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Kentsel Hava Hareketliliğinde İHA'ların Geleceği: Toplumsal Algı ve Endişeler

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Özet

Bu çalışma, İnsansız hava araçlarının (İHA/UAV-Unmanned Aerial Vehicle) kentsel hava hareketliliği (KHH/UAM-Urban Air Mobility) bağlamındaki toplumsal algısını incelemek ve bu yeni teknolojinin yaygın kabulünü ve uygulanabilirliğini değerlendirmek amacıyla gerçekleştirilmiştir. Çalışmada, İstanbul ve Ankara illerinde yaşayan 82 katılımcıyla yarı yapılandırılmış görüşme yapılmıştır. Elde edilen veriler, katılımcıların İHA'lar hakkındaki görüşlerini belirli bir yapıda sınıflandırmak amacıyla tematik analiz yöntemi kullanılarak incelenmiştir. Bu analiz sonucunda katılımcı görüşleri üç ana kategori altında toplanmıştır. Olumlu görüşler arasında katılımcıların İHA'ların acil durum kullanımıyla ilgili beklentileri ön plana çıkmaktadır. Olumsuz görüşlerde ise, İHA'ların güvenlik ve potansiyel riskleri konusundaki endişeler başı çekerken, İHA'ların topluma etkisi, yasal düzenlemeleri ve teknolojik gelişimi hakkındaki karışık düşünceleri nötr kategoriyi oluşturmuştur.

Anahtar Kelimeler: İnsansız hava araçları, kentsel hava hareketliliği, ulaşım, toplum kabulü, otonom araçlar.

The Future of UAVs in Urban Air Mobility: Public Perception and Concerns

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Research Article

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Abstract

This study aims to examine the public perception of Unmanned Aerial Vehicles (UAVs) in the context of Urban Air Mobility (UAM) and evaluate the widespread acceptance and applicability of this new technology. In this study, semi-structured interviews were conducted with 82 participants residing in the provinces of Istanbul and Ankara. The data obtained were analyzed using the thematic analysis method to categorize participants' views about UAVs in a specific structure. As a result of this analysis, participant views were categorized into three main themes: positive views, negative views, and neutral perspectives. Among the positive views, participants' expectations regarding the emergency use of UAVs stand out. In the negative views, concerns about the security and potential risks of UAVs took the lead, while mixed thoughts about the impact of UAVs on society, legal regulations, and technological development formed the neutral category.

Keywords: Unmanned aerial vehicles, urban air mobility, transportation, public acceptance, autonomous vehicles.

1. Introductıon

Technological advancements are fundamentally reshaping the transportation sector in today's world. A significant component of this transformation is the small-sized, electrically powered Unmanned Aerial Vehicles (UAVs) with vertical takeoff and landing capabilities, which have the potential to overcome urban traffic congestion and offer new opportunities for Urban Air Mobility (UAM) (Kai, Jacquillat, & Vaze, 2022). UAVs have emerged as key players in shaping the future of urban transportation with their potential to reduce traffic density and enhance transportation efficiency (Gupta et al., 2021).

UAVs, also known as drones, with their flexibility, low operational costs, eco-friendliness, and energy-saving features, stand out compared to traditional modes of transportation (Li, Liu, & Jiang, 2022). Thanks to these characteristics, UAVs have drawn attention as air vehicles considered part of urban transportation under the concept of UAM.

UAM involves the use of autonomous UAVs in utilizing the third dimension, airspace, to optimize travel routes, reduce travel times, and alleviate traffic congestion in cities (Krull & Muhammad, 2022; Marzouk, 2022). Reiche et al. (2018) estimated the total current market value for UAM in the United States at $500 billion. Bulusu et al. (2021) analyzed traffic demand for UAM in the San Francisco Bay Area and found that even under heavy traffic conditions, 45% of the demand could be met by UAM.

As technology continues to advance in this vast market, UAVs are poised to play an even more critical role in UAM (Ansari et al., 2021). The public acceptance and applicability of this new technology are crucial for the future of UAM (Al-Dosari & Fetais, 2023; Tuncal & Uslu, 2021). The lack of knowledge about UAVs and their potential applications can create complexity among communities that have not fully grasped the technology's potential, influencing public preferences and concerns (Smith et al., 2022).

As public awareness of technology increases, there is a likelihood that perceptions and attitudes toward UAVs may change (Clothier et al., 2015). Previous studies have revealed that public acceptance of such aerial vehicles can be influenced by public knowledge, awareness, and interactions with UAVs (Melo et al., 2023; Tan et al., 2021). In today's urban environments, there is a lack of information about the use of UAVs equipped with advanced autonomous systems within the scope of UAM (Çınar & Tuncal, 2023; Wang, Mutzner, & Blanchet, 2023). A report published in Australia also supports this view, indicating a neutral attitude stemming from a lack of knowledge about UAV technology (Clothier et al., 2015). The deployment of autonomous vehicles (AVs) is an exciting goal for many cities, and AV technologies are currently being trialed around the world (Riggs et al., 2019). Currently, there are not enough studies that fully explain why people would or would not use UAVs (Hogreve & Janotta, 2021). Studies have shown that understanding the people's perspective on UAVs, which will impact urban transportation worldwide, is crucial for the successful implementation of UAM (Al Haddad et al., 2020; Chancey & Politowicz, 2020; Silva et al., 2023).

This study aims to analyze public views regarding the use of UAVs within the concept of UAM. This analysis may contribute to a better understanding of the integration and public acceptance of UAVs in urban transportation systems.

2. Literature

As part of the transformation driven by technological advancements in the transportation sector, UAVs are increasingly gaining attention in today's world (Papa, 2023; Saraçyakupoğlu, Delibaş, & Özçelik, 2021). As a result of this transformation, a new era has begun in urban transportation and logistics, centered around the concept of UAM (Tang, 2021).

Within UAM, UAVs are considered technological tools that will replace existing traditional structures in various tasks such as surveillance, monitoring, emergency response, exploration, logistics, and transportation in urban areas (Bertrand & Shin, 2023). However, the use of UAVs in urban areas is a significant concern in terms of public acceptance (Al-Dosari & Fetais, 2023; Lee, Hess, & Heldeweg, 2022). Studies have highlighted that the greatest challenge in this regard is the acceptance of the system by public (Chancey & Politowicz, 2020; Cohen, Shaheen, & Farrar, 2021; Hogreve & Janotta, 2021; Janotta, Peine, & Hogreve, 2021; Kim, Lim, & Ji, 2023; Stolz & Laudien, 2022). While UAVs present an opportunity to increase transportation capacity in densely populated metropolitan areas, their successful integration into existing transportation systems is heavily reliant on public acceptance (Johnson, Miller, & Conrad, 2022). The rapid growth of the UAV industry has created a psychological fear of the unknown among communities (Çetin et al., 2022). In this context, the integration of UAVs into existing systems under the UAM framework should consider not only technical aspects such as design, certification, operational aspects, and infrastructure requirements but also public acceptance (Schuchardt et al., 2023).

Some research evaluating public acceptance of UAVs in urban logistics has shown a positive attitude toward the use of these vehicles (Melo et al., 2023). However, a lack of knowledge about the use and technological features of UAVs in logistics and

transportation areas can influence these positive attitudes (Smith et al., 2022). Additionally, the guidance of autonomous vehicles like UAVs by a program can create dilemmas among society. While there is generally a positive acceptance, accidents involving program-guided autonomous vehicles can lead to negative perceptions of this technology (Othman, 2021). Furthermore, the success or failure of a new technology often depends on how well it is embraced by society, including end-users, stakeholders, and decision-makers (Ajibade, Ibietan, & Ayelabola, 2017). This is a crucial factor in ensuring the success of this technology (Taherdoost, 2019). Factors such as perceived benefits, perceived ease of use, social impact, and facilitative conditions can all influence the adoption of new technologies (Hossain et al., 2019; Mohamed & Hassan, 2023).

Although UAVs have been used for military purposes for years, concerns that need to be addressed to gain public acceptance have arisen in recent years, despite the significant potential benefits of high-tech UAVs for civilian use. Society has a wide range of opinions, perceptions, and concerns regarding UAVs, including issues related to privacy (Nelson et al., 2019). Factors such as flight safety, noise, environmental impact are among the most important concerns (Janotta, Peine, & Hogreve, 2021; Miethe et al., 2014; Nelson et al., 2019; Park et al., 2022; Silva et al., 2023; Yedavalli & Mooberry, 2019).

The process of gaining public acceptance of UAVs is complex and unpredictable. This process can be shaped by the emergence of new information and the conduct of data collection and evidence-based information campaigns to inform the public. The European Parliament conducts large-scale, long-term research to support this process (European Parliament, 2023).

3. Methodology

This study was conducted using the thematic analysis method. Thematic analysis is an analytical approach used to identify recurring themes or ideas in a text or a collection of texts (Braun & Clarke, 2019; Nowell et al., 2017). In this method, texts are initially segmented into codes to discern meaningful findings. Codes represent specific words or phrases that signify a particular idea or theme within a text. These codes are then grouped into themes, representing common ideas or subjects found within a text or a collection of texts.

In this study, a qualitative approach was employed to examine general perceptions about the use of UAVs in the context of UAM. Data were collected using a semi-structured interview method. The sample consisted of 82 individuals residing in Istanbul and Ankara, two of Türkiye's most populous cities facing traffic issues. The sample primarily consisted of individuals with undergraduate and postgraduate degrees due to the lack of voluntary participation from those with lower educational backgrounds. However, this selection aimed to enhance the study's effectiveness by involving individuals familiar with research methodologies and innovative approaches. Despite not being fully representative, this group's inclusion was pivotal in enriching the study's insights and ensuring a more rigorous examination of the subject matter, leveraging their academic and innovative thinking.

Participants were asked three open-ended questions allowing them to freely express their views on the use of UAVs within the UAM system. The questions are “What are your general thoughts on the use of UAVs in UAM?”, “What concerns or points do you disagree with regarding the use of UAVs in UAM?” and “What aspects of UAV integration in UAM raise uncertainties or undecided thoughts for you?”. Additionally, to foster a more in-depth perspective throughout the discussions and follow the responses based on the flow, the following detailed questions were also included to encourage participants to express more specific and detailed thoughts: “How do you think UAVs in urban areas will affect your daily life?”, “What positive aspects do you see in the use of UAVs in urban areas?”, “What risks do you perceive in the urban use of UAVs?”, “Do you think there are potential security issues with UAVs?”, “What concerns you the most in terms of security?”, “What uncertainties do you face regarding the integration of UAVs into urban transportation?”, “What do you think about balancing the benefits and drawbacks of UAV use in urban areas?”, “What is your perspective on the impact of UAVs on urban infrastructure?”.

The data collection process was concluded due to reaching data saturation, as similar responses were obtained from 82 participants. Achieving a specific sample size was considered crucial to ensure a level of saturation in data collection. The convergence of similar responses indicated the attainment of the set objective and sufficiency in the collected data, leading to the completion of the data collection process.

To enhance the reliability of the study, initially, both researchers independently analyzed participant responses. All responses were carefully read and segmented into codes. During the analysis of these responses, it was observed that sub-themes and quotations overlapped within the categories of positive, negative, and neutral. Subsequently, through discussions, consensus was reached on the findings, and the report was compiled.

4. Findings

In this study, participant views regarding the use of UAVs within UAM, along with their demographic characteristics provided in Table 1, were analyzed. When examining the demographic characteristics of the participants, it is observed that the majority come from Istanbul (61%), and females (54.9%) are slightly more represented than males. The age distribution predominantly consists of young and middle-aged groups, with the largest age group being the 30-39 age range, making up 31.7% of the participants. Their educational levels exhibit a balanced distribution between bachelor's (53.7%) and graduate (46.3%) degrees.

Participant views were analyzed under the themes of positive, negative, and neutral regarding the use of UAVs in the UAM context. This classification enabled to categorize elements perceived as beneficial by participants under the positive theme, concerns they expressed as negative, and uncertainties or indecisions under the neutral theme. The primary reason for categorizing these themes as positive, negative, and neutral was to gain a more detailed and meaningful understanding of participants' perspectives on UAVs and to analyze them effectively. This classification assisted in presenting the perceived benefits, concerns, and impartial perspectives of UAVs more clearly. Furthermore, this categorization allowed us to comprehensively address participants' perspectives on UAVs within a broader analytical framework. Therefore, utilizing these themes as positive, negative, and neutral facilitated a more in-depth examination and comprehension of participant views.

Table 1. Demographic characteristics of participants

		Frequency	%
City	İstanbul	50	61,0
	Ankara	32	39,0
Gender	Female	45	54,9
	Male	37	45,1
Age	18-29 years old	22	26,8
	30-39 years old	26	31,7
	40-49 years old	21	25,6
	50 + years old	13	15,9
Education	Bachelor's Degree	44	53,7
	Graduate Degree	38	46,3
Total		82	100

- **Positive views**

Participants believe that UAVs can provide significant benefits when used in emergency situations. There are expectations that UAVs can be effective tools in scenarios such as the rapid transportation of medical supplies or aid. Additionally, it is thought that UAVs can be beneficial in logistics processes and transportation. It is believed that in areas with heavy traffic, the use of UAVs will reduce traffic-related stress, decrease time losses, and reduce air pollution. Positive views include the perception that UAVs will save time, reduce environmental impacts, and assist in reducing CO2 emissions. In Table 2, these positive contributions and participant quotations' examples are presented under two subthemes.

Table 2. Subthemes of Positive Views and Participant Quotations' Examples

1. Expectations of the Benefits of Using UAVs in Emergency Situations

- (27) I believe they will be very helpful in emergencies, especially in transporting perishable items like organs, needles, blood, etc.
- (31) They can provide fast and efficient intervention, especially in emergency situations.
- (73) They can save time in terms of aiding after potential disasters in the country, both in terms of speed and aid.

2. Expectations of the Benefits of UAVs in Logistics Processes and Transportation

- (8) I believe that especially in areas with high population density exposed to heavy traffic, it will reduce the stress of living due to traffic and positively impact the increase in quality time by reducing the time spent in traffic during the day.
- (12) I also think it will be beneficial in logistics. It will affect cargo costs, etc.
- (71) ... I have no doubt that it will both save time and provide great flexibility.
- (72) ... I view it positively in terms of reducing traffic.
- (52) Time savings will be particularly important.
- (59) It can be used as a tool to reduce the increasing CO2 emissions, especially in today's world.

- **Negative views**

Participants express concerns about the security risks associated with UAVs. Concerns include the potential use of UAVs in terrorist activities, vulnerability to cyberattacks, and invasion of personal privacy. Additionally, there are concerns that UAVs may contribute to noise pollution and increase air traffic. It is believed that UAVs could complicate air traffic in cities and lead to an increase in accidents. Concerns also revolve around the high cost of UAVs and their potential impact on the existing economic structure. There is a fear that while UAVs may create new economic opportunities, they could also reduce existing job opportunities. Furthermore, difficulties related to the integration of UAVs into the existing airspace and transportation network are among the negative views. In Table 3, these concerns and participant quotations' examples are presented under seven subthemes.

Table 3. Subthemes of Negative Views and Participant Quotations' Examples

1.	Concerns about the Security of UAVs
-	(4) I have security concerns, both because they are unmanned and automatic, and because they can reach any place at any time, making them vulnerable to terrorist activities.
-	(45) ...especially cyberattacks are a serious concern.
-	(50) The biggest danger is the possibility of being "hacked" and used as a weapon against my country.
-	(54) I also have concerns about issues like privacy or the restriction of freedom areas, or dangerous manipulations, due to the vulnerability of the easily "hackable" computer system.
-	(81) The security issue is the most fundamental problem in my mind.
2.	Concerns about the Integration of UAVs into the Existing Transportation Network (Roads, Rail Systems, etc.)
-	(1) ...integration into transportation systems is quite challenging.
3.	Concerns about the Noise Generated by UAVs
-	(1) The contribution of low-level flights in UAVs, especially to noise pollution, is undeniable.
-	(2) ...in the vicinity of the environment, with increasing movement and potentially dense traffic, excessive noise pollution could occur.
-	(45) Although it is electric, there will still be noise due to the propellers.
-	(53) As long as the propeller structure continues, there will be a serious noise problem. Regulations regarding this issue should be made.
4.	Concerns about UAVs Increasing Air Traffic
-	(7) It could create a new traffic problem.
-	(22) I fear the dangers that too many UAVs in airspace may pose.
-	(31) ...it may pose a danger to flight safety by increasing air traffic in general use.
-	(60) I believe that instead of car accidents, UAV accidents may increase and be more lethal.
-	(65) As the number increases, I think accidents will become inevitable, and the consequences of such accidents could be highly destructive. I approach this cautiously.
5.	Concerns about the High Cost of UAVs
-	(20) Adding vertical plane management to the horizontal plane will be quite challenging, and instead of building expensive bridges, tunnels, highways, etc., there will likely be significant costs associated with creating radar or similar systems to make flying machines very safe.
6.	Concerns about the Impact of UAVs on the Existing Economic Structure and Labor Market
-	(1) If they become widespread, new job opportunities may arise, but it is likely that job opportunities related to existing transportation will decrease.
-	(19) Issues such as unemployment or the creation of new job sectors are likely to create problems in the short term.
-	(45) With new infrastructure requirements and increased costs, the existing economic environment will be affected despite new economic opportunities.
-	(51) It will not be economically beneficial due to job losses.
7.	Concerns about the Integration of UAVs into the Existing Airspace
-	(1) ... integration into airspace seems quite challenging and complex when considering current procedures.
-	(9) I believe it will have a significant impact on the safety of other air traffic in the airspace.
-	(41) I anticipate challenges regarding regulations related to airspace.

- **Neutral Views**

Some participants hold neutral views regarding the barriers and opportunities for the proliferation of UAVs. It is mentioned that the infrastructure is not yet ready, financial difficulties need to be overcome, and issues like artificial intelligence need careful consideration. Neutral views exist concerning the impact of UAVs on society. It is stated that time is needed for UAVs to be used safely by people and that they may take time to adapt to urban planning. Additionally, neutral views include the need for further innovation in the technological development of UAVs and the necessity of regulations in the legal and regulatory aspects of UAVs. In Table 4, these views and participant quotations' examples are presented under four subthemes.

Table 4. Neutral Views Subthemes and Participant Quotations' Examples

1.	Barriers and Opportunities for the Growth of UAVs
-	(10) Currently, the infrastructure is lacking; there is a long way to go before operations can begin.
-	(78) Financial challenges must be overcome; it should be accessible to everyone.
-	(80) I would like its usage to increase cautiously, but I am in favor of paying attention to artificial intelligence; precautions should be taken for potential concerns.
2.	The Impact of UAVs on Society
-	(13) I believe convincing the public in terms of Autonomous 5 will be the most challenging situation.
-	(27) Although it provides significant benefits in other areas, adapting to urban planning and people will take time.
-	(38) I think it will take some time for people to trust and use UAVs.
3.	The Technological Development of UAVs
-	(35) More innovation is needed, and city infrastructures should be prepared accordingly.
-	(47) ... It will take many years for UAVs to be put into use and become an accessible option for everyone.
4.	The Legal and Regulatory Aspects of UAVs
-	(30) With the necessary regulations and the resolution of logistical challenges, it can become a widespread transportation option.
-	(36) ... if initial planning is based on low traffic percentages in the air, the result may resemble the situation we experience in road traffic. Strong regulations and planning are highly needed.
-	(66) Very effective and strictly defined rules for air mobility should be established.
-	(39) With the introduction of eVTOL vehicles into our lives, urban air mobility is expected to increase, and therefore, work should be done on the design of airspace.

5. Conclusion and Discussion

The research results indicate that society does not yet have a clear view regarding the use of UAVs in the context of UAM. There seems to be a balance between positive and negative views of this technology, highlighting the need for the public to gain more information about the benefits and risks of this technology.

Among the positive views, the importance of using UAVs in emergency situations has been emphasized. UAVs are seen as effective tools for rapid delivery and rescue operations. Additionally, UAVs have been positively evaluated for their potential to save time in urban logistics processes and transportation while reducing environmental impacts.

However, negative perspectives have centered around the potential risks and challenges. Security concerns, particularly regarding terrorist attacks and cyberattacks, may limit the acceptance of UAVs. Also, factors such as noise pollution and increased air traffic can complicate the use of UAVs in urban areas.

Neutral views in the study outline challenges and opportunities for widespread UAV use. Infrastructure deficiencies, high costs, and the need for technological advancements may limit the use of UAVs in UAM. Nevertheless, some participants hold the belief that these problems can be gradually overcome, leading to an easier integration of UAVs.

There is a critical need for a flexible and comprehensive legal framework to adapt to the rapid evolution of UAV technologies. As UAVs become increasingly sophisticated and their applications expand, existing regulations may prove inadequate to ensure the safe, secure, and equitable operation of these vehicles in densely populated urban environments. To foster public acceptance and trust in UAVs, regulations must be transparent, accessible, and

informed by public engagement. Addressing security concerns, data protection, autonomous navigation integration into ATM and public transportation system, and environmental impacts will be essential to ensure the safe, secure, and equitable operation of UAVs in urban environments.

To sum up, gaining public acceptance of UAVs' use in UAM involves a range of complex factors. These factors include security, regulations, technological development, environmental impacts, and economic effects. Future research should delve more deeply into these factors to promote wider acceptance of UAVs in urban areas. Additionally, policymakers need to take appropriate measures to integrate this potential mode of transportation sustainably and safely. Society should be informed about UAV technology, ethical considerations should be enhanced, and regulations should aim to address public concerns. UAVs have great potential in the field of UAM, but the concerns and needs of the public must be considered to realize this potential.

Author contributions

All authors have contributed with maximum contribution. All authors have contributed with maximum contribution.

Conflicts of interest

There are no conflicts of interest in any part of the research paper.

Statement of Research and Publication Ethics

For this type of study formal consent is not required.

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