sustainability

MDPI

Article

Leveraging Drone Technology for Last-Mile Deliveries in the e-Tailing Ecosystem

Hokey Min

Allen and Carol Schmidthorst College of Business, Bowling Green State University, Bowling Green, OH 43403, USA; hmin@bgsu.edu

Abstract: The extended lockdown and limited in-person interactions resulting from the COVID-19 pandemic have radically changed many consumers' shopping behavior. These changes include a rapid rise in online shopping, leading to the fast growth of e-logistics. As the popularity of e-logistics has spread worldwide, many retailers' success hinges on their ability to deliver products to their consumers' doorsteps. This ability cannot be nurtured without handling last-mile delivery services in a cost-efficient and sustainable way. However, last-mile delivery services pose unique and complex challenges since they require individual, door-to-door services that limit the opportunity to consolidate small shipments into large ones and thus increase cost burdens for retailers selling products online. These challenges call for new, innovative ways of managing last-mile delivery services. Such practices include utilizing emerging drone technology that allows retailers to deliver products from point to point ubiquitously without a pilot, driver, or vehicle consuming too much fossil fuel. This paper is one of the first studies to develop viable strategic plans for commercializing drone technology in the e-tailing ecosystem using visual decision-aid tools and performance management systems.

Keywords: drone technology; last-mile delivery; e-commerce; sustainability; supply chain ecosystem

check for updates

Citation: Min, H. Leveraging Drone Technology for Last-Mile Deliveries in the e-Tailing Ecosystem. *Sustainability* **2023**, *15*, 11588. https://doi.org/10.3390/su151511588

Academic Editors: Ripon Kumar Chakrabortty and Wantao Yu

Received: 17 June 2023
Revised: 30 June 2023
Accepted: 26 July 2023
Published: 27 July 2023

1. Introduction

Accelerated by the rapid advance in digital technology and the lingering COVID-19 pandemic, a growing number of consumers have changed their shopping habits from traditional brick-and-mortar visits to online orders. Group M [1] recently reported that global retail e-commerce excluding food and delivery services, reached $3.93 trillion in 2020, amounting to $6.82 trillion by 2024, or 25% of comparable global retail sales. This explosive online sales growth has forced many retailers to transform their business models. The rationale is that online sales necessitate direct deliveries of ordered products to the consumers' doorsteps and require more complex, door-to-door transportation services. These services pose many difficult challenges since the conventional way of creating cheap volume shipments through freight consolidation is nearly out of the question. In addition, individual deliveries often require piece-by-piece order picking and separate but wasteful packaging. This kind of packaging is needed as the byproduct of online sales may also create environmental issues due to mounting packaging waste. Packaging waste can be a big part of online shopping due to the increased risk of spoilage during transit or the higher rate of product returns. For example, shipping perishable items such as meal kits or fruits requires insulated containers packed with dry ice and swaddled with bubble wrap. Kim et al. [2] found that online shopping generated 4.8 times more packaging waste than offline shopping, given the same amount of spending. A case in point is that an iconic e-tailer, Amazon, was found to generate 465 million pounds of plastic packaging waste in 2019 alone. Many of these might have ended up with our everyday ecosystems, fueling serious environmental concerns [3].

Recognizing the unique challenge of last-mile delivery services, drone technology has gained momentum as a viable alternative mode of transportation for e-tailing. Generally, a drone refers to an unmanned aerial vehicle that is typically guided by wireless GPS, cameras, and/or (inertial measurement) sensors that can deliver goods from point to point without a pilot [4]. The buzz around drones intensified after the FAA Reauthorization bill that was recently signed into law for testing and licensing commercial drones by 2015. Although a lack of regulatory approvals for the use of drones and their limited load capacity of five to seven pounds can still be a challenge, drones can revolutionize door-to-door, last-mile delivery services, particularly for reaching small, remote, sparsely populated areas where access to nearby airports is limited [4–6]. Due to drone technology's potential merits, more Americans tend to like the concept of drone delivery than dislike it, although its widespread adaptation may be several years away [7]. Suppose the current technological deficiencies associated with detection, safety, and flight stability can be overcome. In that case, drones can shuttle small packages (e.g., medical supplies, spare parts, books) from central depots or major airports to local pick-up centers or residential homes [4,5]. With this in mind, this paper explores ways to exploit drone technology as an integral part of the circular economy and e-tailing ecosystems in the digital era. Specifically, this paper intends to address the following research questions.

(1) How do we formulate a drone logistics strategy that helps e-tailers deploy drone technology for last-mile delivery services in cost-efficient and eco-friendly manners?
(2) What are the specific challenges and opportunities for leveraging drone technology in handling last-mile deliveries?
(3) What do we want to accomplish with last-mile drone logistics? How do we monitor the progress of a drone logistics project for its successful implementation? How do we measure such progress using the performance metrics relevant to drone logistics operations?

To answer the above questions, the next section summarizes selected prior studies that have become the foundation of current research. The literature review section is followed by the proposals of detailed strategic action plans that could be essential practical guidance for deploying last-mile drone logistics. Section 4 reminds e-tailers interested in last-mile drone logistics of a myriad of cautions to be exercised by drone technology adopters while presenting various managerial opportunities offsetting drone logistical challenges. This section also introduces key research tools, such as strategy map development, as an integral part of qualitative approaches. Section 5 develops specific performance metrics that are useful for evaluating drone logistics projects. The last section highlights this paper's key contributions and concludes with a fruitful future research agenda that extends the current research.

2. Prior Literature

According to Emergen Research [6], the global drone logistics market was estimated to be $7.5 billion in 2020 and is expected to reach $32 billion by 2028. One of the critical factors for the rapid growth of the drone logistics market can be attributed to a massive demand for the speedy delivery of goods when ordered online during the COVID-19 pandemic. Potential cost-saving opportunities created by drone use for last-mile delivery solutions are crucial to fueling the drone logistics market revenue growth. For instance, Prime Air delivery drones from Amazon could ship out parcels directly from the warehouse to the customer within 30 min for a minimal price of one dollar [8,9]. For this reason, e-tailers engaged in last-mile delivery services are considered the most appropriate logistics sector for deploying drone technologies. Rising demand for last-mile delivery by e-tailers such as Amazon drives steady demand for drone logistics operations and is expected to spur endless growth in the future as online transactions dominate the retail industry and drone technology advances over time.

Parallel with the popularity of drone usage, the literature studying drone technology in the logistics sector has risen considerably over the last decade [10–15]. For example, Bamburry [16] described how drones could be utilized for product deliveries based on Amazon, Google, and UPS cases. Despite the potential benefits of drone logistics, there are also alerts about the potential dangers of drone technology, including its vulnerability to product theft, collision with low-flying aircraft, and contraband smuggling. Smith [17] focused on the risks and legal challenges associated with drone technology due to its potentially abusive usage for privacy invasion, interference with commercial aircraft, and home security violations. Lokhande et al. [18] succinctly defined a drone as a quadcopter. They summarized its potential application areas (e.g., aid work in Africa, parcel delivery in Germany), the FAA regulations affecting drone logistics, technological advances in drone technology, and the advantages and disadvantages of drones. Khofiyah et al. [19] explored the possibility of using drone technology in urban areas in Indonesia and identified the critical success factors of drone logistics in Indonesia. These factors included carrying capacity, flight range, government regulations, operational costs, customer perception, environmental impacts, and drone routes and schedules. Sah et al. [20] identified various barriers to drone logistics based on expert opinions and a review of the literature. Some of the most critical obstacles included government regulations, and threats to privacy and security, whereas technical (e.g., flight range, carrying capacity) and economic issues (e.g., initial cost) were less critical. Moshref-Javadi and Winkenbach [10] proposed a systematic classification scheme of drone-based models for logistics while presenting a comprehensive review of drone applications in logistics practice and a synthesis of the extant research on drone logistics. Benarbia and Kyamakya [12] proposed a set of drone research issues and applications of drone technology to parcel deliveries based on a review of the literature. Some of these research issues included drone routing, drone charging station deployment, repositioning, and drone assignment. They also proposed a few future research agenda, including the cost optimization of drones, depots, and recharging station locations. Muricho and Mogaka [13] conducted a systematic review of the literature to explore the use of drone technology for retail logistics in Kenya. They reported that flight regulation, target retail market location, and the perceived benefits of drones could influence the performance of drone logistics.

As this review of the literature reveals, most of the existing literature has focused on the managerial impacts, application areas, technological developments, adoption determinants, and implementation barriers of drone technology. In contrast, the prior literature focusing on the environmental ramifications of drone logistics is scarce. In particular, studies examining drone logistics strategies from sustainable supply chain (SC) perspectives in the closed-loop ecosystem are almost non-existent. To overcome prior drone logistics research shortcomings, this paper develops a strategy map as a user-friendly, easy-to-follow, visual-decision aid tool for deploying a drone logistics strategy in last-mile e-logistics operations. It proposes key performance indicators (KPIs) for drone logistics from environmental (or sustainability) perspectives.

3. Strategy Map for Drone e-Logistics Deployment

This paper employed a strategy map to develop a drone e-logistics strategy, identify key influencing factors for successful drone deployment, and measure its outcomes from sustainable SC perspectives. Herein, a strategy map is a diagram that shows the organization's strategy on a single page [21]. It helps make the organization's strategic action plans transparent and communicates big-picture, long-term goals to every stakeholder in the organization in simple terms [22]. This map ensures that everyone in the organization is on the same page in pursuing the organization's long-term goals [23]. Figure 1 shows a strategy map for deploying drone technology for last-mile delivery services. This strategy map provides practical guidance with detailed action plans to engage an e-tailer's stakeholders, including managers and employees, when implementing last-mile drone logistics strategies. This map represents four different levels of the strategy from varying perspectives: (1) Financial, (2) Customer, (3) Internal, and (4) Innovation [21–23]. To elaborate, the financial action plans presented in this map propose ways to protect the e-tailer's shareholders' financial interests. Customer-oriented action plans primarily aim to enhance online customer satisfaction. Internal actions intend specific missions to be carried out by the e-tailer's management teams and employees. Innovation action plans are designed to develop ways to continuously innovate drone technologies with the goal of improving last-mile delivery performances.

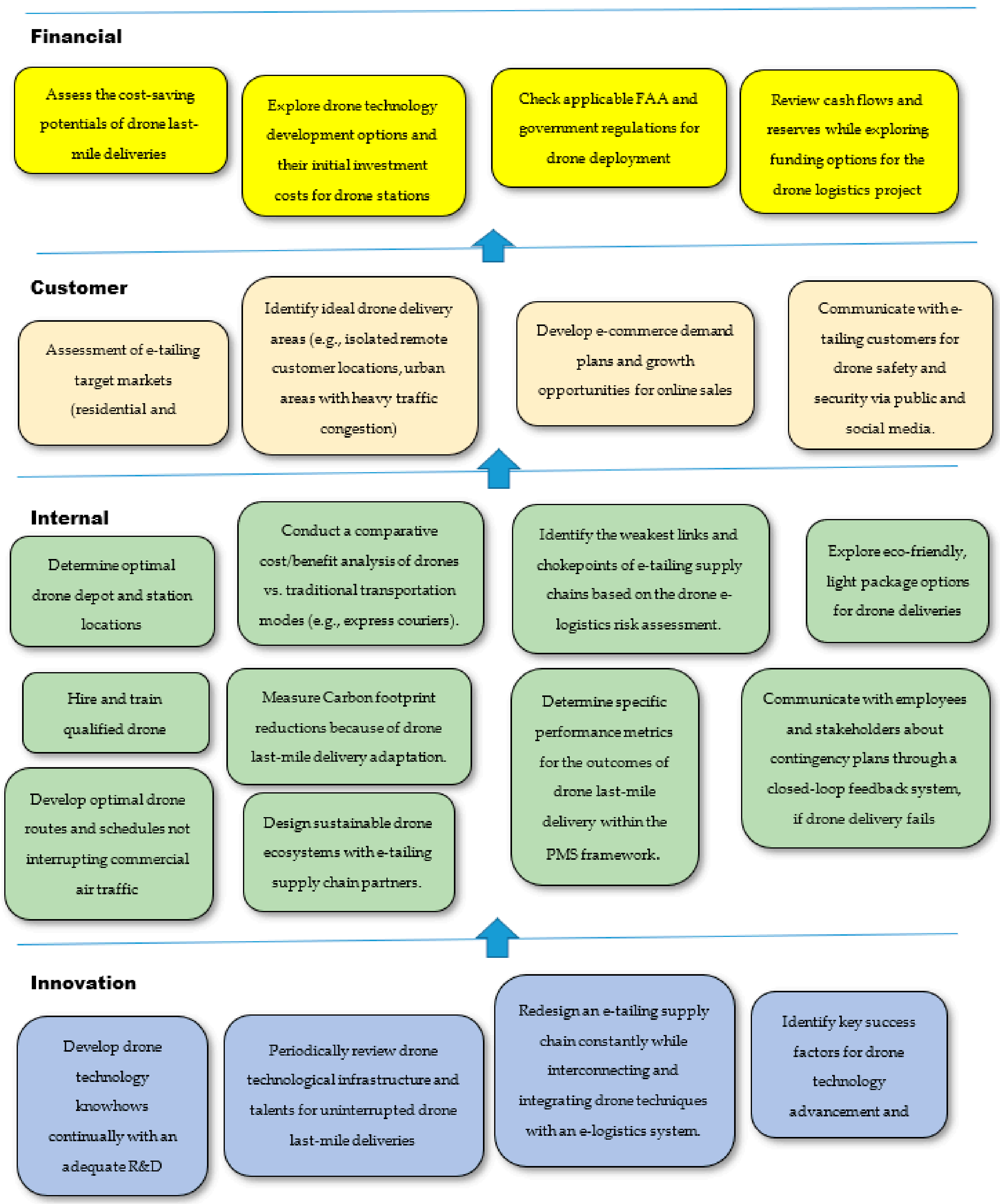

Figure 1. A strategy map of drone deployment for last-mile deliveries.

To better handle drone logistical challenges, e-tailers must identify the weakest link or the most vulnerable segment of last-mile delivery operations. This paper employs supply chain maps. A supply chain (SC) map is a graphical form of a communication device that helps decision or policymakers visualize information regarding drone deployment dynamics, e-tailing product flows, drone infrastructure links, and e-tailing supply chain partnership connections [23–25]. For illustrative purposes, Figure 2 displays the typical e-tailing SC map. This map is useful for identifying the weakest link or chokepoint of e-tailing SC and preventing SC bottlenecks and subsequent failures of drone logistics.

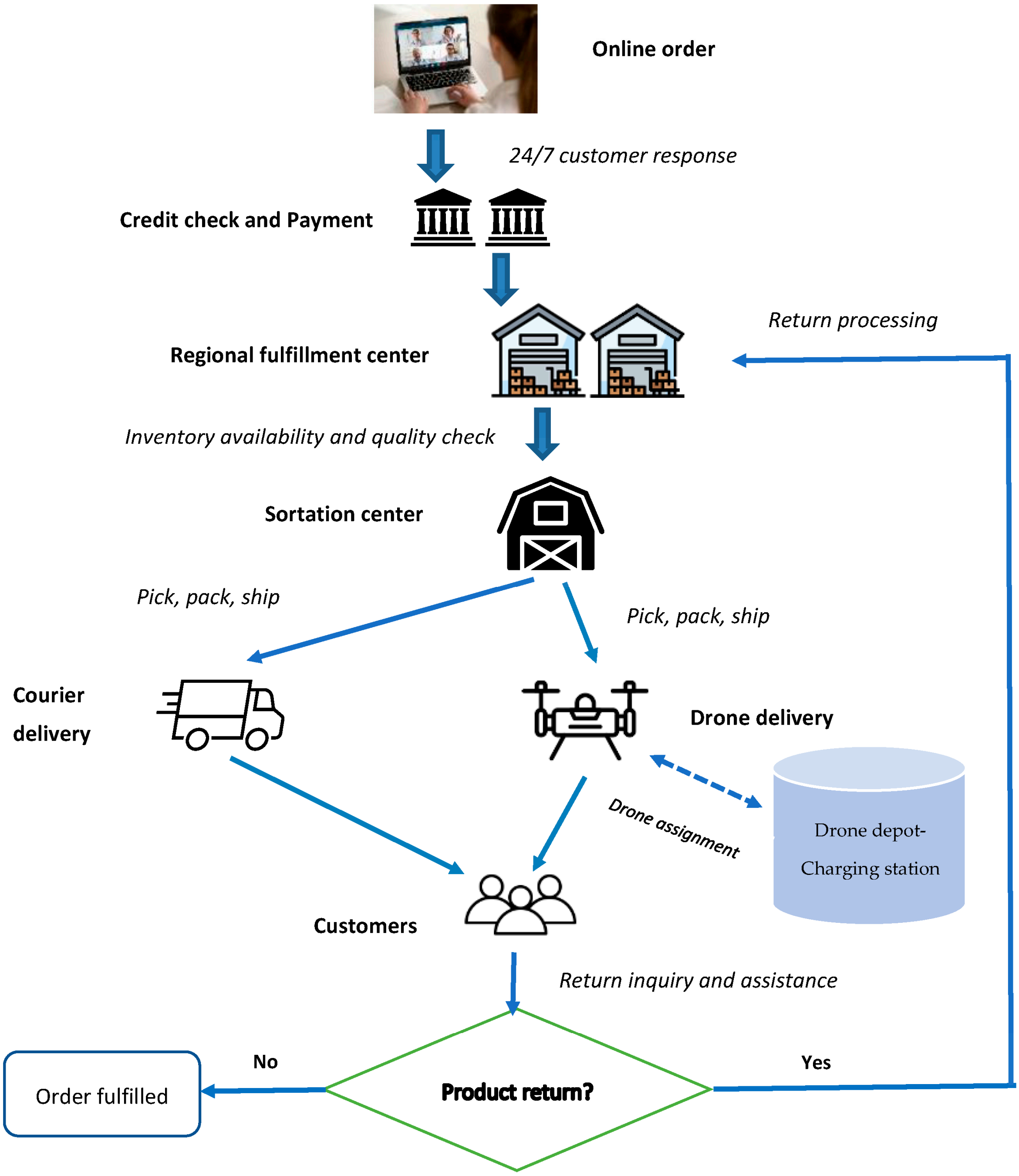

Figure 2. e-tailing supply chain map.

4. Challenges and Opportunities of Last-Mile Drone Delivery

The home delivery of a product ordered online leaves a lasting impression on e-tailing customers since this is likely the last touchpoint of online sales and the actual contact point between e-tailers and their customers. As such, a last-mile delivery service can dictate the e-tailing service quality and, thus, is crucial for retaining online customers.

Indeed, a vast majority (98%) of online shoppers tended to stake their brand loyalty on their delivery experience [26]. In particular, demand for fast last-mile delivery (one- or two-day delivery) skyrocketed by 92.8% from 2019 to 2020 [26]. However, speedy last-mile delivery could increase shipping costs due to its need for a faster but more expensive mode of transportation and a lack of freight consolidation opportunities with many point-to-point direct shipments and poor loading rates. DispatchTrack [27] reported that last-mile delivery for a small package in a high-density delivery area could cost approximately $10 each, while heavy packages in a low-density area were estimated to be around $50—that number could increase for big and bulky items or anything requiring installation. Last-mile deliveries can account for more than 50% (53%) of overall shipping costs and approximately 40% of the entire supply chain cost [27]. Since higher shipping costs increase online customers' delivery charges, e-tailers must trade between shipping costs and delivery speed. In addition to this dilemma, e-tailers should be mindful of environmental concerns associated with rising carbon footprints resulting from the frequent use of gasoline-powered trucks and vans. The carbon footprints of last-mile delivery typically range from 21 to 650 g CO_2 eq per kilogram of goods [28]. Another environmental concern stemming from last-mile delivery is the waste of packaging materials for individual, fragmented shipments. Bosona [29] indicated that last-mile delivery could significantly and negatively impact the sustainability of urban development and the least efficient part of the goods supply chain.

Considering the economic and environmental challenges of last-mile delivery operations, this paper explores a drone or an unmanned aerial vehicle (UAV) as a viable alternative mode of transportation. In 2022 alone, more than 2000 commercial drone deliveries were made every day worldwide [30]. Since a drone is an automatically guided aircraft without any human pilot on board, it does not incur substantial labor costs for loading, moving, and unloading products. According to ZipRecruiter [31], the average annual salary of a US truck driver is $64,900, the average hourly wage is $31.20, and the average driver's pay is estimated to be between 60 and 70 cents per mile as of May 2023. Although a drone operator needs a Remote Pilot 107 Certificate from the Federal Aviation Administration (FAA) and training, drone license and training are not as challenging as the commercial truck driver license and training because a drone operation requires relatively minimal technical backgrounds [32]. More importantly, drone operators do not create serious labor issues associated with truck drivers, such as unionized labor strikes and chronic truck driver shortages/turnovers. Except for restricted, controlled airspace, there is no need to secure any authorization to fly a drone, and thus, a drone offers quick clearance and flexibility [33]. A drone also has greater access to areas that are been inaccessible by foot or surface transportation (e.g., trucks, vans, and trains) [33].

Regarding environmental friendliness, each drone delivery per package costs only 6 cents of the energy cost for a five-mile trip, which is significantly less than USD 2.50 energy cost consumed by a gasoline-powered van for one package (216 cubic-inch package) delivery [30]. CO_2 emissions produced by drones are also substantially lower than the other means of transportation, including electric-powered vehicles [30]. Typical drones consume 94% lower energy per package than other vehicles [34]. A drone could reduce the delivery cost per mile from $2.50 to $0.05 and the delivery time from 30 min to 10 min, compared to conventional last-mile delivery using gasoline-powered vehicles [35].

Despite the benefits of exploiting drones for last-mile delivery, drone logistics poses some challenges. Since a drone uses a camera to deliver packages to the exact location, it can constantly record the actual location, property, and people without their consent. Thus, it may invade the privacy of customers or their neighbors [36]. To reduce privacy concerns, drone operators may need to develop geofencing to restrict the drone's movement into predetermined, authorized zones. Generally, high-end drones could have anywhere from 3.1 to 7.4 miles of flight range, while drones could fly up to 55,000 feet [37,38]. Thus, the drone still has a limited flight range and tends to hover at a relatively low altitude. Drone last-mile delivery operations should be constrained unless drone depots or stations are near customer locations.

5. Performance Management of Last-Mile Drone Logistics

Since undertaking the drone logistics project requires enormous amounts of time, financial and human resources, e-tailers need to ensure that their invested time and resources are well spent. Thus, a drone logistics project should be constantly evaluated and monitored for its progress toward serving online customers, achieving cost efficiency, and improving sustainability. Therefore, a performance management system (PMS) should be in place before implementing a drone logistics project for last-mile delivery. Generally, PMS is a systematic performance evaluation program that establishes a shared understanding of what is to be accomplished and how this can be accomplished by communicating business strategy to multiple stakeholders [39,40]. PMS consists of three phases: (1) setting performance expectations, (2) measuring the actual performance relative to the target expected performance (benchmark or performance standard), and (3) taking corrective actions for reducing or eliminating performance gaps between the actual performance and the benchmark. The details of the proposed PMS for a last-mile drone logistics project are illustrated in Figure 3.

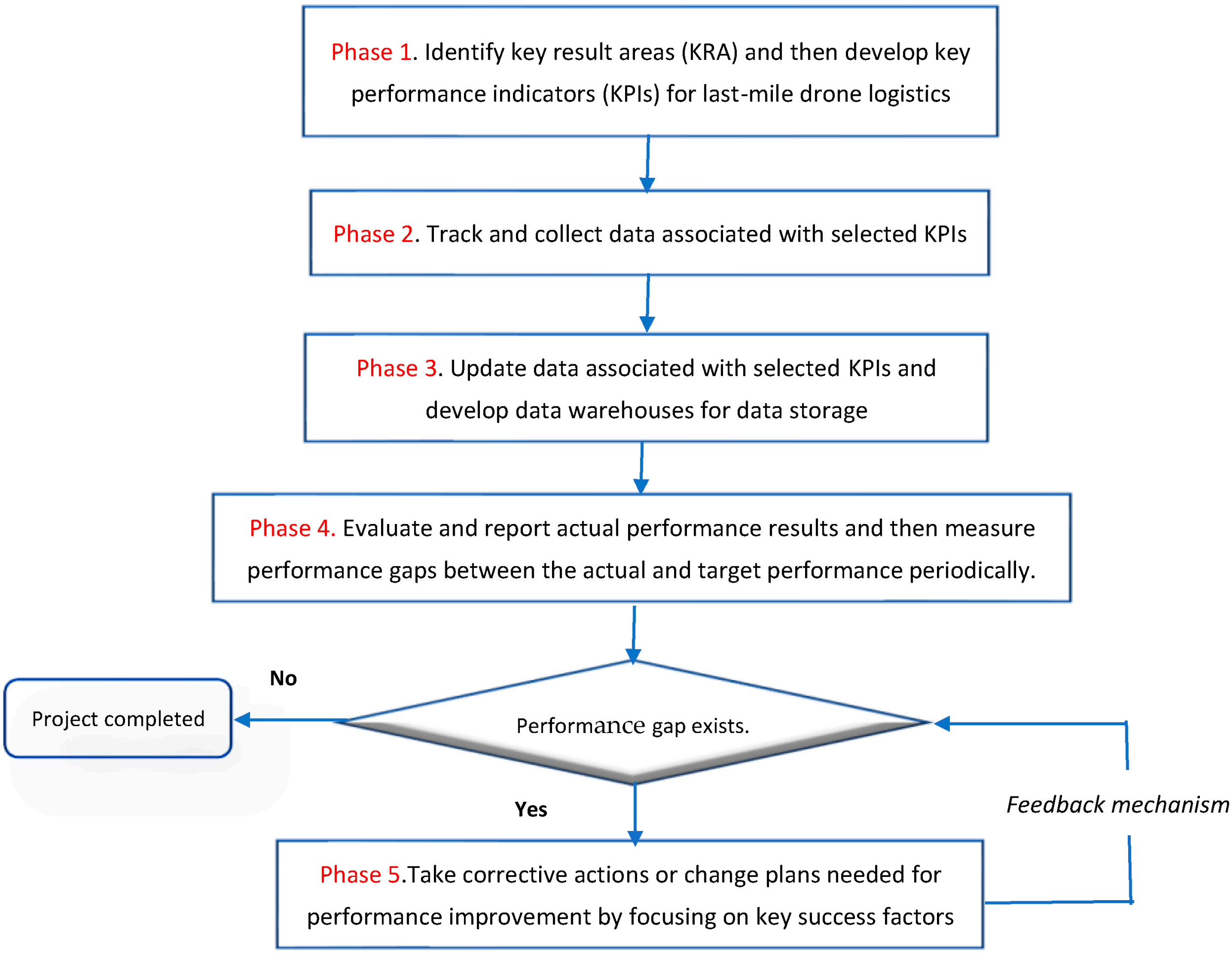

Figure 3. The proposed PMS for last-mile drone logistics.

The proposed PMS brings all the internal stakeholders (e.g., employees and top management) under a single strategic umbrella and unified performance standards. Since these standards should be aligned with KPIs, developing KPIs is a critical prerequisite to PMS. In developing KPIs, this paper followed four principles: (1) KPIs should address the key drivers of drone logistics success from both customer and internal perspectives; (2) KPIs should be universal and sharable across the entire company; (3) KPIs should be the basis of rewards for good performance; (4) KPIs should be objective and quantifiable.

With these principles in mind, Table 1 summarizes KPIs that are suitable for evaluating the performance of last-mile drone logistics operations. These KPIs intend to Nit fuel successful operations of drone logistics for last-mile delivery. Although financial measures such as profitability and annual sales revenue have been used extensively to monitor firm performance associated with the firm's strategic actions, financial measures alone cannot assess the firm's true operational efficiencies and long-term outcomes of firm performance [25]. Thus, within the balanced scorecard framework suggested by Kaplan and Norton [21], the proposed KPIs are divided into four different categories that reflect multiple stakeholders (including customers and management groups) viewpoints, as shown in Table 1.

Table 1. KPIs for last-mile drone logistics.

Perspective	Measure (Metrics)	Formula
Financial	Revenue on drone investment (RDI)	RDI = (Operating income after taxes/drone investment, including the cost of capital) × 100
Internal	Weight miles measuring the movement of packages over the total last mileage	∑ (weights such as pounds or kilograms per shipment × last miles each shipment traveled)
Customer	Freight claims ratio measuring the percentage of damaged or lost shipment	(Number of net claims compensated or paid in a given period)/(Total claims filed in a given period) × 100
Customer	Online order accuracy	(Number of online orders that have been fulfilled accurately and have reached their destination without any error in a given period)/(Total number of online orders in a given period) × 100
Customer	Drone delivery accuracy	(Number of timely, accurately delivered drone shipments)/(Total number of drone deliveries in a given period) × 100
Customer	On-time drone delivery	(Total number of drone deliveries − number of late and early drone deliveries in a given period)/(Total number of drone deliveries in a given period) × 100
Internal	Drone flight time	Flight time of a drone in minutes = [drone battery capacity in milliamp hours (mAh) or amp hours (Ah)] × Battery discharge rate in percentage allowed during the flight (e.g., 80%)]/[Average amp draw (AAD) of your drone, calculated in ampere].
Financial	The total cost of drone delivery per package	(Delivery cost per drone + maintenance and repair cost per drone + cost of capital per drone) × (number of drones used for last-mile delivery in a given period)/(total number of packages delivered by the drones in a given period)
Financial	Drone regulation compliance cost	[(FAA certificate cost per drone operator, including license application and test) × (number of drone operators)] + paperwork cost + anti-collision lighting cost + noise abatement cost
Innovation	Drone's carbon footprint	Metric tons of CO_2 equivalent (MT CO_2e) emitted by a drone per last-mile delivery
Innovation	Drone package waste management's carbon footprint	Metric tons of CO_2 equivalent (MT CO_2e) emitted by the drone package waste treatment

6. Conclusions and Future Research Agenda

As online orders continue to grow due to dramatic changes in post-pandemic shopping behavior and the widespread use of the Internet, last-mile delivery has become the daily routine for the e-tailing industry. The last-mile delivery, however, poses unique logistical challenges since it often requires point-to-point shipments with limited opportunity for freight consolidation and a cheaper mode of transportation, such as rail. Traditionally, trucks, vans, and motorcycles handle last-mile delivery services. Since these modes of transportation are mostly gasoline powered, they can deteriorate greenhouse gas (GHG) emission problems. In addition to this environmental concern, traditional modes of transportation for last-mile delivery are susceptible to chronic driver shortages and turnovers.

Nowadays, drones have emerged as a viable alternative to conventional modes of transportation. Renewable batteries typically power drones and are, thus, more energy-efficient and eco-friendly while not being constrained by urban traffic congestion. This paper has documented various managerial benefits of last-mile drone logistics operations and their ecological impacts while elaborating on the unique challenges of last-mile drone logistics.

In an effort to balance the drone's benefits against its shortcomings, this paper developed a strategy map that could help e-tailers visualize various action plans that are critical to the success of last-mile drone logistics operations. This paper also created a drone SC map to aid the e-tailer in identifying the potential chokepoints or the weakest links of last-mile drone logistics. Furthermore, this paper is one of the first studies to propose the PMS with specific performance metrics that are helpful in evaluating and monitoring the drone logistics project. This PMS is designed to guide first-time drone users in successfully implementing a drone logistics project. The unique features of this paper contribute to the body of literature examining the crucial role of drone technology in the fast-growing e-logistics sector.

Despite some novelties in this paper, it is far from perfect. To expand beyond the scope of this current study, future research endeavors could include a close examination of the impacts of online customer density, delivery time windows, battery charging station locations, and FAA drone regulations on drone logistics efficiency. Another fruitful area of future research includes gauging online customer satisfaction with last-mile drone delivery from both service quality and ecological perspectives.

Author Contributions: Hokey Min designed this research and wrote the entire article all by himself. The author has read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not Applicable since this study did not involve humans or animals for experiments.

Informed Consent Statement: Not applicable.

Data Availability Statement: Secondary data used in this paper may be available from the author upon request.

Acknowledgments: The author would like to express their deepest gratitude to Paul Hong of University of Toledo and Seung-Chul Kim of Han Yang University for their encouragement in this line of research.

Conflicts of Interest: The author declares no conflict of interest.

References

1. Group M. This Year Next Year: E-Commerce forecast. Group Business Intelligence. Available online: https://www.groupm.com/this-year-next-year-ecommerce-forecast/ (accessed on 25 April 2023).
2. Kim, Y.; Kang, J.; Chun, H. Is online shopping packaging waste a threat to the environment? *Econ. Lett.* **2022**, *214*, 110398. [CrossRef]
3. Chua, J.M. Online shopping has boomed in the pandemic. But what about all the packaging? *Vox*, 8 January 2021. Available online: https://www.vox.com/the-goods/22214017/online-shopping-pandemic-packaging-ecommerce-waste-plastic (accessed on 14 June 2023).
4. Min, H. *The Essentials of Supply Chain Management: New Business Concepts and Applications*; Pearson Education: Saddle River, NJ, USA, 2015.
5. Nonami, K. Drone technology, cutting-edge drone business, and prospects. *J. Robot. Mechatron.* **2016**, *28*, 262–272. [CrossRef]
6. Boyle, M.J. *The Drone Age: How Drone Technology Will Change War and Peace*; Oxford University Press: New York, NY, USA, 2020.
7. Office of Inspector General. *Public Perception of Drone Delivery in the United States*; Unpublished RARC Report, Report Number RARC-WP-17-001; United States Postal Services: Washington, DC, USA, 2016.
8. Emergen Research. Drone logistics and transportation market size to reach USD 31.84 billion in 2028. *PR Newswire*, 16 May 2022. Available online: https://www.prnewswire.co.uk/news-releases/drone-logistics-and-transportation-market-size-to-reach-usd-31-84-billion-in-2028-increasing-demand-for-last-mile-delivery-solutions-is-a-key-factor-driving-industry-demand-says-emergen-research-897502108.html (accessed on 17 May 2023).

9. Caon, V. How will drone corridors change the logistics sector? *Investment Monitor*, 16 January 2023. Available online: https://www.investmentmonitor.ai/features/how-will-drone-corridors-change-the-logistics-sector/ (accessed on 17 May 2023).
10. Moshref-Javadi, M.; Winkenbach, M. Applications and Research avenues for drone-based models in logistics: A classification and review. *Expert Syst. Appl.* **2021**, *177*, 114854.
11. Rejeb, A.; Rejeb, K.; Simske, S.J.; Treiblmaier, H. Drones for supply chain management and logistics: A review and research agenda. *Int. J. Logist. Res. Appl.* **2021**, *26*, 708–731. [CrossRef]
12. Benarbia, T.; Kyamakya, K. A literature review of drone-based package delivery logistics systems and their implementation feasibility. *Sustainability* **2022**, *14*, 360. [CrossRef]
13. Muricho, M.W.; Mogaka, C.O. Drone technology and performance of retail logistics. *J. Sustain. Dev. Transp. Logist.* **2022**, *7*, 73–81.
14. Maghazei, O.; Lewis, M.A.; Netland, T.H. Emerging technologies and the use case: A multi-year study of drone adoption. *J. Op. Manag.* **2022**, *68*, 560–591.
15. Eskandaripour, H.; Boldsaikhan, E. Last-mile drone delivery: Past, present, and future. *Drones* **2023**, *7*, 77.
16. Bamburry, D. Drones: Designed for product delivery. *Des. Manag. Rev.* **2015**, *26*, 40–48.
17. Smith, K.W. Drone technology: Benefits, risks, and legal Considerations. *Seattle J. Environ. Law* **2015**, *5*, 291–301.
18. Lokhande, A.P.; Shaikh, A.N.; Patil, O.S. Drones in production, supply chain and logistics. *Int. Res. J. Eng. Technol.* **2018**, *5*, 2179–2182.
19. Khofiyah, N.A.; Sutopo, W.; Hisjam, M. Identification of critical success factor for sustainable supply chain management drone logistics in Indonesia with ISM (Interpretive Structural Modeling) approach. In Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management, Singapore, 7–11 March 2021; pp. 6815–6826.
20. Sah, B.; Gupta, R.; Bani-Hani, D. Analysis of barriers to implement drone logistics. *Int. J. Logist. Res. Appl.* **2021**, *24*, 531–550. [CrossRef]
21. Kaplan, R.S.; Norton, D.P. *Strategy Maps: Converting Intangible Assets into Tangible Outcomes*; Harvard Business Press: Cambridge, MA, USA, 2003.
22. Min, H. Supply chain crisis management in the wake of the COVID-19 pandemic. *Int. J. Logist. Syst. Manag.* **2023**, *44*, 1–16.
23. Lea, B.R.; Yu, V.; Min, H. Data visualization for assessing the biofuel commercialization potential within the business intelligence framework. *J. Clean. Prod.* **2018**, *188*, 921–941. [CrossRef]
24. Gardner, J.T.; Cooper, M.C. Strategic supply chain mapping approaches. *J. Bus. Logist.* **2003**, *24*, 37–64. [CrossRef]
25. Min, H. *The Essentials of Supply Chain Management: Theory and Applications*, 4th ed.; Amazon Direct Publishing, Inc.: Seattle, WA, USA, 2023.
26. Convey. *Last Mile Delivery Wars: How to Keep Your Promises and Win with Reliability*; Unpublished White Paper; Convey: Austin, TX, USA, 2020; Available online: www.getconvey.com (accessed on 28 January 2020).
27. DispatchTrack. Breaking down last mile delivery costs. *Dispatch Track*, 18 June 2021. Available online: https://www.dispatchtrack.com/blog/last-mile-delivery-costs-breakdown (accessed on 22 May 2023).
28. Van Loon, P.; McKinnon, A.C.; Deketele, L.; Dewaele, J. The growth of online retailing: A review of its carbon impacts. *Carbon Manag.* **2014**, *5*, 285–292. [CrossRef]
29. Bosona, T. Urban freight last mile logistics: Challenges and opportunities to improve sustainability: A literature review. *Sustainability* **2020**, *12*, 8769. [CrossRef]
30. Cornell, A.; Kloss, B.; Presser, D.; Riedel, R. Drones Take to the Sky, Potentially Disrupting Last-Mile Delivery. *McKinsey & Company*, 3 January 2023. Available online: https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/drones-take-to-the-sky-potentially-disrupting-last-mile-delivery (accessed on 24 May 2023).
31. ZipRecruiter. Company Truck Driver Salary. Available online: https://www.ziprecruiter.com/Salaries/Company-Truck-Driver-Salary (accessed on 22 May 2023).
32. Equiknox's Drones. 10 Major Pros & Cons of Unmanned Aerial Vehicle (UAV) Drones. *Drone Technology*. 2020. Available online: https://www.equinoxsdrones.com/blog/10-major-pros-cons-of-unmanned-aerial-vehicle-uav-drones (accessed on 22 May 2023).
33. Pilot Institute. The Pros and Cons of Drone Technology. Available online: https://pilotinstitute.com/drone-pros-and-cons/ (accessed on 22 May 2023).
34. Carroll, D. Research Suggests Drones More Efficient for Last-Mile Deliveries. Available online: https://engineering.cmu.edu/news-events/news/2022/09/13-hydrogels.html (accessed on 24 May 2023).
35. Distribution Management. What Are the Benefits and Challenges of Using Drones for Last-Mile Delivery? *Distribution Management*, 27 April 2023. Available online: https://www.linkedin.com/advice/0/what-benefits-challenges-using-drones-last-mile (accessed on 24 May 2023).
36. Grinddrone. Pros and Cons of Delivery Drones. Available online: https://grinddrone.com/info/pros-cons-delivery-drone (accessed on 24 May 2023).
37. Gross, R.J. Drone Range: Find out How Far Can a Drone Fly? 2023 updated. *Propel*, 5 December 2022. Available online: https://www.propelrc.com/how-far-can-a-drone-fly/ (accessed on 24 May 2023).
38. Dronesgator. 15 Best Long-Range Drones in 2023 and How Far Drones Can Fly. Available online: https://dronesgator.com/long-range-drones/ (accessed on 24 May 2023).

39. Douwe, P.; Flapper, S.; Fortuin, L.; Stoop, P.P. Towards consistent performance management systems. *Int. J. Op. Prod. Manag.* **1996**, *16*, 27–37. [CrossRef]
40. Broadbent, J.; Laughlin, R. Performance management systems: A conceptual model. *Manag. Account. Res.* **2009**, *20*, 283–295.