The Role of Low-altitude Economy in Sustainable Urban Development

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***Abstract*—Rapid urbanization is steadily increasing demand for low-carbon, efficient, and resilient systems in cities. Against this backdrop, the low-altitude economy, represented by uncrewed aircraft and electric vertical take-off and landing aircraft, has gradually become an important emerging issue in sustainable urban construction. However, existing studies mostly focus on technological applications, industrial development, or urban air traffic scenarios, and there is still relatively little discussion of how the low-altitude economy systematically contributes to sustainable urban construction. Based on methods of literature review and comparative analysis, this paper explores the role of the low-altitude economy in sustainable urban construction across four dimensions: environment, economy, society, and space. The study concludes that the low-altitude economy can diminish carbon emissions, enhance energy efficiency, and facilitate urban green development via unmanned aerial remote sensing, environmental monitoring, and ecological governance in particular transportation contexts; in the economic dimension, the low-altitude economy helps cultivate low-carbon, intelligent and technology-intensive industrial chains, and simultaneously improves the operational efficiency of urban logistics, inspection and emergency services; in the social and spatial dimensions, the low-altitude economy can enhance urban resilience through risk monitoring, emergency response, post-disaster assessment and other means, and provide new organizational flexibility for limited ground space. The paper argues that the low-altitude economy should not be understood as a comprehensive replacement for traditional ground transportation, nor as a universal large-scale air transportation system for all residents. Instead, it should be defined as a scenario-oriented, function-supplementing type of urban infrastructure. The realization of its sustainable value depends on specific application scenarios, infrastructure layout, airspace management, safety supervision, and coordination with the urban planning system. Therefore, the low-altitude economy offers new technical pathways and spatial governance perspectives for sustainable urban development. However, its development still needs to be advanced within the framework of prudent planning, public interests, and safety governance.**

***Keywords*—low-altitude economy, sustainable cities, urban resilience, urban air mobility, spatial governance**

I. INTRODUCTION

Rapid urbanization is strengthening demand for low-carbon, efficient, and resilient urban systems. The official report of UN SDG11 indicates that currently, more than half of the population lives in cities, and it is predicted that this proportion will approach 70% by 2050 [1]. Meanwhile, although cities are an important engine of economic growth, they consume approximately 75% of global primary energy and generate over 70% of global emissions [2]. However, according to the latest United Nations data from 2023, only about 60% of urban residents worldwide have convenient access to public transportation, and the risks posed by climate disasters and other critical infrastructure in cities are still on the rise [3]. These pressures indicate the need to explore supplementary forms of urban infrastructure to enhance urban mobility, public service capabilities, and urban resilience.

In this context, the low-altitude economy enabled by uncrewed aerial vehicles (UAVs) and electric vertical take-off and landing (eVTOL) aircraft is attracting widespread attention from the academic community. Existing studies show that the low-altitude economy can support various functions in smart cities, such as environmental monitoring, traffic management, logistics distribution, and emergency response. Recent review studies indicate that study in this topic has progressed from technological feasibility to encompass wider issues such as needs, regulation, and integration with urban systems. [4]. However, current research mainly focuses on technical application or industrial development levels, lacking a systematic assessment of how the low-altitude economy promotes sustainable urban development from environmental, economic, social, and spatial dimensions.

This paper explores the role of the low-altitude economy in sustainable urban construction. This paper primarily addresses the following question: how can the low-altitude economy promote carbon reduction, energy efficiency improvements, and the development of ecological governance capacity in the environmental dimension? Second, how can the low-altitude economy promote the formation of low-carbon high-tech industrial chains and improve the operational efficiency of urban logistics, inspection, and public services systems in the economic dimension? Third, how can the low-altitude economy enhance urban resilience and optimize ground transportation and spatial resource allocation in the social and spatial dimensions? Fourth, what are the boundaries of the role of the low-altitude economy in sustainable urban construction, and should it be understood as a universal large-scale air transportation system or a scenario-oriented, supplementary urban infrastructure?

To answer these questions, this paper uses literature and comparative analysis methods, aiming to provide theoretical support for urban planning and policy-making and advocating that the low-altitude economy should be understood as a supplementary, scenario-oriented urban infrastructure rather than a universal, large-scale air transportation system for all.

II. ENVIRONMENTAL DIMENSION

From an environmental perspective, the contribution of the low-altitude economy to sustainable cities primarily lies in three areas: reducing carbon emissions in specific urban transportation scenarios; improving energy efficiency; and enhancing the city's environmental monitoring and ecological governance capabilities.

A. Transportation Carbon Reduction and Energy Efficiency Improvement

There is a clear correlation between the low-altitude economy and the city's carbon-reduction goals [5]. The first contribution at the environmental level is that it may reduce carbon emissions in specific urban transportation scenarios and improve energy efficiency, especially in high-urgency, small-batch, and short-distance delivery tasks, where electric drones or eVTOL systems may exhibit higher energy efficiency than traditional ground transportation methods.

This environmental benefit mainly stems from the following two mechanisms. Firstly, the uncrewed aircraft uses a pure electric power system (a brushless motor and a lithium battery), eliminating exhaust emissions from fuel combustion. Moreover, through artificial intelligence path planning (such as the DQN algorithm), it further reduces the reliance on grid power, thereby indirectly reducing carbon emissions in the power generation process, and even by connecting the solar energy available on building surfaces to the charging system, achieving "zero-emission" drone operation [6]. Second, compared with ground transportation constrained by road network morphology, route organization, and traffic congestion, low-altitude aircraft can operate along more direct point-to-point paths, thus having the potential to shorten transportation distances and delivery times in specific tasks such as medical distribution, emergency transportation, and some end logistics.

The environmental benefits of low-altitude economy-related technologies are most significant in limited urban transportation scenarios. Specifically, medical and emergency distribution has become one of the most mature application scenarios for drones [7]. The transportation objects include blood products, vaccines, prescription drugs, test kits, medical samples, AEDs, and small emergency equipment. These items usually have the characteristics of small size, high value, and high urgency. Traditional ground transportation may require specialized vehicles, longer detours, or emergency dispatches, resulting in higher unit energy consumption. In contrast, electric drones can reduce vehicle travel and road detours by enabling more direct point-to-point routes and improving the efficiency of medical material distribution. For example, the drone blood delivery study in Rwanda shows that drone delivery helps shorten the transportation time of blood products and reduces blood waste； the Swedish AED drone rescue study also shows that, in some cases of suspected out-of-hospital cardiac arrest, drones can arrive at the scene before ambulances, thus providing supplementary support for high-urgency emergency tasks.

In addition, low-altitude transportation also has great potential for urban end-point logistics distribution [8]. The specific transportation objects include medicines, catering, fresh produce, convenience store goods, and lightweight daily necessities. The Amazon Pharmacy pilot project for drone delivery of prescription drugs and Walmart's expansion of drone retail delivery in the Dallas-Fort Worth area demonstrate that drone delivery is expanding beyond the emergency medical field into the daily small-item logistics field. Overall, the environmental benefits of low-altitude transportation mainly come from reducing short-distance vehicle travel, lowering road diversion costs, alleviating local congestion, and improving resource allocation efficiency. Therefore, it should be better understood as a scenario-based, marginal-emission-reduction mechanism rather than a complete replacement for traditional ground transportation and large-scale logistics systems.

B. Environmental Monitoring and Ecological Governance Support

The second environmental contribution of the low-altitude economy lies in enhancing the urban environmental governance capabilities. Compared with satellites, uncrewed aerial vehicle (UAV) remote sensing offers higher spatial and temporal resolution, is better suited for precise identification of the urban environment, and provides more flexible environmental monitoring coverage. It can enter high-risk or inaccessible areas, is less costly, and is more economical and efficient than traditional manned aerial photography.

Specifically, the relevant low-altitude economic environmental monitoring functions can be applied to the following urban environmental fields. First, low-altitude technology can support urban thermal environment and ecological monitoring: thermal comfort monitoring, microclimate diagnosis, and identification of urban heat islands to provide a basis for thermal mitigation and planning [9]; second, UAVs can also be used for building ecological maintenance, including cleaning and watering of plant curtain walls [10] and ecological maintenance of high-rise facades and detailed management of building exteriors. Third, the UAV system can improve the accuracy and precision of feasibility assessment for urban rooftop photovoltaic systems [11], thereby supporting sustainable urban renewable energy planning and improving energy management efficiency.

Unlike the direct carbon emissions and energy impacts discussed in the previous section, the environmental value of low-altitude monitoring primarily lies in its indirect contribution to governance optimization. By enhancing the accuracy, response speed, and spatial coverage of environmental observation, the low-altitude economy can support more evidence-based ecological management and sustainable urban planning.

Overall, the environmental contribution of the low-altitude economy is reflected not only in transportation carbon reduction but also in broader support for ecological governance. However, its significance for sustainable urban development is not limited to environmental performance; it also lies in its ability to reshape urban industrial development and system operation efficiency.

III. ECONOMIC DIMENSION

From an economic perspective, the contribution of the low-altitude economy to sustainable urban development is reflected not only in the development of green, technology-intensive industrial chains but also in improving the operational efficiency of the urban system.

A. Promoting a Low-Carbon High-Tech Industrial Chain

The significant contribution of the low-altitude economy to the broader economy is primarily reflected in its ability to foster a new, low-carbon, intelligent, and technology-intensive industrial system. Unlike traditional transportation industries, the low-altitude economy is not merely a single aircraft manufacturing industry; instead, it is a complex industrial network composed of aircraft research and development and manufacturing, low-altitude infrastructure construction, airspace management, digital communication, intelligent scheduling, energy supply, operation services, and data services [12]. Specifically, its new industries mainly include three aspects: first, the low-altitude aircraft manufacturing industry centered around uncrewed aircraft, eVTOL, electric propulsion systems, advanced batteries, flight control systems, and key components; second, the low-altitude infrastructure and operation services industry centered around vertiports, unmanned aircraft airports, charging and swapping facilities, maintenance support systems, and low-altitude logistics nodes; third, the digital low-altitude management and data service industry centered around low-altitude communication networks, airspace perception systems, unmanned aircraft traffic management platforms, AI scheduling systems, and digital twin platforms [13].

These new industries can further generate broader social and economic effects [14]. On the one hand, the low-altitude economy involves multiple fields such as aviation manufacturing, new energy, communication networks, artificial intelligence, intelligent sensing, and infrastructure construction, which helps to promote the extension of the industrial chain, cross-industry integration, and the clustering of upstream and downstream enterprises, enhancing the innovation capabilities of cities in future transportation, smart infrastructure, and green technology. On the other hand, the new investments and market spaces created by take-off facilities, charging networks, maintenance support, airspace perception, and digital supervision platforms will drive compound job positions such as aircraft research and development, manufacturing, equipment maintenance, platform operation, data analysis, airspace management, and safety supervision. At the same time, since uncrewed aircraft and eVTOLs mostly use electric technology and can be integrated with renewable energy supply systems and intelligent energy management platforms, the low-altitude economy also helps promote the development of industries such as new energy, green manufacturing, and low-carbon transportation equipment.

However, the industrial benefits of the low-altitude economy should not be exaggerated. Its contribution to urban economic transformation depends on the maturity of technology, the completeness of infrastructure, market demand, and institutional support. Therefore, its industrial value should be understood as a potential development path rather than an automatic realization result.

B. Enhancing the Operational Efficiency of Urban Systems

The second contribution of the low-altitude economy in the economic dimension lies in improving the urban traffic efficiency by introducing low-altitude corridors. Traditional urban logistics, inspections, and emergency services mainly rely on the ground road network, and their operation processes are prone to being affected by factors such as road congestion, traffic signals, route detours, and sudden disruptions. In contrast, uncrewed aircraft and eVTOL systems, among others, can utilize the urban low-altitude space for point-to-point operations, expanding the capacity for high-urgency, small-batch, and light-load tasks from a single ground network to a "ground-low-altitude" combined transportation system [4]. The efficiency of these systems lies not only in reducing time but also in minimizing road detours, reducing interference with ground traffic, and improving the accessibility of specific tasks in high-density urban environments. For example, in the traditional ground system, a cross-neighborhood emergency small-package delivery requires detouring along the road network. It is affected by intersections, traffic signals, congested sections, and temporary traffic control. In contrast, low-altitude delivery can adopt a more nearly straight path while complying with airspace rules, transforming the traffic logic from "moving along the road network" to "跨越式 connection" [15]. This advantage is more evident in the edge areas of high-density cities, cluster-type urban new districts, and areas divided by expressways, railways, and rivers. For these regions, the value of low-altitude corridors lies not only in speed improvements but also in reducing traffic losses caused by urban spatial fragmentation.

Therefore, the contribution of the low-altitude economy to urban efficiency should not be merely understood as "faster speed", but as an optimization of the transportation structure. It develops the urban low-altitude space and transfers suitable tasks to the air corridors, thereby enhancing the city's traffic flexibility and operational efficiency for high-urgency services. However, this efficiency improvement has obvious scene dependence. Only with reasonable airspace management, take-off and landing node layout, and safety supervision system support can the low-altitude system truly become an effective supplement to the urban transportation system rather than a complete replacement for ground traffic.

Overall, the economic significance of the low-altitude economy lies not only in the formation of new industrial chains but also in improving urban operational efficiency. However, its significance for sustainable urban construction goes beyond economic value. It involves changes in urban resilience and in methods of spatial organization.

IV. Social and Spatial Dimensions

Apart from environmental and economic benefits, the low-altitude economy may also influence sustainable urban development through social and spatial benefits, particularly in two areas: enhancing urban resilience and reshaping the allocation of spatial resources.

A. Enhancing Urban Resilience

The social value of the low-altitude economy is primarily reflected in enhancing urban resilience. The continuous development of cities is not only confronted with normal operational issues but also with sudden shocks such as floods, earthquakes, extreme weather, and public health incidents. In the face of such uncertain accidents, merely efficient systems may not be sufficient. The construction of sustainable cities also requires the ability to perceive, respond, and recover [16] quickly.

Before disasters or emergencies occur, low-altitude systems can enhance urban resilience by strengthening infrastructure monitoring, risk management, and early warning capabilities. Through flexible aerial observation and localized data collection, they help identify potential hazards, monitor vulnerable infrastructure, and provide support for more targeted emergency preparedness. In the face of sudden disasters and emergencies, the resilience of low-altitude systems becomes increasingly evident. In disaster-affected areas where traditional communication infrastructure is damaged, drones can serve as a rapid-deployment platform to build temporary communication networks [17]. When traditional transportation networks are damaged, drones can undertake key, small-scale, high-efficiency tasks, such as delivering medical supplies and emergency equipment. In addition, drones can enhance situational awareness in high-risk areas through real-time data and monitoring capabilities and provide real-time information to help rescue personnel assess the situation on the ground and support emergency decision-making. After sudden destructive events, rapid and accurate damage assessment of the built environment is crucial for decisions related to safety, recovery, and reconstruction. High-resolution aerial images captured by drones can be used to quickly identify and assess the damage levels of buildings and infrastructure [18], and an automated drone-based damage assessment system can provide real-time traffic network status information, thereby helping the disaster management team optimize recovery routes.

B. Optimize Urban Space

The social spatial role of the low-altitude economy does not merely replace ground transportation but also provides a new supplementary layer for urban spatial organization. Traditional urban transportation and service systems mainly rely on ground roads, parking spaces, loading and unloading areas, and emergency channels, which have long placed significant pressure on limited ground space. The introduction of low-altitude systems enables some high-efficiency, lightweight, and point-to-point tasks to shift from a single ground system to a “ground-low altitude” collaborative system, thereby changing the way urban functions rely on ground space. In other words, the spatial value of low-altitude economy is not just “flying faster”, but rather, by developing urban vertical space, it provides new organizational flexibility for the limited ground space. For example, in high-density commercial areas, if some immediate delivery demands are undertaken by low-altitude systems and centralized take-off and landing nodes, the ground may reduce the short-term parking pressure of scattered delivery vehicles; in the surrounding areas of large hospitals, logistics parks, or transportation hubs, low-altitude take-off and landing points may also be combined with rooftops, platforms, parking buildings, or peripheral public facilities, forming new vertical composite spaces. Its planning significance does not lie in reducing roads on a large scale, but in providing a more flexible organizational method for the limited ground space [19].

Low-altitude economy may also drive urban space to shift from a single ground organization to a three-dimensional composite organization. In the past, urban transportation infrastructure mainly consisted of roads, railways, parking, and pedestrian systems. At the same time, the low-altitude economy will further superimpose aerial routes, vertical take-off and landing nodes, and airspace management interfaces, shifting urban space from “planar transportation organization” to a “ground-building-low altitude” composite organization. For example, hospital rooftop platforms can be combined with emergency sample transportation, the peripheral areas of logistics parks can be combined with drone distribution nodes, and transportation hubs or large public buildings can be reserved for low-altitude connectivity. This three-dimensional composite does not imply that urban space is infinitely expanding upwards, but rather requires careful determination of the layout intensity and applicable scenarios for low-altitude facilities, under the constraints of safety, noise, landscape, and public interests. A review study on vertiport design, capacity, and location also indicates that factors such as the number of take-off and landing pads, waiting/boarding facilities, operational capacity, and surrounding land conditions will all affect the spatial organization method of low-altitude infrastructure [20].

V. Conclusion

This article analyzes the role of the low-altitude economy in sustainable urban construction from the perspectives of environment, economy, society, and space. The research shows that low-altitude economy is not merely a new transportation technology, but a complex urban system composed of uncrewed aircraft, eVTOL, low-altitude infrastructure, airspace management, intelligent scheduling, energy supply, and data services. Its value does not lie in replacing the existing ground transportation system, but in providing supplementary support for specific urban functions.

From the environmental perspective, the low-altitude system can reduce carbon emissions and improve energy efficiency in specific scenarios such as medical delivery, emergency transportation, and small-scale end logistics. At the same time, unmanned aerial remote sensing technology can also support urban environmental monitoring, ecological governance, roof photovoltaic assessment, and thermal environment analysis. From an economic perspective, a low-altitude economy can promote the development of low-carbon, technology-intensive industries such as aircraft manufacturing, charging facilities, digital communication, airspace management platforms, and operational services, and improve the efficiency of urban logistics, inspection, and emergency response through more direct point-to-point routes. From a social and spatial perspective, the low-altitude system can enhance urban resilience by enabling risk monitoring, emergency communication, disaster response, and post-disaster damage assessment. It may also provide new flexibility for urban space organization by connecting ground spaces, building platforms, and low-altitude airspace.

The main conclusion of this article is that low-altitude economy should be understood as a scenario-oriented, function-supplementing urban infrastructure. The realization of its sustainable value depends on appropriate application scenarios, infrastructure layout, airspace regulation, safety management, and collaboration with the urban planning system.

However, this article still has certain limitations. The research is mainly based on literature analysis, lacking specific urban case studies, quantitative assessment, and comparative studies across different urban contexts. Future research can further focus on real urban cases, carbon-emission and efficiency assessment models, take-off and landing facility layouts, public acceptance, safety governance, privacy protection, and how low-altitude systems can be formally integrated into the urban planning system.

Conflict of Interest

The author declares no conflict of interest.

References

[1] United Nations, "The Sustainable Development Goals Report 2023: Goal 11 Sustainable Cities and Communities," New York: United Nations, 2023.

[2] UN-Habitat, "Urban Energy," United Nations Human Settlements Programme.

[3] United Nations, "The Sustainable Development Goals Extended Report 2024: Goal 11 Sustainable Cities and Communities; IPCC AR6 WGII, Chapter 6," 2024.

[4] L. A. Garrow, B. J. German, and C. E. Leonard, "Urban air mobility: A comprehensive review and comparative analysis with autonomous and electric ground transportation for informing future research," *Transp. Res. Part C: Emerg. Technol.*, vol. 132, 103377, 2021.

[5] H. Tan, Z. Guo, J. Yan, D. Zhang, Y. Chen, and H. Zhang, "Advancing low-carbon smart cities: Leveraging UAVs-enabled low-altitude economy principles and innovations," *Renew. Sustain. Energy Rev.*, vol. 222, 115942, 2025.

[6] M. ElSayed, A. Foda, and M. Mohamed, "Autonomous drone charging station planning through solar energy harnessing for zero-emission operations," *Sustain. Cities Soc.*, vol. 86, 104122, 2022.

[7] N. B. Roberts *et al.*, "Current summary of the evidence in drone-based emergency medical services care," *Resuscitation plus*, vol. 13, 100347, 2023.

[8] N. Moradi, C. Wang, and F. Mafakheri, "Urban air mobility for last-mile transportation: A review," *Vehicles*, vol. 6, no. 3, pp. 1383–1414, 2024.

[9] M. V. Rodríguez, S. G. Melgar, and J. M. A. Márquez, "Assessment of aerial thermography as a method of in situ measurement of radiant heat transfer in urban public spaces," *Sustain. Cities Soc.*, vol. 87, 104228, 2022.

[10] Y. Zhou, "Unmanned aerial vehicles based low-altitude economy with lifecycle techno-economic-environmental analysis for sustainable and smart cities," *J. Clean. Prod.*, vol. 499, 145050, 2025.

[11] D. Hu, C. Ma, and T. Rakha, "An integrated framework for rooftop solar viability assessment: Enhancing building reuse and urban sustainability through UAV-Derived 3D modeling and performance simulation," *Energy Build.*, 116847, 2025.

[12] Y. Wang *et al.*, "Toward realization of low-altitude economy networks: Core architecture, integrated technologies, and future directions," *IEEE Trans. Cogn. Commun. Netw.*, 2025.

[13] C. Huang, S. Fang, H. Wu, Y. Wang, and Y. Yang, "Low-altitude intelligent transportation: System architecture, infrastructure, and key technologies," *J. Ind. Inf. Integr.*, vol. 42, 100694, 2024.

[14] X. Liao, C. Xu, and H. Ye, "Benefits and challenges of constructing low-altitude air route network infrastructure for developing low-altitude economy," *Bull. Chin. Acad. Sci. (Chin. Vers.)*, vol. 39, no. 11, pp. 1966–1981, 2024.

[15] F. Borghetti, C. Caballini, A. Carboni, G. Grossato, R. Maja, and B. Barabino, "The use of drones for last-mile delivery: A numerical case study in Milan, Italy," *Sustainability*, vol. 14, no. 3, 1766, 2022.

[16] P. J. G. Ribeiro and L. A. P. J. Gonçalves, "Urban resilience: A conceptual framework," *Sustain. Cities Soc.*, vol. 50, 101625, 2019.

[17] I. López-Villegas, E. A. Martínez-Rios, J. Izquierdo-Reyes, R. Bustamante-Bello, and F. Falcone, "A systematic literature review of emergency communications assisted by unnamed aerial vehicles," *Ad Hoc Netw.*, p. 104063, 2025.

[18] Z. Yang, Y. Xu, H. Song, and K. Yu, "Data-driven structural damage monitoring and assessment based on unmanned aerial vehicle images: a survey," *Int. J. Digit. Earth*, vol. 18, no. 1, 2528617, 2025.

[19] UIC2 – UAM Initiative Cities Community and EU's Smart Cities Marketplace, "Urban Air Mobility and Sustainable Urban Mobility Planning – Practitioner Briefing," Brussels: European Commission, Directorate-General for Mobility and Transport, 2021.

[20] M. Brunelli, C. C. Ditta, and M. N. Postorino, "New infrastructures for Urban Air Mobility systems: A systematic review on vertiport location and capacity," *J. Air Transp. Manag.*, vol. 112, 102460, 2023