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Advancing Social Equity in Urban UAV Logistics: Insights from the Academic Literature and Social Media

Dong Zhang [1], Perry Pei-Ju Yang [2] and Jin-Yeu Tsou [1,*]

[1] Department of Architecture and Civil Engineering, City University of Hong Kong, Hong Kong; dzhan22@cityu.edu.hk
[2] College of Architecture, Georgia Institute of Technology, Atlanta, GA 30308, USA; perry.yang@design.gatech.edu
* Correspondence: jytsou@cityu.edu.hk

Abstract: In recent years, the rapid growth of e-commerce and on-demand delivery services has placed a significant strain on urban logistics systems. Technological advances such as unmanned aerial vehicle (UAV)-based logistics systems have thus emerged as promising solutions in urban environments and are increasingly being piloted worldwide. However, the implementation of UAV logistics risks exacerbating social inequities, particularly in marginalized communities that may disproportionately bear the noise and safety risks. To mitigate these risks, it is crucial to integrate social equity considerations into urban UAV logistics. This study explores social equity factors through a systematic literature review and social media analysis of Xiaohongshu (the Little Red Book), a popular Chinese social media platform known for its extensive user base and active discussions on social issues. This literature review involves a full-text examination, while latent Dirichlet allocation (LDA) topic modeling is used to analyze social media comment datasets. Each method identifies social equity factors and separately assesses their relative importance, resulting in the final identification of 24 key factors that provide a holistic view of public sentiment and academic discourse. The findings reveal a divide between academic concerns around systemic risks and a public focus on immediate needs. By synthesizing these insights, this study provides a social equity landscape for urban UAV logistics and actionable references for policymakers and stakeholders.

Keywords: UAV logistics; social equity; social impact; academic literature; social media

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1. Introduction

1.1. Emerging UAVs Logistics Industry

Over the past decade, the volume of urban deliveries, particularly for goods and e-commerce packages, has surged dramatically [1–3], imposing tremendous costs on cities such as rising traffic congestion [3,4] and higher emissions [5]. In New York, for example, delivering over 2 million e-commerce parcels daily requires around 7800 freight vehicles, occupying city streets for a total of more than 60,000 vehicle-hours each day [2]. The pressure is further intensified by consumers' growing demand for faster services, making the need for instant delivery solutions increasingly urgent. Whether for food, medicine, or everyday essentials, near-instantaneous fulfillment has become the new expectation—a phenomenon known as the "Amazon effect" [6], where rapid delivery has become the industry norm set by e-commerce giants. In China, Meituan, a leading instant delivery service provider, processed 21.9 billion transactions in 2023 [7]; by December 2021, China's online food delivery industry had reached 544 million users [8] and 13 million food delivery riders [9], meaning that for every 100 people, 1 is a food delivery rider, and 39 are ordering food online. It is undeniable that traditional logistics systems are under immense strain. The need for more efficient, safer, and cost-effective delivery methods has become increasingly urgent.

The innovation of drones dates back to the early 1900s, when they were developed initially as flying targets and simple attack tools [10]. Drones evolved through subsequent wars, primarily for military training and reconnaissance purposes [11]. Today, technological advancements in artificial intelligence, urban automation, 5G, Internet of Things (IoT), precise navigation systems, and advanced drone designs [12] have expanded drone use from military to diverse commercial and civilian applications such as photography, agriculture, disaster rescue, and aid operations [13]. In the logistic sector, drones, more commonly referred to as UAVs, have been poised to become a widespread mode of transportation due to benefits such as reducing road congestion and transportation emissions [14–16].

In response, logistics service providers and enterprises worldwide are actively conducting drone logistics pilots. Zipline offers fast, on-demand drone delivery for various sectors with autonomous drones, having completed 1.15 million deliveries, and transported 11.7 million items [17]. The Wingcopter 198 drone enables the rapid and reliable transport of critical healthcare supplies, such as blood, vaccines, and lab samples, to remote areas [18]. Google Wing's delivery drones now deliver groceries for Walmart in Dallas–Fort Worth, Texas, with over 350,000 commercial deliveries across three continents [19]. JD.com established its drone operations center in Suqian, using drones to navigate challenging terrain for efficient deliveries in remote villages [20]. The rapid expansion of drone logistics has brought significant socio-economic benefits in various areas. In remote areas, drone logistics improve access to essential goods and medical supplies, alleviating public health burdens and improving patient health outcomes [21]. Furthermore, drone deliveries support environmental sustainability by optimizing routes, thus lowering CO_2 emissions and fuel consumption [22]. In addition, drone delivery boosts cost-effectiveness in supply-chain management by enhancing logistics efficiency and reducing operational costs, offering more economical solutions for businesses [13].

However, this rapid growth may also encounter significant social resistance [23,24]. For example, Google Wing's drone operations in Australia initially followed a conventional path of technological expansion; however, public opposition in Canberra disrupted this trajectory [23]. Public trust is crucial for the widespread adoption of drone technology; if the expansion occurs too rapidly without addressing key issues, such as privacy and safety, it could lead to solidifying societal mistrust [24]. These underscore the need for a deeper exploration of the broader applications of UAV logistics, ensuring that its growth aligns with public expectations and benefits society.

1.2. Social Equity in UAV Logistics

Historically, technological innovations have tended to disproportionately benefit certain segments of society while marginalizing others [25–27]. In the transportation sector, for example, little attention has been paid to social equity [28]; while the negative impacts are now widely criticized, the damage is too significant to undo [29]. As drone logistics emerge as a new frontier in cities, similar concerns need to be addressed. Drones flying overhead can create noise and pose the risk of objects falling from the sky. Naturally, people would not want them constantly hovering over their homes. Consistent with broader findings in the environmental justice literature, higher-income neighborhoods may have more influence to prevent this, while lower-income areas could bear a disproportionate share of the noise and safety risks [30,31]. There is a risk that these systems will create or exacerbate inequities in urban environments. Statista data [32], derived from the comprehensive analysis of global consumer concerns, shows that these concerns have increasingly focused on social issues. Social inequities remain a top priority, underscoring the enduring importance of integrating equity considerations into urban drone logistics.

Definitions of social equity can vary, but all focus on the ideals of fairness, rights, and justice [33,34]. As highlighted by Walster et al., equity theory posits that mere equality (that is, everyone is allocated the same resources) is insufficient; individual contributions and needs should be considered. Achieving social equity requires a fair allocation of resources tailored to each person's specific circumstances [35]. Guy et al. stress the importance of

clarifying the distinction between equity and equality, asserting that social equity concerns the fair distribution of resources and opportunities within society [33]. Riccucci addressed the challenges of achieving gender and racial equality in public sector employment, emphasizing the necessity of promoting inclusivity and diversity [36]. Frederickson underscores the principle of social equity and civil rights in public administration and proposed proactive policies to support vulnerable groups [37]. Social equity is defined by key aspects that include ensuring equal opportunities for participation, the fair distribution of resources, the elimination of discrimination (e.g., gender, race, religion), the protection of civil rights, and the implementation of proactive policies to support disadvantaged groups [33–37].

In the context of UAV logistics, two key studies were drawn upon to contribute to the concept of social equity. Litman's study, "Evaluating Transportation Equity", categorizes equity into two types: horizontal equity, which ensures fair treatment for those with similar needs by ensuring the equitable distribution of resources and costs; and vertical equity, which supports providing additional resources to disadvantaged groups, thereby fostering inclusivity [29]. The work of Mendonca et al. on advanced air mobility introduced social equity, which focuses on the fair distribution of benefits and impacts within communities, and access equity, which emphasizes equitable access to transport infrastructure [28]. Building on these insights and their historical context, in this study, social equity within UAV logistics refers to ensuring that it does not disproportionately disadvantage any particular group, promoting the fair distribution of resources, leveraging technology to benefit the broader population, and ensuring that benefits are allocated to support those who are most in need while not placing a primary emphasis on factors such as race or gender.

1.3. Research Objectives, Methodology, and Significance

This study aimed to identify key equity drivers and map the equity landscape—which represents a dynamic system of interconnected social equity factors—in the implementation of UAV logistics. It provides a holistic view and actionable insights for policymakers and industry stakeholders, contributing to advancing social equity in UAV logistics.

Our research provides answers to the following questions:

- What social equity factors are discussed in the current academic literature?
- What concerns do the public raise regarding social equity in UAV logistics, specifically within the context of social media data from China?
- How can the analysis of studies in the academic literature and social media data reveal potential mismatches in perspectives, and how can these insights be synthesized for advancing UAV logistics?

To answer these questions, two sources of data are used in this study, studies in the academic literature and social media from the Little Red Book platform in China. The corresponding research methods include a systematic review and content analysis. This review examines existing studies in the academic literature that implicitly address equity within the discussion of social dimensions in drone logistics, identifies key factors, and organizes them into structured classifications. A social media analysis captures real-world comments on Xiaohongshu (the Little Red Book), a popular Chinese social media platform with a large user base and active discussions on social issues [38] that provides a rich data source for analyzing social perceptions. Latent Dirichlet allocation (LDA) is utilized to uncover critical themes that reflect users' real concerns. By deeply integrating and comparing insights from the two datasets, our research gets to the heart of key equity drivers in drone logistics.

Most previously compiled social media datasets have been in English. Xu's study [39] showed that out of 42 social media datasets, 31 focused on English content, while only 2 addressed Chinese content. Given the growing global influence of Chinese-speaking populations [40,41], the study of Chinese contextual data has become crucial for understanding their social dynamics. This study integrates Chinese-language social media into global discussions, enhancing the analysis of public attitudes across different cultural contexts.

This study aims to be the first to systematically explore social equity issues in drone logistics, shifting the traditional focus in the literature beyond technology. In particular, it is the first to utilize social media data to uncover public concerns about potential inequity, providing a fresh perspective on the issue. By comparing and integrating academic and social media findings, it provides an innovative approach to pave the way for future advances in urban planning and technology ethics, thus making a significant and forward-looking contribution.

This manuscript is structured as follows. Section 2 outlines the methodology, including the literature review and social media analysis. Section 3 provides a comprehensive review and analysis studies in the academic literature on social equity in UAV logistics and analyses public concerns through social media (the Little Red Book platform in China). Section 4 compares and bridges the academic and public perspectives, leading to an in-depth discussion of key observations, limitations, and suggestions for future research directions. Finally, Section 5 concludes the thesis by summarizing the main findings and implications.

2. Materials and Methods

2.1. Comparison and Integration of Literature Review and Social Media Insights

An innovative and robust approach was employed, involving a systematic literature review to identify social equity factors discussed in academic outcomes, alongside an analysis of social media data to capture public concerns and perceptions. The findings from the two datasets were then mapped against each other to create a cross-referenced understanding of social equity in urban UAV logistics.

This comparative analysis focused on identifying the overlaps and differences between academic and public perspectives. The overlaps highlight areas of consensus around the core concerns identified in relation to equity issues in urban UAV logistics. The differences reveal gaps in priorities and viewpoints. The findings from both datasets were then integrated to provide a deeper and more nuanced understanding of social equity in urban UAV logistics and a holistic view of the equity landscape.

2.2. Literature Review

While the current literature on UAV logistics does not explicitly discuss social equity, several studies address various social implications of fairness or inequity. This paper highlights these implicit aspects of social equity by analyzing the broader social issues in the literature. Although the studies identified do not directly address equity, they provide a foundation from which relevant social equity factors in the context of UAVs have been derived. This makes our study one of the first to focus directly on the issue of social equity within the field of UAV logistics.

The Scopus database was selected for its comprehensive coverage [42]. One limitation is that Scopus only searches metadata; thus, relevant studies without keywords in the title or abstract may be missed. To identify relevant studies in the literature, an advanced search was conducted using the following query:

TITLE-ABS-KEY(“UAV” OR “Drone” OR “Unmanned Aerial Vehicle*” OR “Unmanned Aerial System*” OR “Autonomous Aerial Vehicle*” OR “Uncrewed Aerial Vehicle*”) AND TITLE-ABS-KEY(“Logistics” OR “Delivery*”) AND TITLE-ABS-KEY (“Urban*”) AND TITLE-ABS-KEY(“social equity” OR “social impact” OR “social fairness” OR “social justice” OR “equity assessment” OR “disparity” OR “community impact”).

However, the search yielded only 8 results, none of which directly addressed the context of social equity, reflecting the underdeveloped and largely absent nature of this emerging field. Given the limited initial results, the scope of the data search was broadened using two sets of keywords (Table 1): “UAV logistics” AND “Urban*”. This adjustment allowed us to capture a wider range of relevant studies and ensured that no potentially valuable articles were missed. A total of 170 articles were obtained relating to UAV logistics in urban scenarios.

Table 1. Search keywords about urban UAV logistics in Scopus (accessed on 15 July 2024).

Include String 1		String 2
"UAV logistics" OR "Drone logistics" OR "Unmanned Aerial Vehicle logistics" OR "Unmanned Aerial System logistics" OR "Autonomous Aerial Vehicle logistics" OR "Uncrewed Aerial Vehicle logistics" OR "UAV delivery" OR "Drone delivery" OR "Unmanned Aerial Vehicle delivery" OR "Unmanned Aerial System delivery" OR "Autonomous Aerial Vehicle delivery" OR "Uncrewed Aerial Vehicle delivery"	AND	Urban

To ensure a focused and high-quality literature review, both exclusion and inclusion criteria were applied. First, the results were manually filtered, restricting the selection to articles and conference papers in English and excluding irrelevant fields such as immunology, nursing, and pharmacology. Next, the titles and abstracts were screened to shortlist articles that closely matched with our research objectives, excluding those that were not available to download. Finally, a full-text review of the shortlisted articles was conducted to assess their relevance to social equity in UAV logistics. After filtering, only 19 articles remained for the final analysis. Within these 19 articles, snowball sampling was used to identify additional relevant material. A further 11 articles were included, bringing the total number for final review to 30. This rigorous process (Figure 1) ensured that only articles providing substantial and relevant evidence were retained.

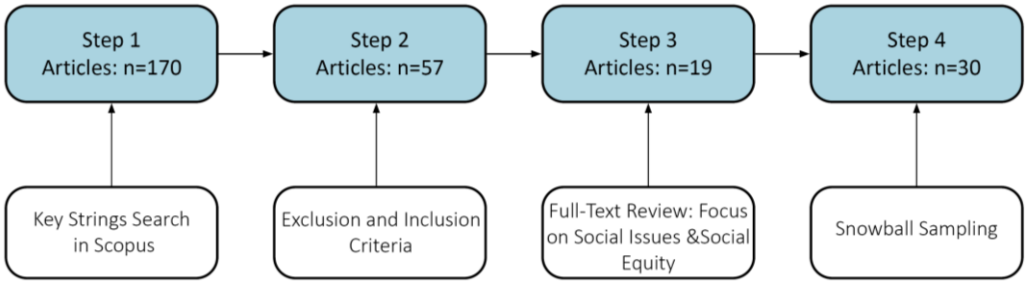


Figure 1. Literature review process flowchart.

2.3. Social Media Analytics

For a more thorough investigation, a social media analysis was incorporated to extract public insights and identify social inequity factors from a large dataset of comments. As of July 2024, there were 5.45 billion Internet users worldwide, representing 67.1% of the world's population [43]. Social networks have become part of many people's daily lives [44], and have become the main channel for expressing opinions and feelings. Social media analysis is a fast-growing research area aimed at extracting useful information [45,46]. Compared to various other data collection techniques, such as questionnaires, interviews, and focus groups, social media analysis works with a larger sample size [44], and allows researchers to gather more authentic, unfiltered information, free from the potential biases introduced by surveys or interviews. This method is particularly well-suited to our research objectives, as it captures real-world concerns and provides valuable insights into UAV logistics practices.

This study did not require ethical approval. All the information collected on social media platforms is in the public domain and does not involve user privacy in any interaction with the user [47].

The social media platform Xiaohongshu (the Little Red Book) was chosen because of its wide user base and active discussions on social issues. As of January 2023, Xiaohongshu had over 350 million users, making it one of the most influential social media platforms in China [38]. In the initial selection of suitable platforms for this study, other major Chinese platforms (Wechat, Weibo, Douyin and Zhihu) were also screened and evaluated. By man-

ually browsing relevant posts, and considering factors such as the quality of comments, accessibility of data, and degree of participation in discussions on social issues, Xiaohongshu was identified as the most suitable choice.

2.3.1. Data Collection

Web scraping was utilized (without time restrictions) to collect blog posts regarding drone logistics by targeting specific Chinese terms: [无人机物流] (UAV logistics), [无人机配送] (UAV delivery), [无人机外卖] (UAV food delivery). The initial search yielded over 1700 posts, many of which were not directly relevant. Unlike academic databases, the social media platform Xiaohongshu relies on an algorithmic recommendation system [48,49], leading to broader, less targeted results. To refine the dataset, a manual screening process was applied. Each post was reviewed based on its content, and the set was narrowed down to 74 blog posts that directly addressed UAV logistics or related applications. From these, post content, comments, timestamps, number of likes, and date details (Table 2) were extracted, resulting in a dataset of 13,578 comments for further analysis.

Table 2. Template of data collection containing core information.

Post Content	Example Comments	Likes	Date
[给我送外卖的居然是无人机!] "I was surprised that the drone was delivering food!"	[无法到达门口,一位外卖员失业。既不能更好服务消费者,也不能带动经济。] "Drone deliveries not only fail to reach the doorstep, but they also result in delivery workers losing their jobs. This does not improve service for consumers nor does it stimulate the economy."	1017	17 August 2023
	[是否可以在盖楼的时候每家每户设计送货通道,无人机送到屋顶,再传送到家里?] "I think when constructing buildings, each household could have a designated delivery channel. Drones could deliver the goods to the rooftop, and then they could be transferred to the home."	8	4 September 2023
	[无人机外卖比较适合公园、景区、人流少、距离远的特定地区。] "Drone deliveries are more suitable for specific areas such as parks, scenic spots, or places with fewer people and greater distances."	72	4 September 2023

2.3.2. Data Cleaning and Preparation

The Python package 'Jieba' was utilized for Chinese text cleaning, segmentation, and preparation [50]. The raw data underwent a rigorous filtering and cleaning process using the 're' module in Python, including the removal of spaces, punctuation marks, hashtags, duplicate content, usernames following the '@' symbol, and numeric data, to focus solely on textual content. The segmentation of Chinese words was necessary because there are no obvious separators between Chinese words [50], and the segmentation process was as follows (Table 3).

Table 3. Template of the Chinese word segmentation process.

Initial Comments	Segmentation Words
以后送外卖的都不好找工作了,而且美团有制空权吗? 如果无人机多了,天上汽车再多了, 都看不见美丽的天空咯。	[以后], [送外卖], [不好], [找工作], [美团], [制空权], [无人机], [天上], [汽车], [看不见], [美丽], [天空]

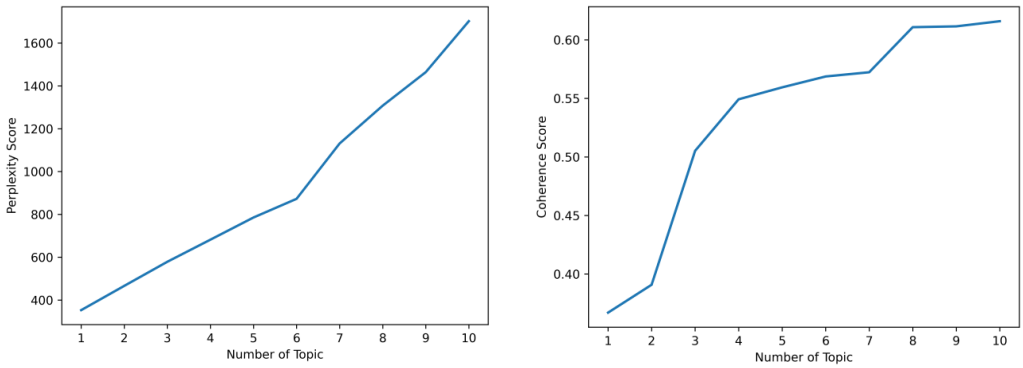
Most importantly, three specialized text libraries—a custom dictionary, a synonym dictionary, and a stop-word dictionary—were developed specifically for the commentary text, ensuring high-quality results. For example, the synonym dictionary included various terms related to "unemployment", such as [失业], [失去工作], [取代骑手], [失去饭碗],

[保不住饭碗], [下岗], and others. Although these Chinese terms comprise different characters, they carry the same meaning. To ensure the accuracy of this analysis, the synonyms need to be normalized and combined into the same standard form, which requires human intervention to define these synonyms and ensure the integrity of the results. The custom dictionary handled fixed Chinese phrases, such as [五险一金] (five social security funds and one housing fund), which would otherwise be incorrectly segmented as [五险] (five insurances) and [一金] (one fund). The stop-word dictionary removed hundreds of non-contributory words, such as [从而] (thus), [除非] (unless), [无人机] (drones), etc., thus preserving the effectiveness of the cleaned corpus [39]. Building these libraries required extensive iterations and reviews, with dictionaries being continuously refined and updated to improve data quality.

2.3.3. Topic Modeling

Topic modeling with latent Dirichlet allocation (LDA) is a computational content analysis technique that can be used to explore the 'hidden' thematic structure of a given collection of text [51]. LDA's ability to systematically uncover themes in large datasets has been valuable in fields such as health, politics, social media analysis, and opinion mining [52]. LDA was used to identify the main themes discussed in relation to UAV deployment and the model was trained on our prepared dataset (13,578 comments processed).

To determine the optimal number of topics, which is crucial for effective modeling, both the coherence and perplexity metrics of the processed database were analyzed [51]. The perplexity metric is the most widely used measure to determine the statistical goodness-of-fit of a topic model [53]. Coherence measures how interpretable the topics are based on the co-occurrence of words. In other words, higher coherence scores suggest that the topics make sense, while lower perplexity values indicate that the model is better at predicting the data and has captured the underlying patterns more effectively. The results from these metrics provided a variation curve along with the number of topics (Figure 2).



(**a**) Perplexity score curve for 1–10 topics (**b**) Coherence score curve for 1–10 topics

Figure 2. (**a**) Perplexity measures the statistical goodness of fit of the topic model, with lower values indicating a better fit to the data; and (**b**) coherence assesses the interpretability of topics, where higher scores suggest that the topics make more sense.

The process began with a close examination of the perplexity curve (Figure 2a), which rose rapidly when the number of topics exceeded six, indicating a higher risk of overfitting. Consequently, the selection was limited to six topics or fewer. Next, the coherence score (Figure 2b) was considered, which showed a relatively stable and high value from four to seven topics. Based on our extensive observations, four to six topics were chosen as the most appropriate, and the number of topics was then manually adjusted (four, five, and then six) to assess the interpretability and accuracy of the results. With four topics, certain high-frequency words, such as [出去取] (pick up) and [送上门] (delivered to the door), appeared in different topics, even though both described the convenience of delivery, suggesting that some related concepts were split into separate topics. In contrast, six topics led

to significant overlap, blurring distinctions. When testing with five topics was tested, there was only a small overlap between topics 4 and 5 (Figure 3), and the high-frequency words within each topic showed a better clustering of similar terms. This suggested, based on our manual assessment, that five topics best represented the underlying data structure. The inter-topic distance map (Figure 3), generated via multidimensional scaling (MDS), visualizes the relationships between topics, illustrating both their distinctiveness and overlaps, with the size of each circle representing the relative prominence of each topic in the dataset.

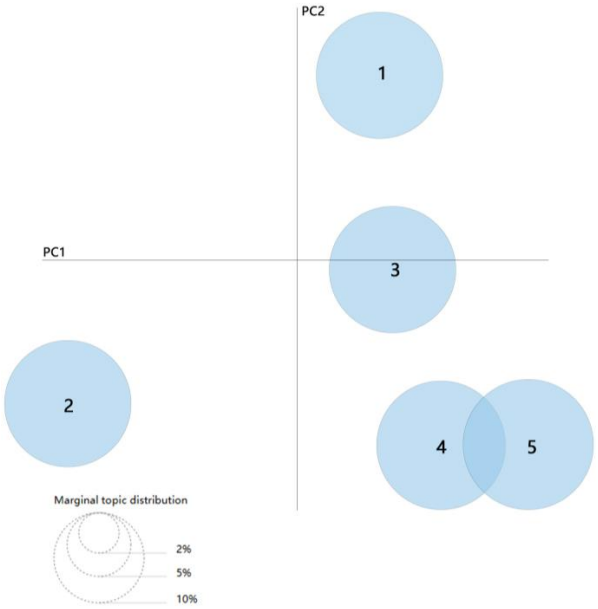


Figure 3. Inter-topic distance map (via multidimensional scaling) generated in LDA.

2.3.4. Topic Interpretation and Validation

A well-known challenge of LDA-based topic analysis is that it struggles to fully capture the contextual meaning behind words, which sometimes makes it difficult to find a reasonable explanation for certain topics. To address this issue, a three-step procedure was developed. First, it was decided that all topic models would contain a fraction of uninterpretable words, which would need to be excluded [51]. Second, the most prominent and relevant words were focused on, and their semantics were examined in the context of the comments [53] to accurately capture the meaning of the topics (Table 4). Third, a full-text database investigation [51,53] was required to manually capture the topics, which, together, better explained the LDA topic results. This is an iterative validation process to ensure that the final topic set accurately reflects the key topics present in the data. By integrating the manual findings with the machine learning results, a set of topics that were both meaningful and aligned with our research objectives was generated.

Table 4. Samples of lexical semantic interpretation in the context of comments.

Core Words	Comment Samples	Semantics
[回收] Recycling [包装] Packaging [浪费] Waste	[外卖箱回收没有浪费。] "The method of recycling delivery boxes does not create waste." [希望回收包装后会有清洁。] "I hope the delivery boxes will be cleaned after they are recycled."	Indicate public strong concerns about environmental protection and sustainability.

Table 4. *Cont.*

Core Words	Comment Samples	Semantics
[意义] Meaning	[没解决最后一公里就毫无意义。] "Drone delivery is pointless if it doesn't solve the last-mile problem." [要下楼取还要回收盒子,意义在哪?] "Drone delivery not only fails to deliver to the home but also requires the delivery boxes to be retrieved. What's the point of it?"	Question the purpose and value of certain aspects of UAV delivery services.

The following methodology flowchart (Figure 4) outlines the entire step-by-step process for conducting our social media analysis of the Little Red Book dataset.

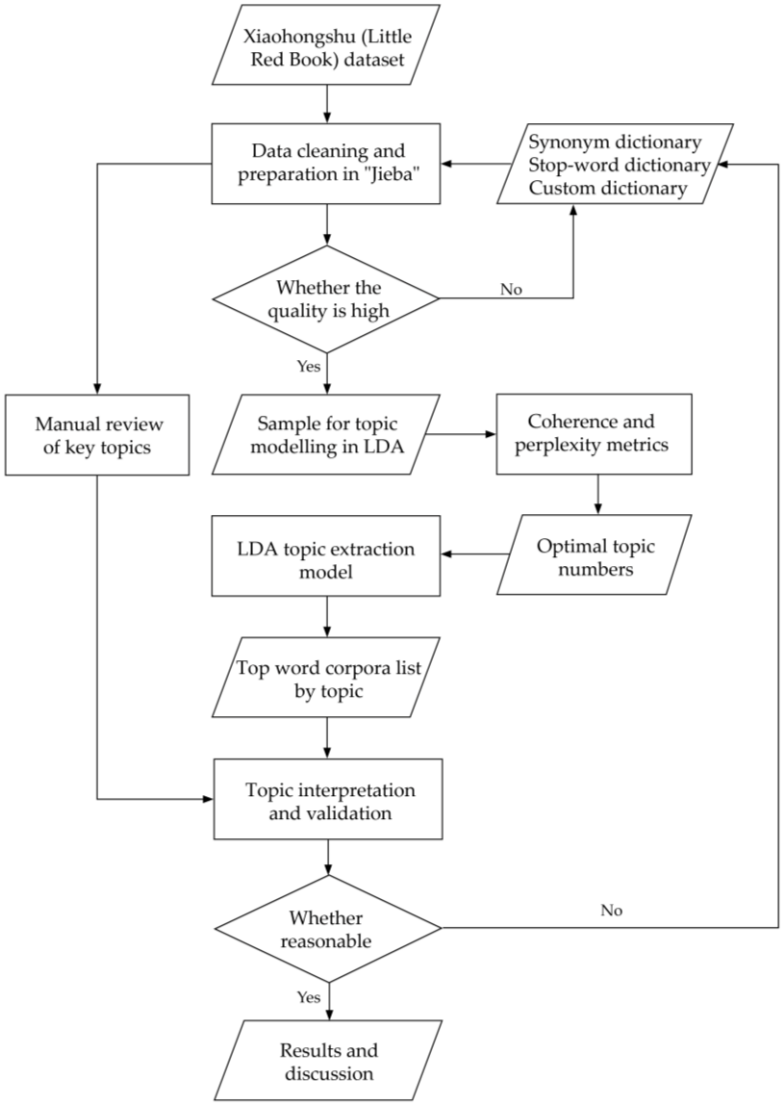


Figure 4. Social media data processing and LDA topic modeling workflow.

3. Results

3.1. Insights from the Academic Literature

3.1.1. Reviewing Equity Factors from the Literature

The results are derived from a full-text review of 30 targeted articles; each was examined to identify and extract equity-related discussions in urban UAV logistics. While these articles do not directly address social equity, they discuss broader social impacts,

from which we were able to derive relevant equity-related factors. The findings were consolidated into a scalable table (Table 5) that presents 21 social equity factors, capturing the breadth of considerations addressed in the existing literature. This foundational table provides a framework that can be expanded upon to build a comprehensive system for addressing social equity in the context of UAV logistics. Each factor indicates a critical aspect that may arise as UAV technology becomes more integrated into urban logistics. The explanations and weights for each factor are as follows.

Table 5. Identified social equity factors from literature review in urban UAV logistics.

Social Equity Factors/Considerations	Local Median income	Cost as a Percentage of Income	Economic Feasibility	Visual Pollution	Noise Pollution	Privacy Concerns	Collision or Fall Risk	Criminal Activity	Infrastructure e.g., Lockers	Airspace Resource	Technology Resource	Healthcare,	Social Isolation e.g., the Elderly	Disability	Low-income Community	Job Displacement	Community Engagement	Flight Path	Business Models	Delivery Efficiency	Emergency Response
Khan et al., 2019 [54]					√	√	√	√													
Zhu, 2019 [55]				√		√	√	√													
Alexander and Whelchel, 2019 [56]					√																
Aydin, 2019 [57]						√	√	√								√					
Torija et al., 2020 [58]					√																
Ren and Cheng, 2020 [59]					√	√	√											√			
Watkins et al., 2020 [60]				√	√	√	√									√		√			
Kellermann and Fischer, 2020 [61]			√	√	√		√	√					√		√	√				√	
Kellermann, 2020 [62]					√	√	√	√								√	√				
Cohen et al., 2021 [63]				√	√	√	√	√	√					√	√						
Cohen and Shaheen, 2021 [64]				√	√	√	√					√		√					√		√
Tan, 2021 [65]						√	√	√													
Sivakumar et al., 2022 [66]							√											√			
Çetin et al., 2022 [67]			√		√	√	√	√								√	√				
Kähler, 2022 [68]				√																	
Mendonca et al., 2022 [28]	√	√		√	√					√				√				√	√	√	√
Seidakhmetov et al., 2022 [69]					√	√	√														
Xie et al., 2022 [70]						√	√	√													
Smith, 2022 [71]					√	√	√														
Aalmoes et al., 2023 [72]				√	√																
zhang et al., 2023 [73]					√		√	√	√		√					√				√	√
Kellermann et al., 2023 [74]					√	√	√									√				√	
Li et al., 2023 [12]				√	√	√	√	√													
Gupta et al., 2023 [75]																√					
Rejeb et al., 2023 [13]						√	√	√	√		√					√		√			
Berke, 2023 [76]						√															
Babetto, 2023 [77]					√		√										√				
Zhao et al., 2024 [78]					√	√	√		√								√				
Yao et al., 2024 [79]						√															
Schmidt, 2024 [80]					√	√	√	√													

- Collision or Crash Risk (17.1%): The literature frequently highlights the potential for collisions, especially in densely populated urban areas [54], emphasizing the fair distribution of accident risks;

- Privacy Concerns (15.5%): The literature highly emphasizes that UAVs activities raise privacy invasion risks, such as compromised personal information [79], third-party access [59], or security negligence [70], indicating the need to address privacy concerns to ensure equitable adoption;
- Noise Pollution (15.5%): UAVs generate noise during flight, especially at low altitudes, which can significantly disrupt community life [73]. A fair distribution of noise helps to avoid disproportionate impacts on certain communities;
- Criminal Activity (10.1%): The literature refers to the use of drones for espionage [69], terrorism [73], and cargo theft [54], risks that could lead to inequitable access to protection;
- Visual Pollution (7.0%): This is an increasingly recognized concern [68]. The frequent appearance of UAVs in urban skies could disrupt cityscapes and visual environments, thus impacting fair distribution;
- Job Displacement (7.0%): The literature notes that UAVs applications could result in significant unemployment, which would not only deepen economic inequity but also risk broader social unrest and rejection [13];
- Flight Path (3.9%): The literature suggests that careful planning of flight paths is necessary to avoid concentrating the impacts (e.g., noise and accident risk) on specific communities [60];
- Delivery Efficiency (3.1%): Ensuring that all communities have equitable access to efficient delivery services is crucial to maintaining fairness in service distribution;
- Infrastructure, e.g., Lockers (3.1%): These offer a cost-effective and secure delivery option [78] that improves accessibility between communities, ensuring equitable access to services;
- Community Engagement (3.1%): Active participation helps to build public trust, incorporate feedback, and ensure that benefits are shared equitably [75];
- Emergency Response (2.3%): This includes the use of drones in critical situations, such as medical deliveries and disaster relief [73], which is essential to ensure equitable access to these benefits and services;
- Disability (2.3%): The literature highlights considering accessibility for disabilities [63] to meet the needs of all individuals regardless of physical ability;
- Low-Income Community (1.6%): Participants questioned whether drone technology is affordable and whether it remains an exclusive service for those who can afford it;
- Business Models (1.6%): Models that focus on profitable areas may neglect underserved and rural communities [64], with the literature indicating that this influences who benefits and who is excluded;
- Technology Resource (1.6%): Ensuring widespread access to technology is necessary to avoid widening the digital divide and to promote equitable participation [80];
- Economic Feasibility (1.6%): The literature identifies economic feasibility as a significant concern for drone adoption [67]. Addressing these barriers will ensure accessibility for all, regardless of economic status;
- Social Isolation, e.g., the Elderly (0.8%): There is concern in the literature that the use of drones for delivery may exacerbate social isolation trends, particularly among older participants [61];
- Healthcare (0.8%): UAVs can improve access to healthcare, particularly in remote or underserved areas [64], ensuring that these benefits are distributed equitably is essential;
- Cost as a Percentage of Income (0.8%): This offers specific insights into the affordability of UAV services relative to individual or household incomes [28];
- Local Median Income (0.8%): This will provide a broad understanding of the economic status of a community [28], ensuring that the growth of UAV logistics does not disproportionately favor wealthier areas;
- Airspace Resources (0.8%): Fair airspace management is necessary to ensure that no community bears an undue cost of the risk.

3.1.2. Frequency Statistics

The bar chart (Figure 5) illustrates the frequency of 21 social equity factors in the academic literature derived in 3.1.1. The frequency represents the number of times each factor is mentioned in the reviewed studies, with the proportion of each factor calculated as a percentage of the total mentions. This highlights the varying levels of attention given to different equity concerns in the literature.

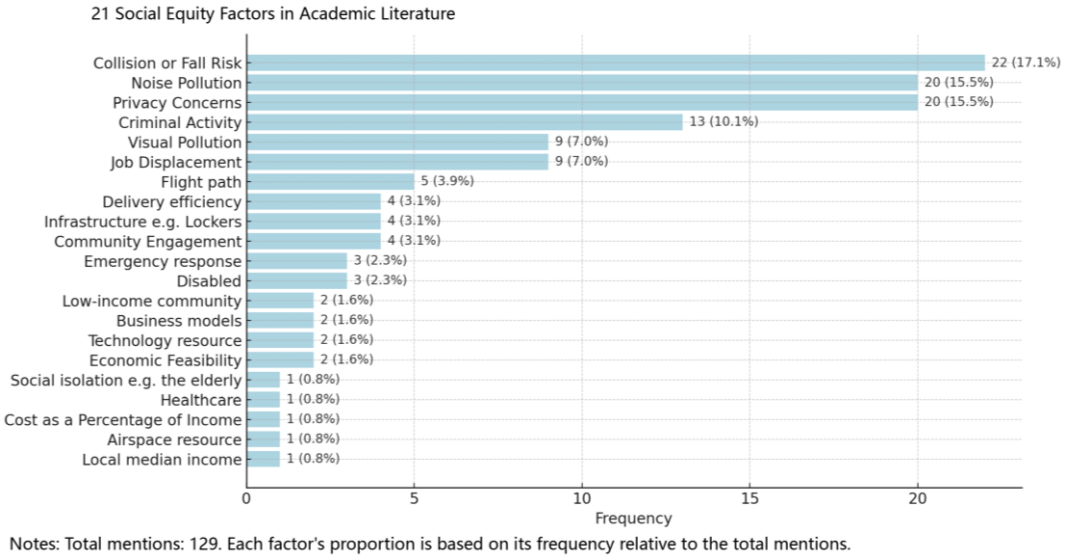


Figure 5. Frequencies of 21 social equity factors in the academic literature on urban UAV logistics.

3.1.3. Types and Dimensions of Social Equity

To better understand the complex landscape of social equity in UAV logistics, the topics were categorized into distinct types and dimensions, providing clearer insights into their meanings and their impact on social equity.

Based on the discussion in the introduction section in this study, social equity within UAV logistics emphasizes, as follows: ensuring that no particular group is disproportionately disadvantaged; promoting the fair distribution of resources; leveraging technology to benefit the broader population; and ensuring that benefits are allocated to support those who are most in need. These insights offer valuable guidance for addressing social equity challenges through structured frameworks and provide lessons that can be adapted to the UAV logistics context. Consequently, a tailored social equity framework was developed.

In the context of UAV logistics, horizontal equity includes the equitable distribution of resources, negative impacts, broad accessibility, and equitable service quality. Vertical equity means providing additional support to vulnerable groups to ensure their inclusion and direct resources to communities with significant needs (Table 6). The scalable classification framework (Table 7) incorporates the 21 factors we have identified and aligns them with related dimensions (e.g., accessibility, inclusivity, affordability, environment, safety, and operations), ensuring that each factor is systematically categorized and addressed within our structure. This framework enables a deeper analysis of how these factors interact and their collective impact on social equity.

Table 6. Two main types of social equity and their meanings.

Types	Description	Main Contents
Horizontal Equity	Horizontal equity assumes that people with similar needs and abilities should be treated similarly [21].	1. Fair resource allocation: fair distribution of resources (e.g., airspace, infrastructure) among all communities.
		2. Fair negative costs allocation: fair distribution of negative impacts (e.g., pollution, safety risks) across all communities.
		3. Fair reach the general population: making UAV logistics services available to the general population, regardless of socioeconomic status.
		4. Fair service: providing an equitable quality of service to all users.
Vertical Equity	Vertical equity assumes that disadvantaged people should receive favorable treatment [21].	5. Vulnerable groups support: offering additional help to ensure that these groups are included in UAV logistics.
		6. Social support: targeting resources to communities with significant needs such as those facing unemployment or who have limited access to essential services.

Table 7. Scalable classification framework for social equity factors in UAV logistics.

Types	Main Contains	Identified Elements	Related Dimensions
Horizontal Equity	1. Fair resource allocation	Airspace Resource	Accessibility
		Technology Resource	Accessibility
		Infrastructure e.g., Lockers	Accessibility
	2. Fair negative costs allocation	Visual Pollution	Environment
		Noise Pollution	Environment
		Privacy Concerns	Safety
		Collision or Fall Risk	Safety
		Criminal Activity	Safety
	3. Fair reach the general population	Local Median Income	Affordability
		Cost as a Percentage of Income	Affordability
		Economic Feasibility	Affordability
	4. Fair service	Flight Path	Operations
		Delivery Efficiency	Operations
		Emergency Response	Operations
		Business Models	Operations
		Community Engagement	Operations
Vertical Equity	5. Vulnerable groups support	Disabled	Inclusivity
		Low-income Community	Inclusivity
		Social isolation e.g., the Elderly	Inclusivity
	6. Social support	Healthcare	Inclusivity
		Job Displacement	Affordability

3.1.4. Core Concern Trends

As shown in Figure 6, the academic literature on urban UAV logistics places the greatest emphasis on safety issues, including risks, such as collisions, falling, criminal activity, and invasion of privacy, especially in high-density urban areas. Another key concern is the urban physical environment, with frequent mentions of noise and visual pollution. The potential for job displacement is also a major concern, particularly for delivery workers, whose job opportunities may already be limited. These six widespread concerns underscore the importance of developing strong policies and technological breakthroughs to safeguard public safety and individual rights as UAV applications integrate into urban landscapes.

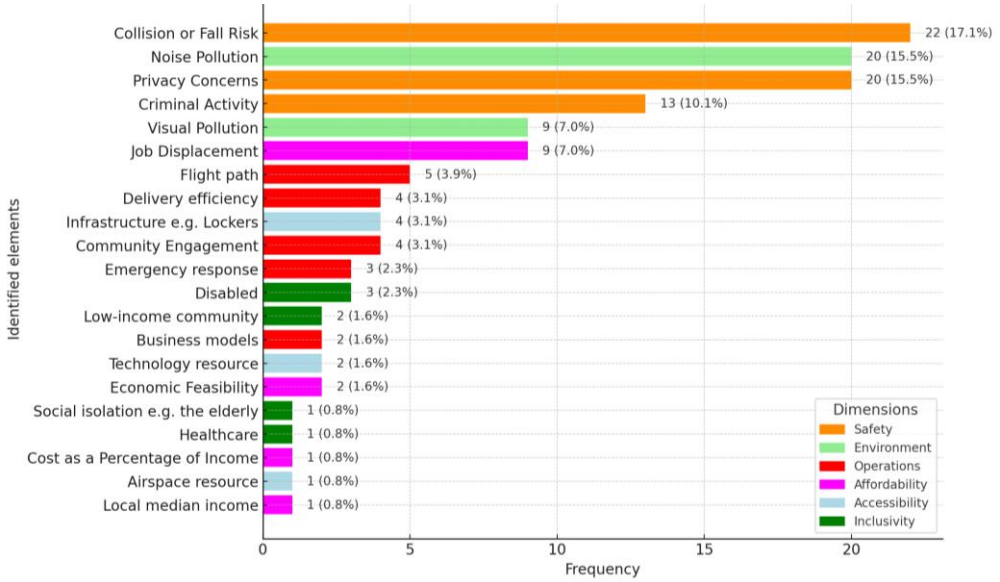


Figure 6. Frequency of 21 social equity factors in academic literature on urban UAV logistics.

Additional factors involve operations-related aspects, such as flight path design, delivery efficiency, emergency response capabilities, and business models, with an emphasis on equitable service provision and fair planning of UAV logistics to avoid negative impacts on specific communities. Accessibility-related aspects, such as the availability of airspace, technology, and infrastructure, are essential to ensure that all communities can benefit and to prevent disparities in underserved areas. Affordability factors, including local median income, cost as a percentage of income, and economic feasibility, highlight that economic status does not hinder access to these services. Lastly, inclusivity factors, such as community engagement, support for people with disabilities and those on a low income, tackling social isolation (especially among the elderly), and enhancing healthcare access, highlight the need to ensure that service delivery benefits all segments of society, especially the most vulnerable, by promoting an inclusive pattern.

Building on the general trends identified in the literature analysis, the following examines how these concerns manifest across different regions. Studies in the United States [57,76] indicate that the public is generally highly vigilant regarding potential privacy invasions and safety risks, with different groups exhibiting varied patterns of risk concern such as immediate versus broader concerns. There is research from Germany [61] indicating that public acceptance of drone technology extends beyond privacy and safety to encompass issues of fairness and quality of life. The German public perceives frequent drone flights in low-altitude airspace as contributing to noise and visual pollution, and views drone deliveries as a potential "elite model" that further exacerbates social inequity. In Singapore [81], studies reveal that the public remains cautious about privacy and safety, showing greater acceptance of drones in industrial and commercial areas and less in residential zones. Meanwhile, studies in Pakistan [54] show that privacy, safety, and crime risks are significant factors affecting public acceptance of drone deliveries. A general consensus emerges across regions, with the public expressing significant concerns about safety risks, environmental impact, and privacy, as highlighted in the overall analysis.

3.2. Insights from Social Media Analytics

3.2.1. Overview of Posts and Comments Data

A total of 74 blog posts and 13,578 associated comments were identified as relevant. The data reveal that discussions about UAV delivery began in March 2023, marking its entry into the public consciousness. Although the volume of posts remained initially modest, it persisted, with a notable increase starting in April 2024 and peaking in July. Comments followed a similar pattern, with a small wave of discussion in July and August 2023, despite

the small number of posts, followed by very low engagement until interest spiked again in April 2024, peaking alongside posts in July (Figure 7). The initially sustained low number of posts reflects a nascent field, while the subsequent surge in posts and comments indicates growing public interest and curiosity as the technology becomes more widely used. This trend demonstrates that drone logistics is an emerging topic that is gradually gaining public attention, with spikes in interest closely tied to specific events, such as Meituan's drone delivery operations in Shenzhen, and that the public is interested in the practical implications, challenges, and benefits of drone delivery.

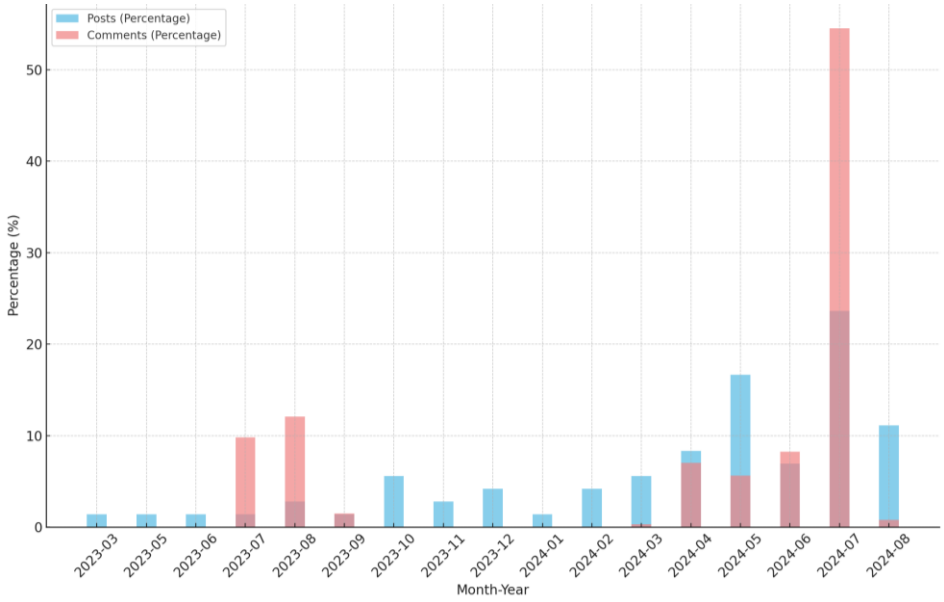


Figure 7. Percentage distribution of posts and comments in the Little Red Book regarding UAV logistics over time.

A broad range of reactions highlighting various concerns emerged in the initial examination of the prevailing sentiment in social media data. Many users expressed dissatisfaction regarding the lack of door-to-door delivery. Concerns centered on potential job losses for logistics personnel and the affordability of delivery services, prompting questions about the necessity for this technology. Conversely, some users adopted a positive and open attitude, emphasizing that technological processes could enhance public services and noting specific benefits for scenarios such as remote areas and parks. Both positive and negative sentiments were prominent in the discussions.

3.2.2. Analysis Topics

In the Methodology section, a three-step procedure was detailed to address the challenge of keyword interpretation in the LDA topic modeling process. Through robust procedures and validation, the five key topics (shown in Table 8) that people are concerned about on the Little Red Book platform were, as follows: (1) Environmental Sustainability and Social Impact; (2) Delivery Convenience and Economic Viability; (3) User Experience and Adoption Challenges; (4) Economic Considerations and Safety Concerns; and (5) Job Displacement and Future of Work. A semantic analysis is not detailed in this study; instead, the weights of the five themes are fairly evenly distributed, with each theme contributing 19–21% of the total data. While Topic 2 holds the largest share at 20.9%, the smallest share is Topic 1, at 19.3%. This indicates that the dataset covers multiple aspects of the discussion, rather than focusing on a single dominant topic. All five topics warrant analysis. The results are presented below.

Table 8. Five topics and keywords identified in LDA topic modeling.

Code	Topic Interpretation	Most Prominent (Top Five) and Other Relevant Words
T1 (19.3%)	Environmental Sustainability and Social Impact	[快递] (Courier), [包装] (Packaging), [回收] (Recycling), [意义] (Meaning), [社会] (Society), [驿站] (Station), [资本家] (Capitalist), [浪费] (Waste)
T2 (20.9%)	Delivery Convenience and Economic Viability	[出去取] (Pick up), [送上门] (Delivered to door), [城市] (City), [机器人] (Robot), [配送费] (Delivery fee), [故障] (Malfunction), [小区] (Residential area), [酒店] (Hotel), [写字楼] (Office building), [隐私] (Privacy)
T3 (19.6%)	User Experience and Adoption Challenges	[公园] (Park), [方便] (Convenient), [普及] (Popularization), [体验] (Experience), [噪声] (Noise), [堵车] (Traffic jam), [小时] (Hour), [操作] (Operation), [服务] (Service), [户外] (Outdoor)
T4 (19.7%)	Economic Considerations and Safety Concerns	[人工] (Manual labor), [成本] (Cost), [电梯] (Elevator), [掉下来] (Fall down), [便宜] (Cheap), [下雨] (Rain), [担心] (Worry), [未来] (Future), [人类] (Human)
T5 (20.5%)	Job Displacement and Future of Work	[失业] (Unemployment), [科技] (Technology), [工作] (Job), [阳台] (Balcony), [空投] (Airdrop), [机器] (Machine), [无人] (Unmanned), [电动车] (Electric vehicle), [外卖柜] (Food delivery locker)

T1. Environmental Sustainability and Social Impact

The frequent mention of "packaging", "recycling", and "waste" reflects strong public concerns about the sustainability of packaging materials and environmental protection. The term "courier" was discussed in the comments as a reference to the growing public interest in integrating drones into everyday logistics. "Society" and "meaning" were used when questioning the purpose and value of certain aspects of UAV delivery services and engaging in discussions about broader societal issues such as the impact of technological advancement on social stability. The mention of "station" highlights concerns about the practicality and inconvenience of drone station locations, while "capitalist" suggests a critical view of how automation might disproportionately benefit large corporations, potentially disadvantaging common workers. Overall, Topic One reveals that public acceptance relies on addressing environmental sustainability and societal benefits, which need to be equitably distributed, particularly when considering its broader social impact.

T2. Delivery Convenience and Economic Viability

There is public skepticism about the convenience of drone deliveries, particularly when compared to "go out to pick up" services with "delivered to door" services. Many expect drones to offer the same door-to-door convenience as traditional methods. People are concerned that drone logistics will only be available in larger "city" centers, potentially leaving smaller cities behind and widening the urban–rural gap. When comparing "robot" delivery in hotels with drone logistics, users question whether drones can effectively reach specific locations such as "residential areas", "hotels", and "office buildings", including delivery to higher floors. There is also uncertainty about the "delivery fee", with users questioning how drones can keep costs down given the high technology and operational costs. Fears of "malfunction" also emerge, with people concerned about the fall risks and who would be held accountable. Concerns about "privacy" are also mentioned, with users worried about the invasion of privacy and illegal data collection. Overall, Topic Two captures malfunction and privacy as secondary concerns, with the primary focus being on convenience and economic feasibility for the broader acceptance of drone logistics.

T3. User Experience and Adoption Challenges

Users see UAV deliveries as particularly beneficial in "parks", where traditional methods may struggle to deliver effectively, and they value the "convenience" that drones offer in "outdoor" scenarios. However, these services are not yet widely "popularized", as they are recognized as a novel technology. People show strong interest in the "experience" of drone delivery, but concerns remain about "noise" pollution, especially in urban areas. As for the term "operation" of drones, people question whether they are fully automated or require human control. Moreover, while the ability of UAVs to bypass "traffic jams"

is appreciated, there is skepticism about their efficiency, particularly in meeting delivery expectations within tight "timeframes" (as extended by the term "hours"). Users are also considering how "service" delivery could be expanded or improved, reflecting a desire for better integration of UAV logistics into daily life. Topic Three discusses the usefulness and convenience of UAV logistics in outdoor scenarios, highlighting their benefits in alleviating traffic congestion. However, skepticism about service efficiency and widespread adoption is expressed, as well as concerns about noise pollution and operational control. Overall, the focus on user experience and the potential pros and cons of UAV usage underscores the key issues within this topic.

T4. Economic Considerations and Safety Concerns

The discussion within this topic context centers on comparing "manual labor" with drone delivery, with a strong focus on serious concerns about "cost" and whether UAVs can truly provide a more economical ("cheap") alternative to human workers. Users question the practicality of drones in urban environments, especially in multi-story buildings where the inability of drones to take "elevators" is a major issue. Worries about potential accidents, such as drones "falling down", and their reliability in adverse weather conditions, such as "rain", further amplify safety concerns. Additionally, the terms "human" and "future" revolve around anxieties about how UAV technology will affect employment and whether these technological advancements will benefit society or pose new challenges. Overall, Topic Four emphasizes the questioning of the economic benefits of drones versus human labor and concerns about key safety challenges.

T5. Job Displacement and Future of Work

Comments on this topic focus on the concerns and implications of "unemployment" and "job" displacement due to the rise of "technology" like drones, which are perceived as potentially accelerating social unrest. Users reflect on a mix of practical suggestions such as using "balconies" for drone deliveries or having "airdrop" systems that become a standard household equipment. The emergence of more and more "machine" and "unmanned" technology highlights the broader trend towards automation, with the term "electric vehicle" discussing how drone delivery methods could potentially bring benefits, such as improved safety, as electric vehicles frequently cause accidents and mix with pedestrian traffic. In addition, a "food delivery locker" is mentioned as a practical, albeit temporary, solution for drone logistics in urban settings, particularly where direct delivery may be challenging. Overall, Topic Five captures the public's deep concerns about job displacement and how it might reshape the future of work and everyday logistics.

3.2.3. Social Equity Factors on the Little Red Book Platform

The five topics above reveal a variety of public concerns and evaluations, providing a wealth of empirical evidence to highlight potential inequities in drone logistics. Table 9 distills the key issues regarding inequity across these topics, corresponding to 13 social equity factors, spanning 5 key dimensions of social equity: affordability, accessibility, safety, environment, and operations. However, the analysis lacks statistical insight into the weight of these concerns, and it is still unclear where people's priorities truly lie.

Table 9. Key potential inequity issues on the Little Red Book platform.

Code	Potential Inequity Issues	Identified Factors	Dimensions
T1, T2, T4, T5	• Automation may benefit large corporations at the expense of common workers, worsening economic disparities. • Drones could be a more costly alternative to human labor. • Growing drone logistics could lead to job displacement, with automation potentially replacing traditional labor in the future.	Job Displacement Economic Feasibility	Affordability

Table 9. *Cont.*

Code	Potential Inequity Issues	Identified Factors	Dimensions
T2, T3, T5	• Inequitable access to technology may lead to widening the urban–rural divide and the disparity between different urban areas. • Infrastructure may be more advanced in certain areas, giving wealthier, more technologically developed regions an advantage in benefiting from automation. • Concerns exist regarding convenience, highlighting the need for equitable access to services across diverse communities.	Technology Resources Infrastructure Convenience	Accessibility
T2, T4	• Malfunction, drop risks, and adverse weather conditions could threaten public safety. • Drones may invade privacy and facilitate criminal activity.	Collision or Fall Risk Privacy Concerns Criminal Activity	Safety
T1, T3	• Concerns exist regarding noise pollution, particularly in urban areas. • Concerns have been raised about the sustainable development of UAV logistics, especially the use of packaging materials and recycling systems.	Noise Pollution Environmental Sustainability	Environment
T1, T3	• Timely delivery may not be guaranteed to all communities, especially within tight timeframes. • Concerns have been voiced on the varying business model distribution of benefits—whether they favor company profits over worker welfare.	Delivery Efficiency Business Models Popularization	Operations

3.2.4. Analysis of Top 30 Most Salient Terms

To address the above limitation, it is necessary to analyze the top 30 most salient terms (a quantitative statistics result from LDA topic modeling) to gain deeper insights into where public attention is focused. The terms listed (Figure 8) represent the top 30 terms most frequently mentioned throughout the full text, highlighting the prominence of these terms within the dataset. Inevitably, however, some of these words have too broad or contextually ambiguous meanings, lacking a specific connotation, and need to be excluded from the analysis. For example, [空投] 'airdrops' is ambiguous and often associated with gaming scenarios. Other terms are categorized into various dimensions according to their semantics, their frequencies within each category are summed, and the proportions of each category are calculated. In this study, the key dimensions influencing public discourse were identified as follows:

- Accessibility (37.2%)—Focus on convenience and practicality;
- Affordability (31.5%)—Concerns about unemployment and economic feasibility;
- Operations (17.9%)—Discussion on popularization;
- Environment (9.3%)—Environmental sustainability concerns;
- Safety (4.1%)—Safety concerns.

While useful, this method has limitations. It only considers the top 30 most salient terms, missing important but less frequent words, and does not account for the contextual nuances of each term. In addition, it cannot fully reflect the entire range of public comments, which affects the accuracy of the results. However, despite these limitations, the analysis provides a representative snapshot of the critical dimensions, allowing us to draw meaningful conclusions about the key concerns present in the data.

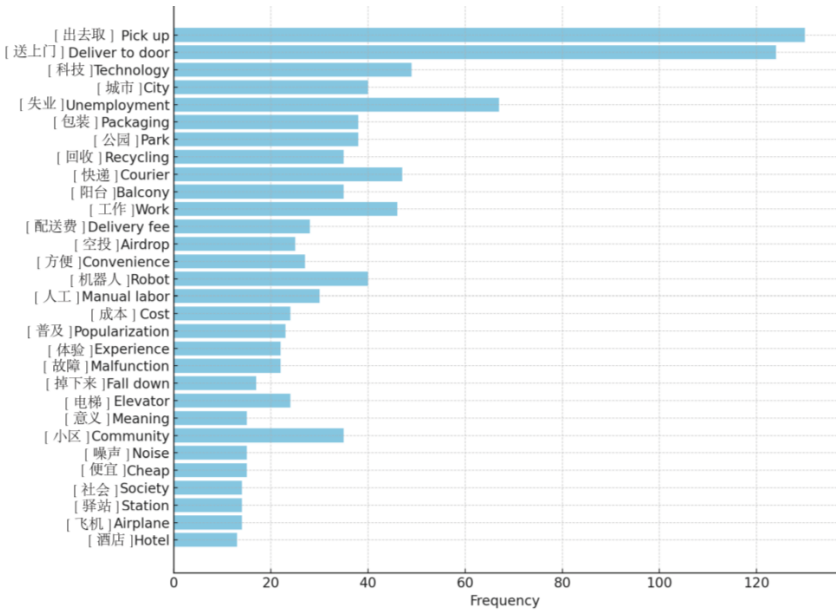


Figure 8. Top 30 most salient terms from LDA topic modeling.

4. Discussion

This study conducted a review of 30 target research papers (methodology detailed in Section 2.2), identifying 21 social equity factors (Section 3.1.1), and analyzing their frequency and relative importance (Section 3.1.3). In parallel, for the social media analysis, 13,578 comments related to urban drone logistics were collected from the Little Red Book platform and analyzed using LDA topic modeling (methodology detailed in Section 2.3). Five key themes were identified (Section 3.2.2), and their associated social equity factors were further analyzed (Section 3.2.3). Finally, the analysis of the top 30 most salient terms provided a weighted snapshot of the critical dimensions (Section 3.2.4). The above findings support the following observations and inferences.

4.1. Twenty-Four Key Factors of Social Equity in Urban UAV Logistics

The 24 key factors influencing social equity in urban UAV logistics were drawn from a combination of studies in the academic literature and social media analysis. Specifically, 21 factors were identified from the literature (as discussed in Section 3.1.1), and 13 factors emerged from the social media analysis (detailed in Section 3.2.3). Among these, 10 factors overlapped between the two sources, resulting in a total of 24 distinct factors (Figure 9). The ten overlapping factors include, as follows: collision or fall risk; privacy concerns; criminal activity; noise pollution; delivery efficiency; business models; technology resources; infrastructure; job displacement; and economic feasibility. These overlapping factors indicate their broader relevance and importance across different perspectives.

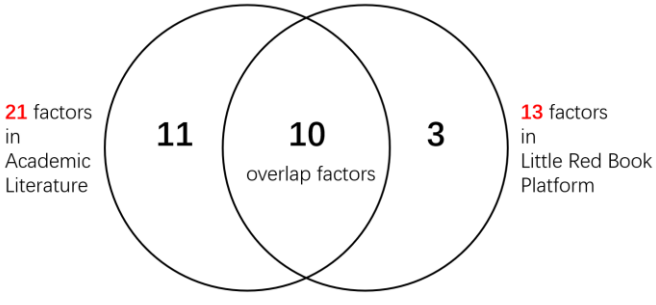


Figure 9. Diagram of social equity factors in UAV logistics: literature and social media perspectives.

The diagram presented below (Figure 10) offers a map of social equity factors in urban UAV logistics, synthesizing findings from both the academic literature and social media discussions. This holistic view organizes the 24 critical factors across six dimensions, as follows: safety; environment; inclusivity; operations; accessibility; and affordability. Within these categories, the diagram highlights how social equity concerns span across technical, economic, environmental, and social domains.

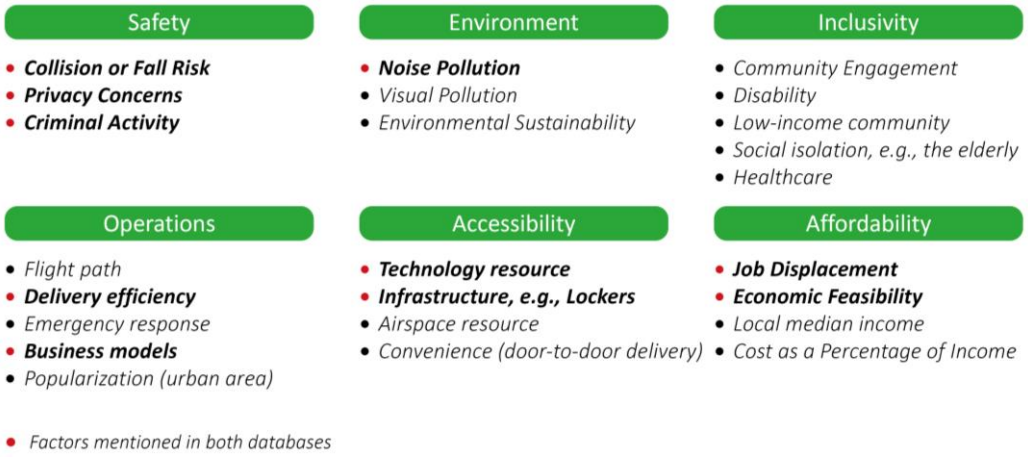


Figure 10. A map of 24 key factors influencing social equity in UAV logistics.

4.2. Comparative Observation

In the academic literature (Figure 11a), safety (42.6%) and physical environment (22.5%) dominate the discourse. The highest points of discussion focus on collision and fall accidents, privacy issues, criminal activity, noise pollution, and visual pollution. Operations (14.0%) and affordability (10.1%) receive less attention, with the focus on potential job losses, flight path design, delivery efficiency, emergency response capacity, and community engagement. Inclusivity (5.4%) and accessibility (5.4%) appear as minor considerations in the literature. The data results were calculated in Section 3.1.2.

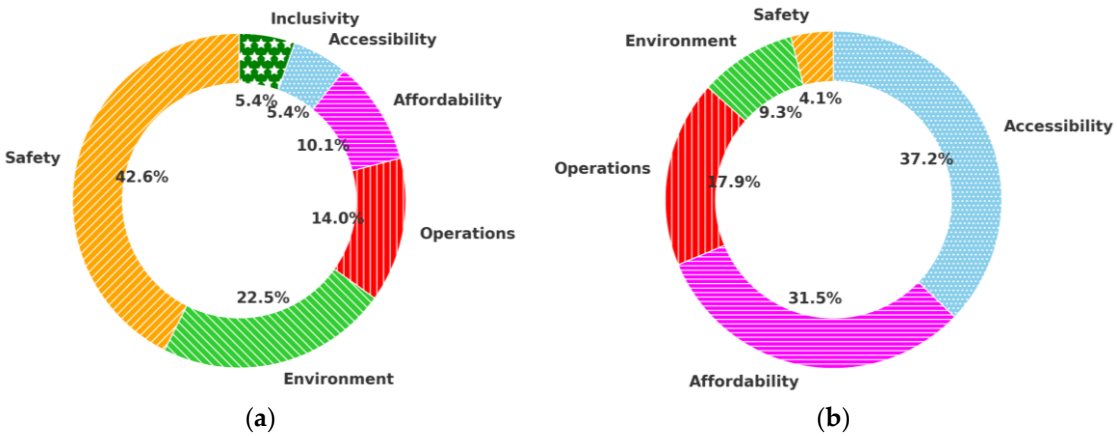


Figure 11. (**a**) Proportions of each dimension of social equity in UAV logistics from the literature review; and (**b**) proportions of each dimension of social equity in UAV logistics from social media.

In contrast, in the social media data (Figure 11b), accessibility (37.2%) and affordability (31.5%) emerge as the most prominent concerns, emphasizing convenience and practicality, followed by economic efficiency and job displacement. Meanwhile, operations (17.9%) also gain some attention, particularly regarding the popularization of UAV logistics. Environmental issues (9.3%) (e.g., material recovery and noise pollution) and safety concerns (4.1%) (e.g., fall risks, privacy invasion) take a back seat in social media conversations. These data results were calculated in Section 3.2.4.

By comparing the findings of two datasets, we found significant divergence in priorities, providing valuable insights into how academics and the general public differently understand and prioritize key aspects of social equity in urban UAV logistics.

The academic focus is largely driven by the need to address public safety and environmental regulations. The lesser focus on operations and affordability might be due to a prioritization of mitigating risks over cost efficiency at this stage of development. The general public is more concerned with immediate, practical implications, such as convenience and cost-effectiveness, rather than the risks and pollution emphasized in academic discourse. People prioritize improving their daily lives and economic opportunities, particularly in terms of affordability and job security, which touch on personal livelihoods. The lesser amount of attention paid to safety and environmental concerns is somewhat surprising, given their potential impact. One possible explanation is that the delivery models discussed on the Little Red Book platform primarily involve outdoor lockers, where privacy and noise concerns are minimized, as drones do not fly directly into residential areas.

Social media users' concerns are rooted in a practical dimension, in stark contrast to the more futuristic focus in the academic literature. These findings suggest that the efforts to promote social equity in urban UAV logistics must address both top-down and bottom-up perspectives to engage with broader societal interests.

4.3. Inclusivity Underrepresentation and Dynamic Relationship Between Factors

Inclusivity is explicitly discussed in the literature (5.4%), highlighting the needs of disadvantaged groups such as the elderly, low-income communities, and those with disabilities, as well as community engagement and healthcare in remote areas. One notable observation is the absence of inclusivity concerns in public discourse. Does this imply that scholars and the public are indifferent to the needs of marginalized groups? Our research suggests otherwise. The reason for this can largely be attributed to the interconnectedness of factors.

When people raise concerns about affordability, they are, in effect, advocating for inclusivity—ensuring that lower-income individuals have equitable access to UAV services. Similarly, concerns about accessibility naturally support marginalized groups such as the elderly and people with disabilities. Inclusivity may not be addressed directly, as it is embedded within broader discussions about affordability and accessibility. As such, inclusivity is indirectly but significantly present in the public discourse and academic research, even if not explicitly highlighted.

These interrelationships reveal the dynamics between various social equity factors, where addressing one aspect often touches on others. This suggests that these factors cannot be viewed in isolation, and their interdependence deserves further exploration, which we will discuss in detail in the following sections.

4.4. An Ecosystem of Social Equity Landscape

Building on this, an understanding of the social equity landscape in UAV logistics requires the recognition of each factor as part of a complex, interconnected system (Figure 12), and an acknowledgement that trade-offs exist between factors such as safety, operations, and affordability [81]. The investment of technology development to eliminate safety risks and protect privacy increases operating costs, which in turn affects the affordability of drone logistics services. Synergistic effects and cross-impact relationships also emerge, with factors, such as accessibility, enhancing inclusivity by benefiting vulnerable groups; affordability naturally boosts accessibility. These dynamic relationships provide deeper insights, demonstrating that UAV logistics is not merely a technical issue but an ecosystem involving economic efficiency, environmental sustainability, and social science.

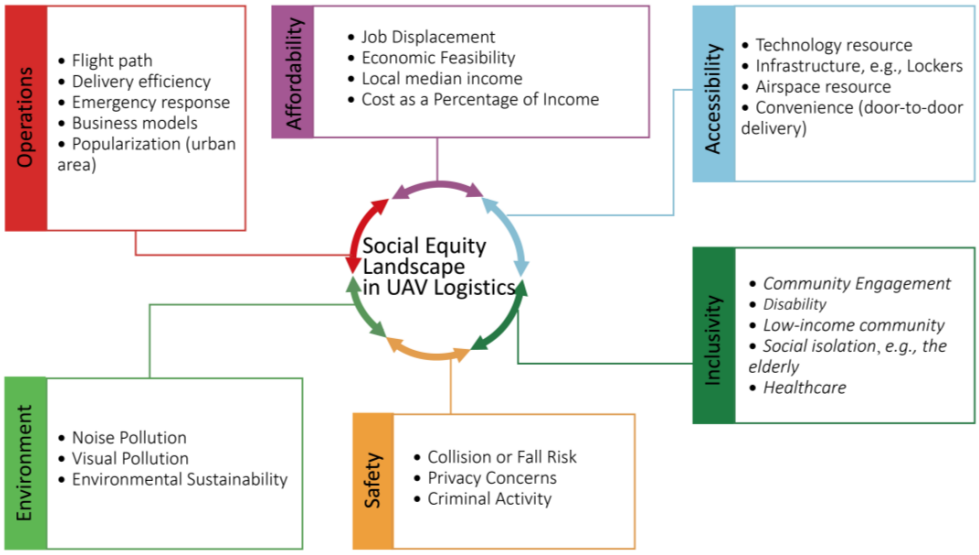


Figure 12. A map of 24 key factors influencing social equity in UAV logistics.

More importantly, these interconnections underscore the need for a systems-thinking approach to understanding and addressing the challenges that UAV logistics present to social equity. Thus, the key opportunity lies in integrating these across the entire lifecycle of drone logistics and embedding them within broader, dynamic urban systems, beyond addressing individual factors. Such an integration should cover all stages from initial deployment to long-term sustainability, with equity as a central guiding principle.

In this context, equity cannot be an isolated objective; it must be closely linked with urban infrastructure, planning, policies, and regulations. A potential framework of equity criteria or safeguards can be built in four main areas for discussion, as follows: (1) establishing criteria (e.g., noise management, distance control, and path planning) that balance technology and social well-being to ensure that specific groups or communities are not negatively impacted; (2) implementing legislation and regulation as a safeguarding framework to institutionalize privacy protection, data management, and flight permissions; (3) integrating participatory planning for low-altitude airspace into urban planning and infrastructure settings; and (4) promoting public participation and information transparency to enhance inclusiveness. Looking to the future, exploring effective implementation pathways for these equity mechanisms within complex urban environments will become a crucial and forward-looking research topic in the field of drone logistics. Further research and stakeholder engagement will be essential to validate these measures and integrate social equity into the spatial, temporal, and systemic dimensions of UAV logistics.

4.5. Limitations and Future Research Directions

The methodology used in the literature review focused solely on whether certain factors were mentioned across the articles analyzed, without quantifying the frequency or intensity of each factor's mentions within each article. This approach has certain limitations, as it does not capture the relative weight or level of attention given to each factor, which may reduce the overall persuasiveness of the findings. Future studies may consider incorporating a more detailed analysis to provide a more accurate reflection of each factor's significance across the literature.

This study draws on data from the Little Red Book platform in China, which introduced geographic limitations to our findings. The sample size of 13,578 comments is relatively small compared to other social media studies that reach hundreds of thousands of data points [82–86]. Furthermore, the user demographics of the Little Red Book may not be representative of the wider public, as younger users are more active on this platform [87],

leading to potential bias. Future research could broaden the data sources to include a wider variety of social media platforms, such as TikTok and WeChat in mainland China, as well as Facebook, Instagram, WhatsApp, and LINE globally. This would allow for the perspectives of various cultural contexts, age groups, regions, and social classes to be captured, ultimately resulting in a more diverse and comprehensive understanding of public opinion, offering a more globalized perspective.

5. Conclusions

This study conducted a systematic review of 30 target research papers and a social media contextual analysis of 13,578 comments related to urban drone logistics on the Little Red Book platform. From this analysis, 21 social equity factors were identified in the academic literature and 13 factors were derived from social media using LDA topic modeling. Among these, 10 factors overlapped, resulting in the final identification of 24 key factors that were categorized into the following six dimensions: safety; environment; inclusivity; operations; accessibility; and affordability. Additionally, a weighted snapshot of their importance in both datasets was conducted, highlighting the different priorities.

These findings provide a holistic view of public sentiment and academic discourse regarding social equity in UAV logistics. The findings reveal a significant divide between academic concerns about systemic risks (e.g., safety and noise pollution) and public concerns about immediate and practical needs (e.g., affordability and convenience). These perspectives highlight the multifaceted challenges and opportunities for achieving equitable outcomes in urban drone logistics. This study also provides an in-depth discussion on how these factors are interrelated, emphasizing the need for a systems-thinking approach to address the complex interplay between technological, economic, and societal dimensions.

A dynamic social equity landscape for UAV logistics was created, ultimately providing policymakers and stakeholders with the valuable insights and data necessary to develop equitable and inclusive policies for the future of drone logistics. These findings are also particularly important for researchers and businesses involved in the development and delivery of drone technology, as this study highlights both public and academic concerns in the implementation of drone logistics. By considering these factors and dimensions, drone developers will be able to contextualize social equity considerations into their planning and operational frameworks. Our research provides a contribution to the roadmap for a more balanced and socially responsible integration of UAV technology into the urban environment.

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