Supply Chain Insider

Supply Chain Insider

Volume 10, Issue 01, 201. 10-10-23
Article Received: 15-08-2023
Accepted: 05-19-2023
Available Online: 03-10-2023
ISSN: 2617-7420 (Print), 2617-7420 (Online)
DOI: 10.5281/zenodo.10030778
supplychaininsider.org

Assessing the Challenges, Benefits and Public Acceptance of Drone Technology for Last-Mile Delivery in Bangladesh

Saad B A Hai[1], Md Joshim U[1]., Abdur Rahman R[1]., Moynul Hasan[1] & Md Mojammel[2].

[1] Institute of Business Administration, University of Rajshahi [2] Department Of Marketing, University of Rajshahi

Abstract

This paper examines the potential for using drone technology to enhance last-mile delivery operations in Bangladesh. A hybrid methodology combined a systematic literature review on drone delivery with primary data collection through surveys assessing public acceptance in Bangladesh. Results indicate cautious optimism towards drone adoption, with recognition of benefits like efficiency and sustainability but concerns around safety, privacy, and job impacts. Addressing these concerns through policies and public education will be key to successful integration. Demonstration projects evidencing reliable operations may also foster acceptance. While still facing limitations like battery life and payload restrictions, strategic focus on short urban routes offers near-term feasibility. Further technological improvements can expand capacity. Overall, deliberative integration of drones holds transformative potential to make last-mile delivery faster, greener, and more accessible.

Keywords: drone delivery, last-mile logistics, public acceptance, bangladesh, technology adoption

1. Introduction

As urbanization and eCommerce continue to grow at an unprecedented scale in developing countries such as Bangladesh, managing last-mile delivery—the 'final leg' of the supply chain—poses significant challenges (Aurambout, Gkoumas, & Ciuffo, 2019). This research paper delves into the promising potential of drone technology as a novel solution to enhance last-mile delivery in areas of Bangladesh.

1.1 The Global Influence of Drone Technology on Last-Mile Logistics

The landscape of last-mile logistics could undergo significant transformation with the introduction of drone technology. This innovation could become an integral part of supply chain automation, holding the potential to provide numerous advantages to both businesses and supply chain management (Mahmud et al., 2020). Following breakthrough announcements by companies like Amazon about their intended usage of drones for retail deliveries, there has been a burgeoning interest in understanding how drone technology will shape future logistics networks (Nicole Shearer, 2020). Notably, in the post-COVID-19 era, demand for touchless doorstep deliveries has surged significantly. Researchers suggest that drone deliveries can drastically change retail logistics networks, enabling better direct-to-consumer delivery strategies (Nicole Shearer, 2020).

1.2 Global Trends and Adoption of Drone Technology in Logistics

Existing research in the EU suggests that drone technology, once realistically deployed, could serve up to 7% of EU citizens—with future technological advancement potentially extending service coverage to 30% of citizens (Aurambout, Gkoumas, & Ciuffo, 2019). Similarly, drone technology is advancing logistics solutions in African countries and parts of Asia, demonstrating clear demand and a shift towards this innovative method (Zipline, 2022; Wonsang Yoo, Yu, & Jung, 2017).

1.3 Scope of the Study: Exploring the Potential Benefits and Challenges in Bangladesh

This paper, therefore, presents an exploration and assessment of the potential benefits, challenges, public acceptance and perception, and wider implications of implementing drone technology for last-mile delivery in Bangladesh's evolving urban landscapes.

2. Literature Review

Last-mile delivery, which constitutes the final crucial phase of transporting goods from central hubs to end-users, has long been plagued by inefficiencies and steep expenses (Wang et al., 2016). The intricate urban landscape of Bangladesh, particularly marked by formidable challenges like rampant congestion, severely restricted parking options, limited accessibility, and geographic constrictions in densely populated zones, has further exacerbated the complications faced during last-mile delivery endeavors (Chowdhury et al., 2022). In this context, conventional strategies heavily reliant on motorbikes and cycle rickshaws have proven to be agile yet environmentally detrimental (Chowdhury et al., 2022). However, to modernize and optimize the last-mile delivery ecosystem in Bangladesh, the advent of drone technology, characterized by its remarkable speed, unparalleled flexibility, and sustainability features, has been proposed (Scott & Scott, 2017). This comprehensive review meticulously examines the multifaceted landscape of drone technology, delving into its inherent challenges, far-reaching advantages, and the critical factor of public acceptance, all within the context of revolutionizing last-mile delivery dynamics in Bangladesh.

2.1 Challenges Enveloping Last-Mile Delivery in Bangladesh

The densely populated cityscape of Dhaka, plagued by ceaseless congestion, poses a formidable impediment to the swift execution of last-mile delivery services. The endemic issue of scarce parking facilities further compounds the predicament, presenting an onerous barrier to the unhampered mobility of delivery vehicles (Chowdhury et al., 2022). Such bottlenecks inevitably culminate in unwarranted delays, the exacerbation of pollution through vehicular idling, and a subsequent escalation of operational costs (Eskandaripour & Boldsaikhan, 2023). While conventional transport modes like motorbikes and rickshaws are inherently nimble, their concurrent contribution to congestion, emissions, and road accidents significantly diminishes their efficacy in this intricate equation (Chowdhury et al., 2022).

2.2 Revolutionizing Last-Mile Delivery through Drone Technology

As unmanned aerial vehicles (UAVs), drones transcend the limitations imposed by terrestrial congestion, harnessing the power of direct flight trajectories to drastically truncate delivery durations (Kim, 2015). Remarkably, drones not only circumvent such impediments but also tout the unique ability to access hitherto inaccessible locales, such as towering skyscrapers, thus elevating the scope and capacity of delivery services (Moshref-Javadi et al., 2021). Research underscores the potential for drones to effectuate a reduction of 30-70% in costs as compared to conventional vans, primarily by curbing fuel consumption and labor expenditure (Stolaroff et al., 2018). Moreover, the eco-friendly nature of drones, characterized by diminished emissions and noise pollution of traditional vehicles, augments their allure as an alternative delivery medium (Scott & Scott, 2017).

2.3 Global Precedents and Widespread Potential

On an international scale, expansive drone delivery networks are already operational in China, with industry giants like Amazon, UPS, Google, and DHL actively conducting delivery trials across the United States and Europe (Kim, 2015). Pervasive analyses consistently underscore the superiority of drones in terms of cost reduction, emissions mitigation, and streamlined delivery schedules, especially when juxtaposed against conventional last-mile methodologies (Moshref-Javadi et al., 2021; Wang et al., 2016). Such resounding success stories illuminate the transformative potential of drones within the logistics realm.

2.4 A Skyline of Opportunities for Bangladesh

In the context of Bangladesh, characterized by urban density and unyielding congestion, the proposition of drone delivery resonates as an astute solution. Drones, with their ability to traverse optimized aerial routes over narrow streets, have the potential to dramatically curtail last-mile transit times (Kim, 2015). Moreover, the vertical expanse of high-rise structures offers a plethora of landing sites, ensuring efficient drone-based parcel delivery (Moshref-Javadi et al., 2021). The implications are profound, encompassing reduced costs stemming from meticulous routing strategies (Chowdhury et al., 2022), mitigation of pollution by curbing road vehicle deployment (Scott & Scott, 2017), and a heightened safety quotient by minimizing traffic density and associated accidents. Additionally, drones harbour the capacity to extend delivery reach to remote and underserved areas, further expanding their utility (Eskandaripour & Boldsaikhan, 2023).

Despite their promise, drones have yet to fully surmount public apprehensions revolving around concerns such as noise pollution, safety, and privacy (Kim, 2015). The regulatory and infrastructural framework supporting drone operations remains in its infancy, characterized by a paucity of designated aerial corridors and landing hubs (Eskandaripour & Boldsaikhan, 2023). Technical hurdles, such as limited battery life, further temper the potential of drone integration (Sarker et al., 2021). A concerted and systematic approach to address these challenges is imperative to seamlessly assimilate drones into the intricate tapestry of last-mile delivery in Bangladesh.

3. Methodology

3.1 Hybrid Approach: Systematic Review and Data Collection

This research follows a hybrid methodology that combines a systematic review of existing literature from international and other countries' sources with Bangladeshi literature to comprehensively examine the challenges and benefits of drone technology for last-mile delivery in Bangladesh.

3.2 Systematic Review of Literature

The systematic review starts by conducting an extensive literature search in academic databases, such as Google Scholar, IEEE Xplore, Scopus, PubMed, and other reputable sources. The search focuses on studies, articles, conference papers, and reports that discuss drone technology implementation for last-mile delivery. Both international and Bangladeshi literature are considered to capture diverse perspectives.

In the systematic review, strict inclusion and exclusion criteria are applied to select articles that specifically address the challenges and benefits of using drone technology for last-mile delivery in similar areas. International and other countries' studies are included to fill the gaps and provide insights from similar environments.

Data extracted from the selected articles, regardless of their origin, are organized, synthesized, and compared to identify common themes concerning the challenges and benefits of drone technology for last-mile delivery. This approach ensures a comprehensive understanding of the subject matter beyond the limitations of Bangladeshi-specific literature.

3.3 Primary Data Collection - Surveys

In addition to the systematic review, primary data was collected through a structured survey consisting of three sections to assess customer perception and acceptance of drone technology in Bangladesh. The structured survey included both closed-ended and open-ended questions to capture quantitative and qualitative insights from a representative sample of residents in Bangladesh.

In Section 1, participants provided essential demographic information, including age, gender, and occupation, to contextualize the findings. In Section 2, participants used a Likert scale to rate their agreement with specific statements related to drone technology, assessing perceptions about efficiency, environmental impact, reliability, and future popularity. Section 3 included two open-ended questions aimed at capturing qualitative insights into participants' perceived benefits and concerns regarding drone use for last-mile delivery. The survey was distributed both online and through physical paper forms.

Throughout the data collection process, ethical considerations are diligently followed, with informed consent obtained from all participants, and measures taken to ensure confidentiality and anonymity.

3.4 Data Analysis

The survey data are analyzed quantitatively using statistical software to generate descriptive statistics and identify trends in customer perception and acceptance. Qualitative data are analyzed thematically, transcribed, coded, and grouped to extract meaningful insights specific to the Bangladeshi context.
The final step involves integrating the findings from the systematic review and primary data collection, allowing

for a comprehensive assessment of the challenges and benefits of drone technology for last-mile delivery. By combining international and other countries' literature with Bangladesh's perspectives, this hybrid methodology ensures a robust analysis, informed conclusions, and valuable implications for drone technology adoption in the specific context of Bangladesh's logistics.

4. Challenges of Last-Mile Drone Delivery:

4.1 Navigating Regulatory Labyrinth: Navigating the Regulatory Skies

The use of drones for delivery in Bangladesh is still in its early stages, and there are a number of regulatory challenges that need to be addressed before it can be widely adopted. The Civil Aviation Authority of Bangladesh (CAAB) has issued some guidelines for the use of drones, but these are not comprehensive and there is still a great deal of uncertainty about how drones can be used legally.

There are concerns about the safety of drone delivery, particularly in a densely populated country like Bangladesh. These concerns include the risk of drones colliding with people or objects (Cornell et al., 2023), the risk of packages falling from drones (Benarbia & Kyamakya, 2021), and the risk of drones being used for malicious purposes (Frąckiewicz, 2023).

Drone usage in Bangladesh has witnessed significant growth since 2016, reaching an estimated count of 7000 commercial and recreational users. The reason behind this surge is the government's initiatives like the introduction of the Bangladesh Drone Alliance (BDA) in 2018. However, the implementation of regulatory requirements like operator registration, licensing, insurance for delivery drones and designated no-fly zones, established by the Civil Aviation Authority of Bangladesh (CAAB), indicate the challenges faced in managing this technology (Frąckiewicz, 2023).

In order to address these challenges, the Civil Aviation Authority of Bangladesh (CAAB), needs to develop clear and comprehensive regulations for the use of drones. These regulations should address safety, privacy, and other concerns. The government should also work to raise awareness of the potential risks and benefits of drone delivery.

4.2 Technical Turbulence: Overcoming Technological Hurdles

Drones are still subject to a number of technical limitations, including battery life, adverse weather conditions, and limited payload capacity (Balassa et al., 2023). These limitations can affect the efficiency and reliability of drone delivery services .

Battery life is one of the most significant technical limitations of drone delivery. Drones typically have a battery life of only a few hours, which limits the distance they can travel and the amount of weight they can carry (Finio, 2020). This can make it difficult to use drones for last-mile delivery in large or spread-out urban areas (Gao et al., 2021).

Adverse weather conditions of Bangladesh can also pose a challenge for drone delivery. Drones are not able to fly in strong winds or rain, which can limit their operational hours. This can be a problem in many countries, as they are prone to adverse weather conditions (Gao et al., 2021).

The technical limitations of drone delivery can be addressed through technological advancements. For example, the development of longer-lasting batteries and drones that are more resistant to adverse weather conditions could make drone delivery more feasible. However, these advancements are still in the early stages of development, and it is unclear when they will be widely available.

4.3 Payload Puzzles: Beyond Weighty Limitations

The limited payload capacity of drones is a major barrier to the adoption of this technology for last-mile delivery. Businesses that offer drone delivery services are limited in the types of products they can offer, which can reduce their market share (Wang et al., 2023).

The limited payload capacity of drones is also a safety hazard. If a drone is carrying a heavy package, it is more likely to crash. This could pose a risk to people and property on the ground (Khalid et al., 2021).

Currently, most drones can only carry a few pounds of weight, which limits the size and weight of the items that can be delivered. This is a challenge for drone delivery companies, as they need to be able to offer a wide variety of products to their customers (Wang et al., 2023).

There are a few reasons why drone payload capacity is limited. One reason is that the weight of the drone itself, including the battery, motors, and other components, takes up a significant amount of space (Wang et al., 2023).

Another reason is that the aerodynamics of drones makes it difficult to carry heavy loads. Finally, the regulations governing drone flight often limit the maximum weight that a drone can carry (Nentwich & Horváth, 2018).

4.4 Constricted Skies: Breaking Through Flight Range Limits

Drones are also limited in their flight range (Hong et al., 2017). This means that they can only travel a certain distance from their takeoff point before they need to be recharged or refueled (Dukkanci et al., 2021).The limited flight range of commercially available drones poses challenges for utilizing them in last-mile delivery across Bangladesh. Consumer drones typically have a maximum flight time under 30 minutes, restricting their range to just 1-10 km before requiring recharge (Wang et al., 2016). This makes them unsuitable for long-distance deliveries between cities. While hobbyists can modify drones to extend range, most off-the-shelf models remain limited in endurance (Murray & Chu, 2015). This reduces the feasibility of reaching remote rural areas lacking road infrastructure. However, for short-distance deliveries within urban areas, restricted range is less problematic. Focusing on small-payload, intra-city delivery sectors aligns well with consumer drone capabilities (Rao et al., 2021). But as drone technology rapidly evolves, newer generations will likely offer expanded range and duration. Drone delivery services in Bangladesh must adapt platforms to maintain sufficient range for diverse coverage across both urban and rural locales. But the current range limitations make drones best suited for short, localized delivery routes rather than long-haul transport between population centers.

4.5 Airspace Tango: Choreographing Congestion and Coordination

Rising drone operations will intensify congestion in low-altitude airspace shared with conventional aircraft. Even though there are not many low-altitude aircraft is being used in Bangladesh, as more and more drones are used for delivery, it is important to ensure that they do not interfere with other aircraft or people. This will require the development of new regulations and procedures for managing drone traffic (Manrique et al., 2017).

The government needs to develop a framework for managing drone traffic in urban areas. This framework should include regulations on the use of drones in different airspaces, as well as procedures for coordinating drone flights (Hong et al., 2017).

The development of a framework for managing drone traffic is a critical step in the adoption of drone delivery. Without this framework, the safe and efficient use of drones for delivery will be difficult to achieve (Hong et al., 2017). Drones are sharing the airspace with other aircraft, such as aeroplanes and helicopters (Grote et al., 2022). This can create airspace congestion and coordination challenges, which can make it difficult for drones to fly safely and reliably.

4.6 Collision Quandaries: Steering Clear of Mishaps

Drones are vulnerable to accidents or collisions (Khalid et al., 2021). This is because they are small and difficult to see, and they can be easily damaged by wind or other weather conditions. If a drone were to collide with another aircraft or person, it could cause serious injury or death (Wild et al., 2016).

The potential for accidents or collisions is a major safety hazard associated with drone delivery. Businesses that offer drone delivery services need to take steps to mitigate this risk, such as using drones with collision avoidance systems and flying drones in well-lit areas (Ngui, 2020).

Avoiding obstacles like trees and power lines during drone flights is a global concern. In Bangladesh, it's just as crucial due to the country's dense urban fabric and natural terrain that involves rivers and forests (M. Kantardzic & Zhang, 2021). The government also needs to take steps to mitigate the risk of accidents or collisions involving drones. This could include developing regulations on the use of drones in certain areas, as well as requiring businesses to obtain insurance for their drone delivery operations.

4.7 Privacy and Secuity: Risk in the Open Sky

The monitoring potential of drone-mounted cameras raises significant privacy concerns (Seo et al., 2016). The threat of drones poses growing security concerns for critical infrastructure like nuclear facilities. Drones could be used by adversaries for surveillance, smuggling weapons or explosives, or carrying out kinetic attacks (Islam et al., 2018). Between October-November 2014, unidentified drones were spotted flying over 13 of France's 19 nuclear plants, exposing vulnerabilities (Islam et al., 2018). It is important to develop regulations that protect people's privacy and security when using drones for delivery (Seo et al., 2016).

These regulations should include restrictions on the use of drones in sensitive areas, such as military bases or government buildings. They should also include requirements for drones to be equipped with security features, such as encryption and geo-fencing (Mekdad et al., 2023).

4.8 Hacking Hazards: Shielding Against Unwanted Intrusions

Drones are also vulnerable to hacking or unauthorized access. This is because they are often connected to the internet, and they can be controlled remotely (Seo et al., 2016, p. 32). If a drone were to be hacked, it could be used to deliver dangerous or illegal materials.

The use of drones isn't limited only to commercial and personal purposes but includes law enforcement and border control surveillance teams, who employ drones for various operations (Siddiqi et al., 2022). Even in the face of catastrophic scenarios, search and rescue teams deploy drones to gather critical information or to drop essential supplies. On the flip side, these versatile tools can be leveraged by unethical users to achieve malicious objectives (Yaacoub et al., 2020).

Businesses that offer drone delivery services need to take steps to mitigate this risk, such as using drones with security features and encrypting their data. Utilizing technologies like blockchain, first introduced in 2008 by Satoshi Nakamoto (Haque et al., 2022), for data encryption could effectively aid in risk mitigation. Blockchain is widely acknowledged as the next revolutionary step in the realm of information technology, following the progression of computers, the Internet, and smartphones(Shikder et al., 2022).

5. Benefits of Last-Mile Drone Delivery:

5.1 Speedy Deliveries: Faster and More Agile

The integration of drone technology into last-mile delivery operations in Bangladesh has the potential to revolutionize the pace and agility of deliveries like never before. Drones offer unmatched speed advantages compared to traditional ground transportation methods. By taking direct aerial routes and bypassing congested roadways, drones can significantly shorten delivery times and provide near-instant fulfillment of customer orders (Scott & Scott, 2017). According to an studies, for the short OUS transport distances, drones decreased the transport times by of 30–40% during heavy traffic hours (Johannessen, 2022). This accelerated delivery pace aligns perfectly with evolving consumer expectations and demand for instant gratification. Customers today expect to receive purchases immediately with minimal wait times. Drone delivery provides the agility to meet these expectations and can reshape consumer perceptions of delivery speed.

The swift delivery capabilities of drones also enhance operational agility and flexibility for businesses. Companies can respond rapidly to customer orders or changes in demand instead of being constrained by traffic conditions. Drones circumvent congested urban areas through direct air routes, removing a major bottleneck that has long plagued ground transportation (Schweiger & Preis, 2022). Businesses gain the nimbleness to adjust delivery schedules and volumes on-the-fly based on real-time requirements. This gives companies a powerful competitive edge to provide superior responsiveness. Drones may also facilitate predictive analytics for deliveries using AI and machine learning.

Drones will provide particular speed advantages for time-sensitive deliveries such as medical supplies, critical spare parts, or other urgent shipments. While medical supplies may take days to reach remote areas by ground, drones can reduce this to a few hours, saving lives (Thiels et al., 2015). Drones also promise faster deliveries in disaster response scenarios for supplies like food, water and medicine by avoiding damaged infrastructure. A study found drones lowered drug delivery times to clinics in rural Tanzania from 4 hours to 15 minutes (Scott & Scott, 2018). Drones can support police operations by providing real-time aerial surveillance feeds faster than dispatching helicopters. The hyper-responsive capabilities of drones will be indispensable for time-critical applications.

5.2 Cost Savings: Financial Efficiency

The economics of last-mile delivery appear poised for major cost savings and financial optimization with the emergence of drone technology. Studies have estimated drone delivery to reduce per-package costs by 70% or more compared to standard delivery trucks (Stolaroff et al., 2018) and a 60% reduction in customer waiting time (Moshref-Javadi et al., 2021). These formidable cost reductions are driven by drones' greater energy efficiency and cuts to expensive labor costs associated with human drivers. Cost advantages extend throughout the delivery chain. Warehouse storage and sorting facilities can be right-sized and consolidated since drones enable faster turnaround trips and need minimal infrastructure (Stolaroff et al., 2018).

These substantial savings get passed onto businesses in the form of enhanced profitability and consumers through lower delivery fees. Delivery costs can be reduced to just a few dollars, granting access to a wider population, especially in emerging economies (Scott & Scott, 2018). Affordability may encourage consumers to opt for delivery rather than personal shopping trips, providing opportunities for expanded business reach and orders. Cost savings also allow companies to divert resources into other areas like better customer service or sustainability initiatives. The overhead reductions from drone delivery unlock new possibilities for operational strategy.

However, realizing the full cost-saving potential relies on massive scaling of drone networks for economy of scale. Building out city-wide drone infrastructure requires significant upfront investment, which may limit near-term cost benefits (Rao et al., 2021).

5.3 Enhanced Accessibility: Connecting Beyond Boundaries

One of the most socially transformative impacts of drone delivery technology lies in its potential to enhance access to goods for underserved communities bounded by geography. Drones can efficiently deliver to rural or remote areas with limited transport infrastructure that lack reliable roadway access (Thiels et al., 2015). This bridges a major logistical gap that has made home deliveries impractical for many rural consumers in Bangladesh dependent on making long drives to shops in distant towns and bazars. Drones change the equation by taking straight-line aerial routes beyond the constraints of ground terrain. Even remote areas with challenging geography like hills, forests and islands can be easily connected to delivery networks.

Drone delivery also provides accessibility to isolated communities with low population density where businesses find it unprofitable to operate ground delivery fleets. Serving these areas typically requires federal subsidies or charities (Flemons et al., 2022). But drones offer affordability and flexibility to connect rural towns and villages to on-demand delivery services that were previously out of reach. Enhanced rural access can provide economic uplift by linking producers and artisans to expanded urban markets. Drones also enable access to life-enhancing goods like medicine, vaccines, equipment supplies in remote areas to improve health and living standards that were hitherto logistically unfeasible (Scott & Scott, 2018).

Urban environments stand to gain accessibility too. High-rise apartments, multi-level buildings and congested districts remain difficult for trucks to penetrate. But drones offer rapid roof-to-door drop-offs without navigating streets (Kannan & Min, 2022). This opens delivery access to millions of city-dwellers in vertical neighborhoods. Drones also present opportunities to connect disadvantaged urban communities by bypassing infrastructure and security complications that limit surface access. The democratizing dimension of drones to bring delivery access across boundaries holds meaningful societal promise.

5.4 Improved Efficiency: Boosting Productivity

Drone delivery promises a massive leap in supply chain efficiency, enabling significant productivity gains for last-mile logistics operations. This allows fulfilling substantially more deliveries per vehicle. Drones also eliminate the need to return to a central warehouse after each delivery, further maximizing efficiency (Bertram & Chi, 2017). Vehicle capacity increases too since drones carry only small payloads.

The workforce efficiencies are just as substantial. Each drone can fulfill multiple deliveries in one flight on a continuous loop. This amplifies the productivity of human roles coordinating drone missions rather than performing individual trips. Drones will integrate into hybrid systems relying on humans and automation cooperatively. But the time savings add up to significant efficiency gains. According to the study by the University of California, Berkeley, drone delivery networks in cities could reduce greenhouse gas emissions by 6% to 54% compared to truck-based delivery, depending on the level of congestion and the type of drones used. The study also estimated that drone delivery could save up to 8.5 minutes per delivery, and reduce energy use by 9% to 28% per package (Shahzaad et al., 2023).

Efficiency also improves through drone delivery optimization algorithms and data analytics. Machine learning can closely match drone supply to fluctuating delivery demand for maximum productivity (Rao et al., 2021). Route optimization considers real-time constraints like weather, wind patterns and congestion to plot the most efficient drone missions. The layers of technological sophistication will amplify the underlying efficiency of drone delivery in Bangladesh.

5.5 Eco-Friendly Delivery: Sustainability Takes Flight

The ecological sustainability impacts projected from large-scale drone delivery adoption hold monumental importance as a tool to combat climate change. One study published in Nature found that greenhouse-gas emissions per parcel were 84% lower for drones than for diesel trucks, and drones also consumed up to 94% less energy per parcel than did the trucks(Kreier, 2022). This stems largely from drones eliminating idling time and traffic congestion and adopting direct point-to-point routes instead of meandering streets. Further gains arise from drones' exceptionally low energy consumption during flight and lighter-weight profiles. Lifecycle analyses estimate drone delivery operations to have around one tenth of the carbon footprint of ground-based delivery fleets (Goodchild & Toy, 2018).

The radically reduced emissions footprint aligns drone delivery with corporate sustainability goals and climate action initiatives. Logistics account for nearly 5% of global carbon emissions currently, presenting a major opportunity for improvement (Rao et al., 2021). Drone adoption helps businesses shrink their supply chain's environmental impact as part of CSR and ESG efforts. This also generates goodwill by showcasing a company's commitment to green innovation. From a policy perspective, drones help urban planners meet emissions reduction targets through clean delivery alternatives to legacy transport (Fu, 2021). Mainstream drone delivery integration is poised to directly contribute to vital climate change mitigation efforts. With conscientious implementation, drone delivery serves as a potent tool for environmental stewardship.

5.6 Urban Traffic Relief: Transforming Urban Mobility

The potential for drone delivery systems to alleviate chronic urban road congestion presents a major value proposition, both efficiency-wise and for improving quality of life. Traffic congestion costs the Bangladesh's economy between 6 to 10 percent of its GDP every year (Haider & Papri, 2021). That is equivalent to about $18.5 to $30.8 billion USD, based on the 2022 GDP estimate of $308.6 billion USD. This is a huge amount of money that could be used for other development purposes. Drones provide welcome relief by taking to the skies and bypassing clogged road networks. Widespread drone delivery adoption could significantly reduce truck trips from city roads each year (Wang et al., 2023). This eases traffic flows by reducing vehicular density, benefitting commuters, public transit and active transport modes.

The efficiency gains from mitigating congestion ripple throughout the transportation system. Studies have quantified that travel times reduced by just 5% during peak hours save billions in recovered economic activity (Rao et al., 2021). Drones also mean fewer delivery trucks occupying curbside access and parking spaces, opening up urban real estate for other uses. Decluttering the streets facilitates better urban mobility and smarter city planning centered on human-centric rather than vehicle-centric design principles. Planners can repurpose parking infrastructure and roadway lanes for parks, bicycle paths, dedicated bus routes and other amenities improving livability.

5.7 Safety Assurance: Secure Deliveries

Safety poses a critical concern when assessing new delivery methods like drones. But research suggests that drone delivery may significantly enhance safety across numerous dimensions compared to traditional ground transportation (Stolaroff et al., 2018). By eliminating onboard drivers, drone delivery removes major human risks associated with driving, including fatalities from accidents. Studies estimate drone delivery reduces driver deaths by over 90% (Scott & Scott, 2018). Incorporating cutting-edge encryption technologies like blockchain, which employs a decentralized encrypted database to enhance traceability of operations and streamline resource management within a corporate network (Hasan et al., 2022), has the potential to significantly bolster the security of anonymous data management. Autonomous control also averts driver exhaustion or distractions that trigger unsafe conditions. Drones constantly sense their aerial environment and can precisely maneuver to avoid collisions, minimizing crash risks.

Furthermore, drones separate delivery personnel from consumer interactions during drop-offs. This provides protection against assaults, injuries or abuse that delivery drivers unfortunately encounter (Scott & Scott, 2018). Customers also avoid risks from unsafe driving behaviors. Drones offer assured reliability without human variability. Drone delivery occurs in controlled airspace away from pedestrian and cyclist activity on the ground. This segregated operational environment enables intrinsically hazard-free interactions.

However, consumer privacy and nuisance concerns exist regarding low-flying drone activity and packages left on doorsteps vulnerable to theft (Rao et al., 2021). Malfunctions or software glitches also pose risks as with any technical system. Extensive fail-safes and redundancy are necessary to prevent unsafe drone behavior. But overall, the research firmly establishes drones as a far safer option compared to status quo ground delivery, where traffic fatalities remain high (Stolaroff et al., 2018). With prudent safeguards and infrastructure, drones significantly enhanced safety for all stakeholders involved in the delivery process. The lifesaving potential from removing risky human driving cements drones as an innovation priority.

5.8 Innovative Customer Experience: Exciting Customer Journeys

Drone delivery offers a gamechanger for elevating customer experience with cutting-edge innovation and futuristic appeal. The wow factor of deliveries arriving by drone rather than standard trucks injects novelty, excitement and convenience into the customer journey (Chen et al., 2022). This differentiates brands embracing drone technology as pioneering adopters shaping the future. Customers feel engaged as early co-creators of an emerging capability on the leading edge of possibility. The drones themselves essentially become marketing tools spreading awareness and visibility for their operators. To better understand the view of consumers, social media presents could be a remarkable avenue for engaging with audiences, enabling direct interaction through messages, reviews, comments, and user-friendly accessibility (Islam et al., 2022).

The drone delivery service can also be used in reverse logistics, where customers can request drones to pick up unwanted or defective products from their homes and return them to the retailer. This would enhance the customer experience and reduce the cost of reverse logistics for the retailer. (Benarbia & Kyamakya, 2021). AI integration lets drones interact verbally with customers upon arrival to confirm delivery instructions. Real-time tracking integration into company apps keeps customers informed each step of the process. Certain drones can even carry small screens to display personalized messages and advertising to the recipient (Jesse Young, 2023). Instead of simply facilitating transactions, drones allow brands to build memorable engagement moments. The strategic customer experience possibilities unlock value across marketing, sales and service.

5.9 Crisis Support: Aiding Humanity in Times of Need

Beyond daily commercial deliveries, drones hold invaluable life-saving potential when mobilized for crisis response scenarios as agile support assets. Drones grant quick access to deliver emergency supplies when ground infrastructure is damaged or unsafe (Thiels et al., 2015). Whether natural disasters, accidents or conflict, drones provide essential aid transport. Their small size allows navigating through tight spaces to affected populations. Drones also speed crucial data gathering using aerial imaging and sensors. This bird's-eye situational awareness supports superior crisis decision-making (Scott & Scott, 2018).

Medical applications draw particular interest regarding drone crisis support. Drones offer rapid response for moving vaccines, medicines, blood and organs safely over long distances with minimal delays (Balasingam, M. 2017). This promises major healthcare impact in remote or disaster-struck areas where mobility is constrained. Drones can even provide automated external defibrillators for cardiac arrest response. The emerging capabilities position drones as first responders in their own right alongside human teams. Lives will be saved by their ability to reach scenes faster. Drones can provide unprecedented speed in delivering medical supplies that are critical for patient care during disasters. Aerial access over terrain that ground transport cannot traverse makes them a versatile new platform for improving humanitarian outcomes. (T.C. Thiels et al. 2015).

6. Public Acceptance of Drone Technology for Last-Mile Delivery in Bangladesh

The survey on public acceptance of drone technology for last-mile delivery in Bangladesh garnered responses from 177 participants. This section presents a comprehensive analysis of the collected data, focusing on demographic information, attitudes, and perceptions towards drone technology, and the insights gathered from open-ended questions. The findings provide a nuanced understanding of the public sentiment surrounding the integration of drones in last-mile delivery services.

6.1 Demographic Profile of Participants:

The following tables (1,2,3) along with figures (1,2,3) provide an overview of the demographic distribution of participants in the survey on public acceptance of drone technology for last-mile delivery in Bangladesh:

Table 1. Age Distribution

Age Group	*Number of Participants*	*Percentage (%)*
18-24	84	47.5
25-34	43	24.3
35-44	29	16.4
45-54	16	9.0
55+	05	2.8

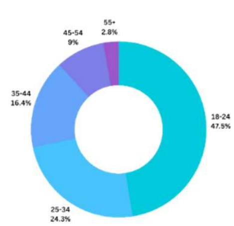

Figure 1. Age Distribution

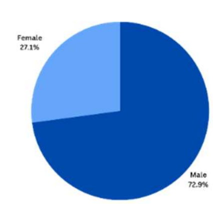

Figure 2. Gender Distribution

Table 2. Gender Distribution

Gender	Number of Participants	Percentage (%)
Male	129	72.9
Female	48	27.1
Others	0	0.0

Table 3. Occupation Distribution

Occupation	Number of Participants	Percentage (%)
Student	103	58.2
Professional	39	22.0
Business Owner	24	13.6
Other	08	4.5

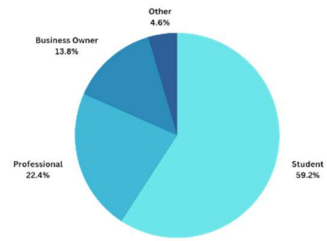

Figure 3. Occupation Distribution

6.2 Attitudes and Perception:

Participants were asked to indicate their level of agreement with statements related to drone technology using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The mean scores and standard deviations for each statement were as follows:

Table 4: Attitudes and Perception

Statement	Mean	Standard Deviation
Drones can improve the efficiency of last-mile delivery...	4.12	0.84
Drones can help reduce traffic congestion in urban areas...	3.98	0.91
I am concerned about the privacy implications of drone...	3.31	1.04
Drones are a reliable mode of last-mile delivery...	3.84	0.88
I believe drone delivery will become popular in the...	4.07	0.77

6.3 Open-Ended Questions:

Responses to the open-ended questions provided qualitative insights into the perceived benefits and concerns of using drone technology for last-mile delivery.

Table 5. Main Benefits of Using Drones

Main Benefits of Using Drones for Last-Mile Delivery in Urban Areas
Quick Delivery: A recurring theme was the recognition of drones' ability to expedite the delivery process.
Lower Cost: Several respondents acknowledged the potential cost-saving implications of drone delivery.
Time Savings: Many participants emphasized the time efficiency associated with drone technology.
Low Labor Force: Drones were seen as reducing the dependence on manual labor for last-mile delivery.
Reduced Environmental Pollution: Environmental benefits were highlighted, with participants noting the potential reduction in pollution.

Table 6. Challenges and Concerns About Drone Technology

Challenges and Concerns About Drone Technology for Last-Mile Delivery
Safety and Privacy: The dominant concern revolved around safety and the potential invasion of privacy.
Higher Cost of Implementation: Some participants expressed reservations about the initial investment required for implementing drone technology.
Payload Capacity: Concerns about the weight drones could carry and deliver were raised.
Lack of Understanding and Fear of New Technology: A lack of familiarity with drone technology and associated fear were highlighted.
Weather Conditions: The influence of adverse weather conditions on drone operations was a notable concern.

6.4 Discussion on the Data:

The data analysis underscores a generally positive outlook towards the integration of drone technology into last-mile delivery services in Bangladesh. Participants expressed optimism about the potential benefits, including enhanced efficiency, traffic reduction, and environmental preservation. However, concerns surrounding privacy, safety, and potential job displacement emerged as key considerations. The variations in mean scores across different statements reflect the nuanced nature of public perceptions.

The findings align with existing literature, indicating a blend of optimism and caution in embracing drone technology. The observed concern about privacy and potential job losses emphasizes the need for robust regulatory frameworks and public awareness campaigns. These findings are invaluable for policymakers, businesses, and stakeholders aiming to introduce drone technology while addressing public concerns and fostering public acceptance.

In the subsequent section, we delve into a comprehensive exploration of the broader implications of these findings, examining potential strategies to harness the benefits of drone technology while effectively addressing the identified challenges.

7. Results

The systematic review of both international literature and Bangladesh's sources revealed that drone delivery offers numerous potential benefits but also faces substantial challenges to integration. Identified benefits applicable to the Bangladeshi context include faster delivery times by avoiding congestion, lower costs and emissions due to efficiency gains, and improved safety through removing human drivers. However, challenges around regulations, technical factors like battery life, safety, infrastructure, and public acceptance emerge as critical considerations.

Analysis of survey data on public acceptance reinforces this mix of optimism and caution among Bangladeshis regarding drone delivery. Perceived benefits like speed, cost savings, and congestion reduction were weighed against concerns surrounding safety, noise, and privacy. This ambivalence highlights the need for policies and corporate practices that proactively address public concerns through means like community engagement, demonstrations, and transparency. Incremental adoption on limited short-haul routes may be advisable to establish operational reliability and trust.

While the literature affirms the considerable promise of drone delivery, realizing the full potential requires surmounting key challenges across regulations, technology, infrastructure, and public perceptions. A collaborative multi-stakeholder approach is vital, suggesting niche opportunities now and emphasizing ongoing technological advancement.

8. Conclusion

This study underscores the transformative potential of drone technology to modernize last-mile logistics in Bangladesh through gains in speed, efficiency, sustainability and accessibility. However, prudent integration demands addressing complex challenges across policy, technology, infrastructure, operations, and public perceptions. A phased approach focused first on suitable urban use cases with small payloads can demonstrate viability while allowing the system to mature. But realizing the full scope of benefits will require coordinated efforts across sectors to optimize drones for mass-scale delivery spanning the nation. With careful implementation, drones can provide greener, safer, and more inclusive last-mile services essential to Bangladesh's continued economic progress.

References

Balassa, B. E., et al. (2023). Sustainability aspects of drone-assisted last-mile delivery systems—A discrete event simulation approach. *energies*, 16(12), 4656. https://doi.org/10.3390/en16124656.

Balasingam, M. (2017). Drones in medicine—The rise of the machines. *International Journal of Clinical Practice*, 71(9), e12989. https://doi.org/10.1111/ijcp.12989.

Benarbia, T., & Kyamakya, K. (2021). A literature review of drone-based package delivery logistics systems and their implementation feasibility. *Sustainability*, 14(1), 360. https://doi.org/10.3390/su14010360.

Bertram, R. F., & Chi, T. (2017). A study of companies' business responses to fashion e-commerce's environmental impact. *International Journal of Fashion Design, Technology and Education*, 11(2), 6. https://doi.org/10.1080/17543266.2017.1406541.

Chen, C., Leon, S., & Ractham, P. (2022). Will customers adopt last-mile drone delivery services? An analysis of drone delivery in the emerging market economy. *Cogent Business & Management*, 9(1). https://doi.org/10.1080/23311975.2022.2074340.

Finio, B. (2020, June 23). Does Weight Affect a Drone's Battery Life? Retrieved from https://www.sciencebuddies.org/science-fair-projects/project-ideas/Aero_p053/aerodynamics-hydrodynamics/does-weight-affect-drone-battery-life (Accessed: 13 August 2023).

Chowdhury, M., Emelogu, A., Marufuzzaman, M., Nurre, S. G., & Bian, L. (2022). Drones for last-mile delivery: A review and future research directions. *International Journal of Production Economics*, 244, 108609. https://doi.org/10.1016/j.ijpe.2021.108609.

Cornell, A., Riedel, R. and Miller, B. (2023) Solving the 'last-meter' challenge in drone delivery, McKinsey & Company. Available at: https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/future-air-mobility-blog/solving-the-last-meter-challenge-in-drone-delivery (Accessed: 12 August 2023).

Dukkanci, O., Kara, B. Y., & Bektaş, T. (2021). Minimizing energy and cost in range-limited drone deliveries with speed optimization. *Transportation Research Part C: Emerging Technologies*, 125, 102985. https://doi.org/10.1016/j.trc.2021.102985.

Eskandaripour, H., & Boldsaikhan, E. (2023). Last-mile drone delivery: Past, present, and future. *Drones*, 7(2). https://doi.org/10.3390/drones7020077.

Flemons, K., Pham, T., Redmond, J. L., Lachica, J., Lane, C., ... Shebib, N. (2022). The use of drones for the delivery of diagnostic test kits and medical supplies to remote First Nations communities during COVID-19. *American Journal of Infection Control*, 50(8), 851. https://doi.org/10.1016/j.ajic.2022.03.004.

Frąckiewicz, M. (2023) Bangladesh's thriving drone sector: Opportunities and challenges, TS2 SPACE. Available at: https://ts2.space/en/bangladeshs-thriving-drone-sector-opportunities-and-challenges/ (Accessed: 14 July 2023).

Fu, E. (2021.). Autonomous drone networks are a faster route to sustainable supply chains. *World Economic Forum*. https://www.weforum.org/agenda/2021/11/drone-delivery-supply-chains/.

Gao, M., Hugenholtz, C., Fox, T., Kucharczyk, M., Barchyn, T., & Nesbit, P. (2021). Weather constraints on global drone flyability. *Scientific Reports*, 11, 12092. https://doi.org/10.1038/s41598-021-91325-w.

Goodchild, A., & Toy, J. (2018). Delivery by drone: An evaluation of unmanned aerial vehicle technology in reducing CO2 emissions in the Delivery Service Industry. *Transportation Research Part D: Transport and Environment*, 61, 58–67. https://doi.org/10.1016/j.trd.2017.02.017.

Grote, M., et al. (2022). Sharing airspace with Uncrewed Aerial Vehicles (UAVs): Views of the general aviation (GA) community. *Journal of Air Transport Management*, 102, 1-2. https://doi.org/10.1016/j.jairtraman.2022.102218.

Haider, M. Z., & Papri, R. S. (2021). Cost of traffic congestion in Dhaka Metropolitan City. *Public Transport*, 13(2), 287–299. https://doi.org/10.1007/s12469-021-00270-4.

Haque, A.K.M.Z., Shuvo, A.A., Hossain, M.M., & Ebrahim, J.A. (2022). A scenario of adopting blockchain technology in supply chain: A study of e-commerce in Bangladesh. *Supply Chain Insider*, 8(1), 37-51.

https://supplychaininsider.org/ojs/index.php/home/article/view/20.

Hasan, N., Khan, M.T., Fahmida Adiba, N., & Ibna Shams, K.A. (2022). Implementing blockchain in the supply chain of FMCG companies for better demand forecasting and logistics operation. *Supply Chain Insider*, 8(1), 89-102. https://supplychaininsider.org/ojs/index.php/home/article/view/18/.

Hong, I., Kuby, M., & Murray, A. (2017). A deviation flow refueling location model for continuous space: A commercial drone delivery system for urban areas. *Advances in Geocomputation*. https://doi.org/10.1007/978-3-319-22786-3_12.

Islam, M. S., Ahmed, M. M., & Islam, S. (2018). A conceptual system architecture for countering the civilian unmanned aerial vehicles threat to nuclear facilities. *International Journal of Critical Infrastructure Protection*, 23, 139-149. https://doi.org/10.1016/j.ijcip.2018.10.003.

Islam, T., Ruksana, R., Raihan, M.J., Zahin, F., & Afrin, L. (2022). An overview of the impact of social media usage on supply chain and customers in Bangladesh. *Supply Chain Insider*, 7(1), 25-50. https://supplychaininsider.org/ojs/index.php/home/article/view/7/.

Jesse Young. (2023, July 26). 5 best drones with screen on controller 2023. *DroneGuru*. https://www.droneguru.net/best-drone-with-screen-on-remote/.

Johannessen, K. A. (2022). A conceptual approach to time savings and cost competitiveness assessments for drone transport of biologic samples with unmanned aerial systems (drones). *Drones*, 6(3), 11. https://doi.org/10.3390/drones6030062.

Kannan, S.S. & Min, B.-C. (2022). Autonomous drone delivery to your door and yard, *2022 International Conference on Unmanned Aircraft Systems (ICUAS)*. IEEE. https://doi.org/10.1109/ICUAS54217.2022.9836219.

Khalid, M., Namian, M. & Massarra, C. (2021). The Dark Side of the Drones: A review of emerging safety implications in construction. *EPiC Series in Built Environment*. https://doi.org/10.29007/x3vt.

Kim, N. V. (2015). Automated decision making in road traffic monitoring by on-board Unmanned Aerial Vehicle System. *Indian Journal of Science and Technology*, 8(s(10)). https://doi.org/10.17485/ijst/2015/v8is(10)/85406.

Kreier, F. (2022, August 5). Drones bearing parcels deliver Big Carbon Savings. *Nature News*. https://www.nature.com/articles/d41586-022-02101-3.

M. Kantardzic, L. Zhang, "Data Mining: Concepts, Models, Methods, and Algorithms", John Wiley & Sons, 2021 (Book)

Mahmud, S., Parthib, N.H., Muntasir, T., & Hasan, M. (2020). Supply chain automation: Key stage in supply chain that can benefit. *Supply Chain Insider*, 3(1). https://supplychaininsider.org/ojs/index.php/home/article/view/33.

Manrique, P., Johnson, D., & Johnson, N. (2017). Using competition to control congestion in Autonomous Drone Systems. *Electronics*, 6(2), 1. https://doi.org/10.3390/electronics6020031.

Mekdad, Y., Aris, A., Babun, L., Fergougui, A. E., Conti, M., Lazzeretti, R., & Uluagac, A. S. (2023). A survey on security and privacy issues of UAVs. *Computer Networks*, 224, 109626. https://doi.org/10.1016/j.comnet.2023.109626.

Mehmet Tuğrul, K. (2023). Drone technologies and applications. *Drones - Various Applications* [Working Title] [Preprint]. https://doi.org/10.5772/intechopen.1001987.

Mohsan, S. A., Masud, M., Anwar, H., Shabbir, W., Iftikhar, S., Baloch, M. A., Javaid, N., & Khalid, A. (2023). Unmanned aerial vehicles (UAVs): Practical aspects, applications, open challenges, security issues, and future trends. *Intelligent Service Robotics*. Advance online publication. https://doi.org/10.1007/s11370-022-00452-4.

Moshref-Javadi, M., Hemmati, A., & Winkenbach, M. (2021). A comparative analysis of synchronized truck-and-drone delivery models. *Computers & Industrial Engineering*, 162, 107648. https://doi.org/10.1016/j.cie.2021.107648.

Murray, C. C., & Chu, A. G. (2015). The Flying Sidekick Traveling Salesman Problem: Optimization of Drone-assisted Parcel Delivery. *Transportation Research Part C: Emerging Technologies*, 54, 86–109. https://doi.org/10.1016/j.trc.2015.03.005.

Nentwich, M., & Horváth, D.M. (2018). The vision of delivery drones: Call for a technology assessment perspective. *TATuP - Zeitschrift für Technikfolgenabschätzung in Theorie und Praxis*, 27(2), 47,49. https://doi.org/10.14512/tatup.27.2.46.

Ngui, M. F. T. (2020). Crashed! Why drone delivery is another tech idea not ready to take off. *International Business Research*, 13, 251. https://doi.org/10.5539/ibr.v13n7p251.

Rao, B., Gopi, A. G., & Maione, R. (2016). The societal impact of commercial drones. *Technology in Society*, 45, 83–90. https://doi.org/10.1016/j.techsoc.2016.02.009.

Schweiger, K. & Preis, L. (2022). Urban air mobility: Systematic review of scientific publications and regulations for vertiport design and operations. *Drones*, 6(7), 179. https://doi.org/10.3390/drones6070179.

Scott, J.E. & Scott, C.H. (2017). Drone delivery models for healthcare. *2017 50th Hawaii International Conference on System Sciences (HICSS)*. https://doi.org/10.24251/hicss.2017.399.

Scott, J. E., & Scott, C. H. (2018). Models for drone delivery of medications and other healthcare items. *International Journal of Healthcare Information Systems and Informatics*, 13(3), 20–34. https://doi.org/10.4018/ijhisi.2018070102.

Seung-Hyun Seo, Jongho Won, Elisa Bertino, Yousung Kang, and Dooho Choi. 2016. A Security Framework for a Drone Delivery Service. In Proceedings of the 2nd Workshop on Micro Aerial Vehicle Networks, Systems, and Applications for Civilian Use (DroNet '16). *Association for Computing Machinery*, New York, NY, USA, 29–34. https://doi.org/10.1145/2935620.2935629.

Shahzaad, B., Alkouz, B., Janszen, J., & Bouguettaya, A. (2023). Optimizing drone delivery in smart cities. *IEEE Internet Computing*, 27(4), 32-39. https://doi.org/10.1109/MIC.2023.3267266.

Shikder, R., Siddique, Z., Ratul, E.F., & Tabassum, N. (2022). A roadmap for the implementation of blockchain technology throughout the rice supply chain in Bangladesh. *Supply Chain Insider*, 8(1). https://supplychaininsider.org/ojs/index.php/home/article/view/16/.

Siddiqi, M. A., Iwendi, C., Jaroslava, K., & Anumbe, N. (2022). Analysis on security-related concerns of unmanned aerial vehicle: Attacks, limitations, and recommendations. *Mathematical Biosciences and Engineering*, 19(3), 2641-2670. https://doi.org/10.3934/mbe.2022121.

Stolaroff, J. K., Samaras, C., O'Neill, E. R., Lubers, A., Mitchell, A. S., & Ceperley, D. (2018). Energy use and life cycle greenhouse gas emissions of drones for commercial package delivery. *Nature Communications*, 9(1). https://doi.org/10.1038/s41467-017-02411-5.

Thiels, C. A., Aho, J. M., Zietlow, S. P., & Jenkins, D. H. (2015). Use of unmanned aerial vehicles for Medical Product Transport. *Air Medical Journal*, 34(2), 104–108. https://doi.org/10.1016/j.amj.2014.10.011.

Velmurugan, S. S. (2020). Last mile delivery by drone. *International Journal of Engineering Research & Technology (IJERT)*, 8(7). http://dx.doi.org/10.17577/IJERTV8IS070129.

Wang, X., Liu, Z. and Li, X. (2023). Optimal delivery route planning for a fleet of heterogeneous drones: A rescheduling-based genetic algorithm approach. *Computers & Industrial Engineering*, 179, 2-3. https://doi.org/10.1016/j.cie.2023.109179.

Wang, X., Poikonen, S., & Golden, B. (2016). The vehicle routing problem with drones: Several worst-case results. *Optimization Letters*, 11(4), 679–697. https://doi.org/10.1007/s11590-016-1035-3

Wild, G., Murray, J., & Baxter, G. (2016). Exploring civil drone accidents and incidents to help prevent potential air disasters. *Aerospace*, 3, 22. https://doi.org/10.3390/aerospace3030022.

Yaacoub, J., Noura, H., Salman, O., & Chehab, A. (2020). Security Analysis of Drone Systems: Attacks, Limitations, and Recommendations. *Internet of Things*, 11, 100218. https://doi.org/10.1016/j.iot.2020.100218.