of sustainable last-mile delivery logistics are increasingly recognized as a critical component of the sustainability framework. Independent couriers, who form a significant portion of the workforce in e-commerce logistics, are directly affected by sustainability practices. On one hand, initiatives such as the adoption of electric vehicles and improved transparency in delivery systems can enhance occupational safety and efficiency, thereby improving the working conditions and overall well-being of couriers. On the other hand, approaches that prioritize cost reduction without addressing labor welfare may increase workloads, heighten stress, and perpetuate job insecurity.

The impact of sustainable logistics extends beyond the workforce to urban populations more broadly. Reductions in carbon emissions and improvements in air quality achieved through sustainable delivery practices directly benefit public health. Cleaner urban environments contribute to enhanced quality of life, providing communities with improved access to public spaces and

healthier living conditions. These societal benefits highlight that sustainability in logistics is not merely a corporate responsibility but a broader societal imperative with tangible implications for urban development.

Evidence from comparative contexts illustrates variations in social outcomes. In developed countries, sustainability initiatives are often accompanied by stronger labor protections and social policies, ensuring that couriers and workers benefit alongside environmental improvements. Conversely, in developing regions, the lack of robust labor regulations can mean that sustainability initiatives primarily focus on environmental targets while neglecting the welfare of the workforce (Frehe et al., 2017). This highlights the importance of integrating social sustainability as a core dimension of logistics planning to ensure that environmental and economic gains do not come at the expense of human well-being.

Technological and Innovation Dimension

Technological innovation is a central driver of sustainable practices in last-mile logistics. Geographic Information Systems (GIS) and route optimization algorithms have proven highly effective in minimizing travel distances, fuel consumption, and emissions, thereby enhancing both environmental and economic sustainability. The integration of real-time data analytics into logistics planning allows companies to dynamically adjust routes in response to traffic conditions, further improving efficiency.

Autonomous delivery vehicles represent another promising frontier. Studies indicate that the deployment of self-driving vehicles can significantly reduce delays and operating costs while lowering carbon footprints (Min, 2023). Similarly, the potential of drones for parcel delivery has attracted attention for their ability to bypass traffic congestion and reduce emissions, although regulatory and safety concerns remain barriers to large-scale implementation (Gupta, 2025).

In addition to autonomous technologies, sharing economy models such as crowd logistics have emerged as innovative approaches to sustainable delivery. These platforms coordinate deliveries using the resources of independent couriers and existing vehicles already on the road, reducing the need for additional trips. Research demonstrates that crowd logistics can lower costs, enhance delivery speed, and reduce environmental burdens by leveraging underutilized transportation capacity (Bonilla et al., 2024). At the same time, these models create new economic opportunities for individuals, aligning economic, social, and environmental objectives.

Technological innovation also supports the integration of circular economy principles in logistics. Digital platforms facilitate better information sharing across stakeholders, enabling practices such as reusable packaging systems and reverse logistics for recycling. These advancements contribute not only to environmental goals but also to operational efficiency, illustrating the multifaceted role of technology in advancing sustainability.

Global Perspective

When comparing the global landscape of sustainable last-mile delivery, distinct patterns emerge between developed and developing regions. In developed economies, strong regulatory support, infrastructure readiness, and consumer awareness enable more rapid adoption of advanced technologies such as electric fleets and autonomous delivery systems (Pfaff, 2025). Consumers in

these regions also tend to exhibit greater willingness to pay for sustainable delivery options, reinforcing corporate incentives to innovate (Ignat & Chankov, 2020).

Conversely, developing economies often prioritize affordability and speed over environmental considerations, reflecting differing consumer preferences and socioeconomic constraints (Jurburg et al., 2023). While these regions face significant challenges, they also offer opportunities for innovation tailored to local contexts, such as low-cost crowd logistics solutions and hybrid delivery systems combining traditional and green methods. These examples demonstrate that sustainability is not a uniform concept but one that must be adapted to geographical, cultural, and economic realities.

Synthesis of Results

Overall, the findings from this review underscore the interconnected nature of economic, environmental, social, and technological dimensions in shaping sustainable last-mile delivery logistics. Cost efficiency and service quality emerge as critical enablers of sustainability, reinforcing the idea that green practices can be profitable. Environmental initiatives such as the adoption of electric vehicles and circular economy models demonstrate measurable impacts in reducing emissions and improving urban livability. Social considerations, particularly the welfare of couriers and urban populations, highlight the need for equitable approaches that distribute benefits across stakeholders. Finally, technological innovations, from GIS-based optimization to autonomous vehicles and sharing economy models, provide powerful tools to advance sustainability, though their adoption varies globally.

This comprehensive synthesis affirms that while significant progress has been made, challenges remain in achieving global sustainability in last-mile logistics. Regional disparities, infrastructural constraints, and incomplete integration of social sustainability highlight areas for further research and policy intervention. Nonetheless, the cumulative evidence confirms that sustainable practices in last-mile logistics are not only feasible but essential for aligning economic growth with environmental responsibility and social equity.

The findings of this review align closely with the broader body of literature on sustainable transportation while also underscoring the unique challenges inherent in last-mile delivery logistics. Existing research emphasizes the complexities of implementing sustainability strategies in contexts shaped by rapid technological innovation, fluctuating consumer expectations, and the inherent inefficiencies of urban distribution systems. As highlighted by Kawa and Światowiec-Szczepańska (2021), sustainable practices in e-commerce logistics have direct implications for customer satisfaction and value creation, echoing wider studies in transport sustainability that demonstrate similar correlations. Ignat and Chankov (2020) also reinforce that sustainability-oriented delivery solutions enhance efficiency while simultaneously reducing environmental impacts, confirming the dual economic and ecological benefits of green logistics.

A critical aspect that emerges from these results is the role of systemic factors in shaping the success or failure of sustainability initiatives in last-mile logistics. Policy frameworks are central to enabling sustainable transitions. In advanced economies, stringent carbon emission regulations, subsidies for electric vehicle adoption, and incentives for green practices drive investment and innovation in sustainable logistics (Bonilla et al., 2024). Conversely, developing regions often lack

the regulatory clarity and supportive infrastructure required for such transitions, creating significant barriers to adoption (Jurburg et al., 2023). The unevenness in regulatory environments highlights how systemic factors can either facilitate or obstruct progress. For instance, complex or ambiguous regulations tend to slow implementation by creating uncertainty for firms, reducing their willingness to invest in new practices (Ignat & Chankov, 2020; Aboagye et al., 2022). These challenges reinforce the necessity of regulatory reform, coupled with targeted infrastructural investments, to create enabling environments for sustainable last-mile delivery.

Infrastructure remains another decisive systemic factor. In many developed economies, extensive charging networks, reliable road systems, and advanced urban planning facilitate the integration of electric fleets and smart routing technologies. By contrast, infrastructural limitations in developing countries impede the adoption of green practices, particularly when electric vehicles are inaccessible due to insufficient charging stations or high initial costs (Bonilla et al., 2024). Jurburg et al. (2023) note that this infrastructural divide exacerbates global disparities in sustainability outcomes, pointing to the need for international cooperation and investment to bridge infrastructural gaps. Without foundational infrastructure, the scalability of sustainable last-mile solutions will remain constrained in much of the Global South.

The systemic dimension of labor policies also requires attention. Independent couriers are central to last-mile delivery systems but often operate under precarious conditions. While sustainable practices such as electric vehicle adoption and improved delivery transparency can benefit couriers through safer and more efficient operations, approaches that focus narrowly on efficiency risk exacerbating work pressures and insecurity (Frehe et al., 2017). These dynamics suggest that systemic labor protections and fair compensation policies must be integrated into sustainability frameworks to ensure equitable outcomes.

Potential solutions to address these challenges have been widely discussed in the literature. Urban Consolidation Centres (UCCs) have been shown to reduce the number of delivery vehicles entering congested city centers, thus lowering emissions and improving efficiency (Paddeu et al., 2018; Nguyen et al., 2022). However, the success of UCCs depends heavily on policy support and collaboration among logistics providers, municipalities, and retailers. Data-driven innovations, such as route optimization algorithms and GIS-based systems, also hold promise for improving operational efficiency while reducing carbon footprints (Andrei et al., 2024; Purno et al., 2023). By leveraging real-time data, logistics firms can dynamically adjust delivery routes to minimize environmental impacts while maintaining service quality.

Sharing economy models, particularly crowd logistics, provide another avenue for overcoming barriers to sustainability. These models rely on decentralized networks of independent couriers, effectively mobilizing underutilized resources to improve efficiency and reduce environmental impacts. Research by Zhang et al. (2023) and Frehe et al. (2017) illustrates how crowd logistics not only reduces costs but also strengthens community participation in sustainable logistics. By integrating local actors into delivery systems, these models democratize sustainability, transforming last-mile logistics from a top-down corporate initiative into a participatory framework that engages communities.

The role of multi-stakeholder collaboration cannot be overstated. Paddeu et al. (2018) emphasize the importance of aligning government, industry, and civil society in advancing sustainable logistics

strategies. Similarly, Guo et al. (2019) and Cassaro (2025) demonstrate that cross-sectoral partnerships enhance resource allocation and foster innovation by combining diverse expertise and interests. Such collaborations are particularly critical in overcoming systemic barriers, as they pool resources to finance infrastructure, share knowledge, and establish governance frameworks conducive to sustainability.

While the current body of literature provides valuable insights, several limitations constrain the ability to draw definitive conclusions. First, much of the evidence is concentrated in developed economies, where supportive infrastructure and regulatory frameworks enable sustainability practices to flourish. This geographic imbalance limits the generalizability of findings to developing regions, where systemic challenges differ markedly. Second, the focus of many studies is on environmental and economic dimensions, often neglecting the social aspects of sustainability, such as labor welfare and equity in access to sustainable delivery options. Bonilla et al. (2024) and Jurburg et al. (2023) highlight the urgent need for more research on the social implications of sustainability transitions in logistics, particularly in contexts with weak labor protections. Third, longitudinal studies assessing the long-term impacts of sustainability practices on business operations, consumer behavior, and ecological outcomes are scarce. Without such data, it is difficult to evaluate the durability of current innovations or predict their systemic impacts over extended periods.

Future research should therefore pursue several directions. Comparative studies across diverse geographical and socio-economic contexts are essential to provide a more balanced understanding of global sustainability practices. Such research should explore how infrastructural limitations, policy frameworks, and consumer attitudes interact to shape sustainability outcomes in different regions. Additionally, interdisciplinary approaches that integrate insights from supply chain management, urban planning, environmental science, and labor studies can provide a more holistic picture of the sustainability landscape. Finally, greater attention to social sustainability, particularly the welfare of couriers and equity of consumer access to green delivery options, will ensure that sustainability frameworks do not perpetuate inequalities while pursuing environmental and economic goals.

CONCLUSION

This narrative review has examined the economic, environmental, social, and technological dimensions of sustainable practices in last-mile delivery logistics. The findings highlight that cost efficiency and service quality serve as critical enablers of sustainability, with evidence showing that environmentally responsible practices can reduce operational costs while simultaneously enhancing customer satisfaction and loyalty. Environmentally, the transition to electric vehicles, bicycles, and other green transport modes has proven effective in reducing carbon emissions, although significant disparities remain between developed and developing economies due to differences in infrastructure and policy support. Socially, the integration of sustainability into logistics improves both courier welfare and urban livability, yet risks remain when efficiency is prioritized without safeguarding worker protections. Technological innovation, including GIS-based optimization, autonomous delivery vehicles, and crowd logistics, offers promising solutions for overcoming systemic barriers, although adoption levels differ widely across global contexts.

The urgency of advancing sustainable last-mile logistics cannot be overstated, particularly given the rapid expansion of e-commerce and its disproportionate impact on urban emissions. Policy interventions are needed to support the development of green infrastructure, provide regulatory clarity, and incentivize investment in sustainable technologies. Collaborative frameworks among governments, industry, and civil society are also vital for addressing systemic barriers and ensuring equitable outcomes. Future research should expand comparative studies across diverse geographies, place greater emphasis on social sustainability, and include longitudinal assessments to evaluate long-term impacts. Ultimately, sustainable practices in last-mile delivery represent not only a logistical necessity but also a societal imperative, demanding coordinated strategies that balance economic viability, ecological responsibility, and social equity.

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