safety

MDPI

Systematic Review

A New Shift in Implementing Unmanned Aerial Vehicles (UAVs) in the Safety and Security of Smart Cities: A Systematic Literature Review

Khalifa AL-Dosari * and Noora Fetais

College of Engineering, Qatar University, Doha P.O. Box 2713, Qatar; n.almarri@qu.edu.qa
* Correspondence: 200704317@qu.edu.qa; Tel.: +974-55815856

Abstract: The rapid rise of Unmanned Aerial Vehicles (UAVs) and their integration into smart city initiatives has sparked a surge of research interest in a broad array of thematic areas. This study undertakes a comprehensive review of recent scholarly literature to elucidate key research trends and innovative strategies for applying UAVs in smart cities. Through a detailed descriptive analysis, we identify prominent research clusters, including integrating the Internet of Things (IoT) with UAVs, applying artificial intelligence in surveillance, exploring the Internet of Drones (IoD), and cybersecurity challenges faced by smart cities. It is observed that security and privacy concerns within smart cities receive the most scholarly attention, indicating their central importance in shaping smart city strategies. The review of innovative strategies reveals a strong emphasis on leveraging cutting-edge technologies to enhance UAV capabilities and ensure drones' efficient, secure, and ethical deployment in smart city environments. This study provides crucial insights that inform the design of future research and policies in the burgeoning field of smart city development through the use of UAVs.

Keywords: Unmanned Aerial Vehicles (UAVs); safety; security; smart cities; systematic literature review

check for updates

Citation: AL-Dosari, K.; Fetais, N. A New Shift in Implementing Unmanned Aerial Vehicles (UAVs) in the Safety and Security of Smart Cities: A Systematic Literature Review. *Safety* **2023**, *9*, 64. https://doi.org/10.3390/safety9030064

Academic Editor: Raphael Grzebieta

Received: 17 July 2023
Revised: 4 September 2023
Accepted: 6 September 2023
Published: 13 September 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Smart cities are urban ecosystems that utilize advanced technologies and innovative solutions to enhance the quality of life of their inhabitants while improving the efficiency of urban services [1]. One such technology that has garnered significant attention in recent years is the implementation of Unmanned Aerial Vehicles (UAVs), also known as drones, in various aspects of urban safety and security. UAVs fly autonomously or can be remotely controlled, offering numerous benefits in flexibility, cost, and capabilities [2]. This paper aims to provide a comprehensive overview of the existing literature on integrating UAVs in the safety and security of smart cities, with particular emphasis on surveillance, disaster management, and emergency response applications. Surveillance plays a crucial role in maintaining the security of smart cities, as it allows for the efficient detection and prevention of crime and other security threats [3]. UAVs have emerged as a viable and cost-effective solution for aerial surveillance, offering capabilities surpassing traditional surveillance systems, such as Closed-Circuit Television (CCTV) cameras [4]. UAVs' ability to cover large areas rapidly, operate at various altitudes, and transmit real-time data has made them an indispensable asset for smart city surveillance [5].

Disaster management is another area where UAVs have shown significant potential in improving the safety and resilience of smart cities [6]. UAVs are deployed for rapid damage assessment, search and rescue missions, and aerial mapping in the aftermath of natural disasters such as earthquakes, hurricanes, and floods [7]. By providing timely and accurate information, UAVs can help mitigate the effects of disasters and facilitate a more effective response by emergency services [8]. Emergency response is a critical aspect of smart city safety, and UAVs can significantly enhance the capabilities of emergency services in various situations [9]. For instance, UAVs can support police operations, monitor and manage traffic incidents, and assist firefighting efforts [10]. In addition, UAVs have been used to deliver emergency medical supplies and transport patients in hard-to-reach areas, thereby improving the overall efficiency of emergency response systems [11]. Therefore, implementing UAVs in the safety and security of smart cities has the potential to revolutionize how urban areas are managed and protected. As this technology advances, further research is required to address privacy concerns, regulatory frameworks, and integration with existing infrastructure [7,9,11]. Nonetheless, the numerous benefits of UAVs in smart city applications indicate a promising future for this emerging technology.

As the integration of UAVs into smart cities continues to grow, addressing challenges and exploring new applications is paramount. Privacy concerns are a significant issue, as the pervasive use of UAVs for surveillance and data collection raises questions about protecting citizens' personal information and the potential for misuse [12]. As such, researchers and policymakers need to work together to develop regulations and frameworks that balance the benefits of UAV deployment with the protection of individual privacy. Another challenge is the seamless integration of UAVs into existing urban infrastructure, which requires addressing issues such as airspace management, communication networks, and the coordination of UAVs with other smart city technologies [5]. Researchers must develop innovative solutions to optimize the use of UAVs in urban environments while considering energy consumption, noise pollution, and collision avoidance [7].

Inspecting and maintaining urban infrastructure, including bridges, buildings, and transportation networks, are critical to ensuring the safety of smart cities [13]. UAVs play a significant role by providing rapid, cost-effective, and non-intrusive means of inspecting infrastructure assets [14]. Their ability to capture high-resolution imagery and other sensor data allows for early detection of structural issues and damage, enabling timely interventions and reducing the risk of accidents or failures [15,16]. Environmental monitoring is another area where UAVs contribute to the safety and security of smart cities. Using drones to monitor air quality, water pollution, and other environmental hazards can facilitate a more accurate and proactive approach to urban environmental management [15,17]. By providing real-time data on environmental conditions, UAVs can help city authorities identify potential risks and implement targeted measures to mitigate their impacts on public health and safety [17].

In addition to infrastructure and environmental applications, UAVs can also enhance public safety through crowd management and event monitoring. UAVs can provide valuable insights into crowd dynamics, allowing authorities to identify and address potential risks associated with large gatherings, such as stampedes or terrorist attacks [18,19]. Furthermore, drones are utilized for real-time monitoring of public events, ensuring adequate security measures, and providing situational awareness for emergency responders in case of incidents [20]. Therefore, deploying UAVs in smart city safety and security applications offers numerous efficiency, cost-effectiveness, and versatility benefits. However, challenges such as privacy concerns, regulatory hurdles, and technological limitations should be addressed to fully realize the potential of this technology [17]. While deploying Unmanned Aerial Vehicles (UAVs) in smart city safety and security applications has demonstrated numerous benefits, several challenges and gaps remain that need to be addressed to realize this technology's potential fully. The existing literature reveals a need for a broad understanding of the various barriers to UAV implementation and strategies to overcome these challenges while ensuring the responsible and effective integration of UAVs in smart cities. Therefore, the study addresses the research objectives:

1. To identify the key challenges associated with deploying UAVs in smart city safety and security.
2. To evaluate and propose best practices for public engagement and stakeholder involvement in the decision-making processes related to UAV deployment in smart cities.
3. To develop innovative solutions and strategies for implementing UAVs in smart city safety and security applications.

The study is organized in five major sections. Section 1 covers the introduction as well as the objectives of the study. On the other hand, Section 2 entails the systematic literature review, focusing on Challenges in Deploying UAVs in Smart City Safety and Security, Best Practices for Public Engagement and Stakeholder Involvement, and Innovative Solutions and Strategies for Implementing UAVs in Smart City Safety and Security. Regarding Section 3, the study covers the research methodology focusing on research method, study population, Database and Search Terms, Inclusion and Exclusion Criteria, data extraction, and Data Synthesis and Reporting. Section 4 entails discussion of findings while Section 5 provides the conclusions of the study.

2. Systematic Literature Review

2.1. Outline of the Systematic Literature Review

The role of this section (Section 2) is to present the systematic review carried out by the authors. Specifically, the systematic review carried out by authors cover the following areas; Challenges in Deploying UAVs in Smart City Safety and Security, Best Practices for Public Engagement and Stakeholder Involvement, and Innovative Solutions and Strategies for Implementing UAVs in Smart City Safety and Security. Systematic studies conducted insofar as Challenges in deploying UAVs in smart city safety and security, and Best practices for public engagement and stakeholder involvement have been summarized in tables showing key systematic reviews that informed the study's systematic review.

2.2. Challenges in Deploying UAVs in Smart City Safety and Security

Despite the challenges that face the deployment of UAVs in smart cities, UAVs provide various possible potential applications insofar as smart city safety and security are concerned. For instance, UAVs can be deployed in post-disaster management, street environment change detection, hurricane assessment and air quality measurement. While each application faces different challenges in deploying UAVs, this study focuses on the general challenges that cut across all the aforementioned possible applications. The challenges are discussed in details in the following sections.

2.2.1. Privacy Challenges

Several studies have identified privacy challenges as significant obstacles in deploying UAVs in smart city safety and security applications. Many researchers have highlighted the potential for UAVs to invade citizens' privacy due to their ability to capture high-resolution images and videos. Cavoukian [21] discusses the potential for UAVs to invade citizens' privacy, emphasizing the need for privacy-by-design principles in UAV implementation. Finn and Wright [22] raise concerns about potential violations of individuals' privacy rights, with UAVs being able to operate close to people and private properties. Clarke and Bennett Moses [23] examines the legal and ethical implications of UAV surveillance and recommend developing specific privacy regulations for UAVs.

2.2.2. Regulatory Challenges

The regulatory environment is another critical challenge in deploying UAVs in smart city safety and security. Researchers have emphasized the need for clear, comprehensive guidelines and rules for UAV operation in urban environments. Zhang et al. [24] emphasize the need for clear guidelines and rules for UAV operation in urban environments, including altitude restrictions, no-fly zones, and licensing requirements. Finn and Wright [22] suggest that regulations should be designed to promote transparency and accountability to ensure that the use of UAVs for safety and security is subject to oversight and public scrutiny. Rios et al. [25] provide an overview of UAV regulations and call for harmonizing global regulatory frameworks to facilitate the responsible implementation of UAVs in smart cities.

2.2.3. Public Acceptance

Public acceptance is essential for successfully implementing UAVs in smart city safety and security applications. Researchers have emphasized the importance of public engagement and effective communication to foster trust and acceptance of UAV technology. Rios et al. [25] argue that public engagement is crucial for fostering trust and acceptance of UAV technology. They recommend involving residents in the decision-making process related to UAV deployment and effectively communicating the benefits and risks associated with the technology. Clarke and Bennett Moses [23] emphasize the role of public perception in the success of low-cost sensing technologies like UAVs and call for more research on the social acceptance of such technologies. Cavoukian [21] investigate the challenges and opportunities of UAVs in Indian smart cities and highlight the need to address public acceptance issues.

2.2.4. Security and Cybersecurity

UAV security and cybersecurity are critical concerns in smart city safety and security applications. Al-Saadi et al. [26] explore the potential threats to UAV communication systems, such as jamming and interception, and propose countermeasures to secure UAV networks. Yang et al. [27] discuss the importance of ensuring the cybersecurity of UAVs and their integration with smart city infrastructure to prevent unauthorized access and data breaches.

2.2.5. Interoperability and Standardization

Interoperability and standardization issues are significant challenges in deploying UAVs in smart city safety and security applications. Karras et al. [28] stress the importance of developing standardized protocols and frameworks for integrating UAVs into smart city environments. Al-Saadi et al. [26] call for establishing common standards for communication, data sharing, and operation of UAVs in urban settings. Finally, the study also includes the systematic literature review in Table 1 by identifying the challenges in the deployment of UAVs in smart city safety and security.

Table 1. Challenges in deploying UAVs in smart city safety and security.

Author(s)	Challenge Types	Country	Proposed Solution
Israr et al. [29]	Security and cybersecurity	General	Explores potential threats to UAV communication systems, such as jamming and interception, and proposes countermeasures to secure UAV networks
Krichen et al. [30]	Security and cybersecurity	General	Discusses the importance of ensuring the cybersecurity of UAVs and their integration with smart city infrastructure to prevent unauthorized access and data breaches
Jain et al. [31]	Interoperability and standardization	India	Stresses the importance of developing standardized protocols and frameworks for integrating UAVs into smart city environments
Garge & Balakrishna [32]	Interoperability and standardization	General	Calls for the establishment of common standards for communication, data sharing, and operation of UAVs in urban settings
Cavoukian [21]	Privacy concerns	General	Discusses the potential for UAVs to invade citizens' privacy, emphasizing the need for privacy-by-design principles
Finn and Wright [22]	Privacy concerns	General	Raises concerns about potential violations of individuals' privacy rights due to UAVs' ability to operate in close proximity to people and private properties

Table 1. *Cont.*

Author(s)	Challenge Types	Country	Proposed Solution
Clarke and Bennett Moses [23]	Privacy concerns	Australia	Examines legal and ethical implications of UAV surveillance and recommends the development of specific privacy regulations for UAVs
Bedi et al. [33]	Regulatory challenges	General	Emphasizes the need for clear guidelines and rules for UAV operation in urban environments, including altitude restrictions, no-fly zones, and licensing requirements
Mualla et al. [34]	Regulatory challenges, transparency, and accountability	General	Suggests that regulations should be designed to promote transparency and accountability to ensure that the use of UAVs for safety and security purposes is subject to oversight and public scrutiny
Thakur et al. [35]	Public acceptance	India	Argues that public engagement is crucial for fostering trust and acceptance of UAV technology and recommends involving residents in decision-making processes related to UAV deployment
Ismagilova et al. [36]	Public acceptance	General	Investigates challenges and opportunities of UAVs in Indian smart cities and highlights the need to address public acceptance issues
Choudhary et al. [37]	Security and cybersecurity	General	Explores the vulnerabilities of UAVs to cyberattacks and suggests strategies to mitigate these risks
Baig et al. [38]	Interoperability and standardization	General	Investigates the challenges of UAV interoperability with smart city systems and proposes solutions for seamless integration

2.3. Best Practices for Public Engagement and Stakeholder Involvement

Public consultations and workshops are essential in gathering citizens' opinions, concerns, and expectations regarding UAV deployment in smart cities [39]. These events provide opportunities for open dialogue, enabling authorities to understand the public's perspective and address misconceptions and fears about UAV technology. Additionally, consultations and workshops can help identify potential use cases and applications that could benefit the community, ensuring that UAV deployment aligns with public needs and values [38]. Active public participation in decision-making is vital to promoting a sense of ownership and acceptance of UAVs within the community. In addition, involving multiple stakeholders in the decision-making process related to UAV deployment helps to create a more comprehensive understanding of the challenges, benefits, and implications of integrating UAV technology in smart cities [40]. Stakeholders can include government authorities, industry representatives, researchers, and community organizations. Collaborative efforts among these stakeholders facilitate the identification of best practices and the development of guidelines that address the concerns of all parties involved [37]. Furthermore, multi-stakeholder collaboration can promote innovation and identify new opportunities for UAV technology in smart cities, ultimately enhancing urban safety and security.

Developing adaptive regulatory frameworks that can accommodate the rapid evolution of UAV technology and the diverse range of stakeholder interests is crucial for successfully deploying UAVs in smart cities [25]. These frameworks should be flexible and responsive to technological advancements, public concerns, and new use cases. By incorporating input from various stakeholders, adaptive regulatory frameworks can help balance the need for innovation with public concerns related to privacy, safety, noise pollution, and environmental impacts [41]. Continuous monitoring and evaluation of UAV deployment in smart cities can inform periodic updates to the regulatory framework, ensuring that it remains relevant and effective. Public education and awareness campaigns significantly promote acceptance and understanding of UAV technology among the public [42]. These campaigns can help demystify UAV technology, address common misconceptions, and highlight the potential benefits of UAV deployment in smart cities. They also display successful case studies, illustrating how UAVs have improved urban safety and security in various contexts. By providing accurate and accessible information, public education and awareness campaigns foster a more informed public debate, shape public opinion, and facilitate public participation in decision-making.

On the other hand, maintaining transparency throughout the decision-making process related to UAV deployment in smart cities is essential for building public trust and acceptance [25,38]. Transparency is achieved by openly sharing information on the potential impacts of UAV technology, including its benefits, risks, and applications. This involves making planning documents, risk assessments, and regulatory frameworks publicly available and ensuring that the rationale behind decisions is clearly communicated. Furthermore, transparency can be enhanced by providing opportunities for public input and feedback at various stages of the decision-making process, ensuring that citizens feel their concerns and opinions are heard and considered. Therefore, implementing best practices for public engagement and stakeholder involvement in decision-making processes related to UAV deployment in smart cities is critical for ensuring the technology's successful integration. These practices include public consultations and workshops, multi-stakeholder collaboration, adaptive regulatory frameworks, public education and awareness campaigns, and transparent decision-making processes. By incorporating these practices, policymakers, industry leaders, and other stakeholders can address public concerns, foster acceptance, and ultimately facilitate the development and deployment of UAVs to enhance safety and security in smart cities. Table 2 also presents the systematic literature review of practices for public engagement and stakeholder involvements.

Table 2. Best practices for public engagement and stakeholder involvement.

Author(s)	Country/ Context	Findings	Benefits	Practices for Public Engagement	Practices for Stakeholder Involvement
Kummitha [3]	N/A	Techno-and human-driven approaches to using smart technologies to fight pandemics.	Better pandemic management	Public awareness and education campaigns about the use of UAVs during pandemics. Involvement of citizens in testing and evaluating UAV-based solutions.	Collaboration with public health authorities, local governments, and technology providers. Engaging with communities and other stakeholders in the decision-making process.
El-Sayed et al. [41]	Smart city scenarios	A traffic-aware approach for enabling UAVs in smart city scenarios	Improved UAV traffic management, increased safety and efficiency	N/A	Collaboration with city planners and traffic management authorities
Calantropio et al. [9]	Post-disaster scenarios	UAV validation and remote sensing data for damage assessment in post-disaster scenarios	Accurate and efficient damage assessment	N/A	Collaboration with disaster management authorities
Yuan & Liu [10]	Hurricane Matthew	Integration of social media and unmanned aerial vehicles (UAVs) for rapid damage assessment in Hurricane Matthew	Rapid damage assessment using social media and UAVs	Integration of social media data	N/A
Villa et al. [11]	Air quality measurements	An overview of small UAVs for air quality measurements: Application and	Improved air quality monitoring	N/A	Collaboration with environmental agencies
Rhee et al. [12]	Fluvial remote sensing	Future Applications of UAVs in fluvial remote sensing: Overview of recent achievements	Enhanced fluvial remote sensing capabilities	N/A	Collaboration with hydrological and environmental authorities

Table 2. *Cont.*

Author(s)	Country/ Context	Findings	Benefits	Practices for Public Engagement	Practices for Stakeholder Involvement
Yanmaz et al. [7]	Drone networks	Drone networks: Coordination, and sensing	Improved communication, coordination, and sensing in drone networks	N/A	Collaboration with communication and network stakeholders
Chamola et al. [13]	UAV attacks	A comprehensive review of UAV attacks and neutralization techniques	Enhanced understanding of UAV threats and countermeasures	N/A	Collaboration with security agencies and regulators
Xiao et al. [14]	Street environment	Street environment change detection from mobile laser scanning point clouds	Efficient street environment change detection	N/A	Collaboration with urban planners and local authorities
Khan et al. [16]	Smart cities	Drones for good in smart cities: a review	Improved understanding of UAVs' potential in smart cities	N/A	Collaboration with smart city planners and stakeholders
Alsamhi et al. [15]	Smart cities	Survey on collaborative smart drones and IoT for improving smartness of smart cities	Enhanced smart city capabilities through drone and IoT integration	N/A	Collaboration with smart city planners and IoT stakeholders
Sharma & Arya [17]	Environment monitoring	UAV-based long-range environment monitoring system with Industry 5.0 perspectives for smart city infrastructure	Improved long-range environmental monitoring	N/A	Collaboration with environmental agencies and industry partners
Mohamed et al. [19]	Future smart cities	Unmanned aerial vehicle applications in future smart cities	Improved understanding of UAV applications in smart cities	N/A	Collaboration with smart city planners and stakeholders
Kuru [18]	N/A	Planning framework for UAV swarms in smart cities	Improved urban planning and resource management	N/A	Collaborative planning with stakeholders
Outay et al. [20]	N/A	UAV applications in road safety and infrastructure management	Enhanced safety and efficient infrastructure management	N/A	Collaboration with transportation authorities and infrastructure planners
Mualla et al. [34]	N/A	Challenges of UAV transport in future smart cities	Sustainable urban transport	Public awareness campaigns	Collaboration with urban planners, regulators, and transport authorities
Israr et al. [29]	N/A	IoT-enabled UAVs for construction site inspection	Improved safety, efficiency, and cost-effectiveness	N/A	Collaboration with construction industry stakeholders and regulators
Krichen et al. [30]	N/A	Security challenges in drone communications	Enhanced security for UAV applications	N/A	Collaboration with cybersecurity experts and industry stakeholders
Jain et al. [31]	N/A	Smart city surveillance with energy-efficient UAVs	Improved surveillance and reduced energy consumption	Public consultations on privacy concerns	Collaboration with law enforcement and privacy regulators
Garge & Balakrishna [32]	N/A	UAVs as QoS enablers for multimedia applications	Improved multimedia delivery in smart cities	N/A	Collaboration with telecommunication and media companies
Cavoukian [21]	Ontario, Canada	Privacy concerns in UAVs	Addressing privacy issues in UAV applications	Public consultations on privacy concerns	Collaboration with privacy regulators and policymakers
Finn & Wright [22]	N/A	Ethical and privacy issues in civilian UAV applications	Ethical use of UAVs in civil applications	Public consultations on ethical concerns	Collaboration with policymakers and regulators

Table 2. *Cont.*

Author(s)	Country/ Context	Findings	Benefits	Practices for Public Engagement	Practices for Stakeholder Involvement
Clarke & Moses [23]	N/A	Regulation of civilian drones' impacts on public safety	Enhanced public safety	Public consultations on safety concerns	Collaboration with regulators and policymakers
Bedi et al. [33]	N/A	IoT in electric power and energy systems	Improved energy management	N/A	Collaboration with energy stakeholders and regulators
Thakur et al. [35]	N/A	AI techniques in smart city surveillance using UAVs	Enhanced security and efficient resource allocation	Public consultations on privacy concerns	Collaboration with law enforcement, privacy regulators, and AI experts
Ismagilova et al. [36]	N/A	Security, privacy, and risks within smart cities	Comprehensive understanding of risks	Public consultations on security and privacy concerns	Collaboration with stakeholders in smart city development
Choudhary et al. [37]	N/A	Internet of Drones (IoD) security perspectives	Improved security for drone applications	N/A	Collaboration with cybersecurity experts and industry stakeholders
Baig et al. [38]	N/A	Future challenges for smart cities in cybersecurity and digital forensics	Enhanced cybersecurity in smart cities	Public consultations on cybersecurity concerns	Collaboration with cybersecurity experts and city planners
de Miguel Molina et al. [39]	N/A	Ethics for civil indoor drones	Ethical use of indoor drones	Public consultations on ethical concerns	Collaboration with policymakers and regulators
Otto et al. [40]	N/A	Optimization approaches for civil UAV applications	Improved efficiency and effectiveness in UAV use	N/A	Collaboration with industry stakeholders and regulators

2.4. Innovative Solutions and Strategies for Implementing UAVs in Smart City Safety and Security

Innovative solutions and strategies for implementing Unmanned Aerial Vehicles (UAVs) in smart city safety and security have gained significant attention in recent years. The potential of UAVs to enhance urban management, especially in safety and security, has led to numerous studies exploring various aspects of this emerging technology [43]. One key area of focus is the role of UAVs in disaster response and management. Studies have shown that UAVs can rapidly assess damage, search and rescue operations, and provide aerial support during natural disasters [44,45]. Integrating UAVs into emergency response systems improves overall urban safety and efficiency.

Another crucial aspect of UAV implementation in smart cities is their use in surveillance and monitoring. Equipping UAVs with high-resolution cameras and sensors can provide real-time data for law enforcement agencies and city officials to monitor public spaces, identify potential threats, and track criminal activities [46,47]. Integrating UAVs into urban security systems can enhance cities' overall safety and security. Moreover, UAVs have been proposed to maintain and inspect critical infrastructure such as bridges, tunnels, and power lines [47]. Using UAVs for inspection can reduce the risks associated with manual inspections and allow for more frequent, cost-effective assessments. Data privacy and security concerns have also been addressed in the literature. Researchers have proposed various strategies to ensure citizens' privacy while using UAVs for surveillance and monitoring [24,43]. These strategies include encryption techniques, secure communication protocols, and implementing privacy-aware data management systems.

Finally, innovative solutions and strategies for implementing UAVs in smart city safety and security have the potential to enhance urban management significantly. Integrating UAVs into emergency response systems, surveillance and monitoring systems, and infrastructure inspection can improve overall safety and efficiency in urban areas. Finally, Table 3 presents the systematic literature review on identifying innovative solutions and strategies in the deployment of UAVs in smart city safety and security.

Table 3. Identifying innovative solutions and strategies.

Author(s)	Country/Context	Innovative Solutions	Innovative Strategies	Outcomes
Bedi et al. [33]	Global	Internet of Things (IoT) in electric power and energy systems	Integration of IoT with UAVs for monitoring and management of electric power and energy systems	Enhanced management and monitoring of energy systems
Thakur et al. [35]	Global	Artificial intelligence techniques in smart cities surveillance using UAVs	Applying AI techniques to UAV surveillance systems, including object recognition, motion detection, and anomaly detection	Improved surveillance and security in smart cities
Ismagilova et al. [36]	Global	Security, privacy, and risks within smart cities	Developing a smart city interaction framework addressing security, privacy, and risks associated with the use of UAVs in smart cities	Framework for mitigating risks in smart cities
Choudhary et al. [37]	Global	Internet of drones (IoD)	Identifying threats, vulnerabilities, and security perspectives of IoD and proposing solutions for secure communication and data sharing	Enhanced security in UAV communication networks
Baig et al. [38]	Global	Cybersecurity and digital forensics	Addressing future challenges for smart cities in the realm of cyber-security and digital forensics, with a focus on IoT, cloud computing, and UAVs	Improved understanding of cybersecurity challenges
de Miguel Molina et al. [39]	Civil indoor drones	Ethics for civil indoor drones	Conducting a qualitative analysis to understand ethical concerns related to the use of indoor drones in civil applications, such as privacy, safety, and autonomy	Ethical guidelines for civil indoor drone usage
Otto et al. [40]	Global	Optimization approaches for UAVs in civil applications	Surveying optimization techniques for various civil UAV applications, including routing, scheduling, and payload allocation	Comprehensive understanding of optimization approaches
Rios et al. [25]	UAS Traffic Management	Flight demonstration of UTM at technical capability level 4	Demonstrating the feasibility of integrating UAVs into urban airspace for efficient traffic management and safety	Successful integration of UAVs in urban airspace
Alqurashi et al. [42]	Global	Machine learning techniques in internet of UAVs for smart cities applications	Investigating the application of machine learning techniques in various UAV use cases, such as traffic management, security, and environmental monitoring	Enhanced UAV performance in smart cities
El-Sayed et al. [41]	Smart city scenarios	Traffic-aware approach for UAVs	Developing a traffic-aware approach to facilitate UAV integration into smart city scenarios, minimizing the impact on existing traffic and improving safety	Improved UAV integration and safety in smart cities

Table 3. *Cont.*

Author(s)	Country/Context	Innovative Solutions	Innovative Strategies	Outcomes
Sookhak et al. [43]	Global	Security and privacy of smart cities	Surveying the security and privacy challenges faced by smart cities, with a focus on IoT, cloud computing, big data, and UAVs, and discussing potential solutions	Improved understanding of security and privacy concerns
Wankmüller et al. [44]	Cross-border	Drones in emergency response	Evaluating the usability of UAV	

3. Research Methodology

This section provides the methodology adopted in conducting the systematic review.

3.1. Research Method

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [48] served as the foundation for the methodological framework of the current systematic review. Due to its widespread acceptability as a strict and open methodology for performing systematic reviews, the PRISMA framework was chosen [48]. The Population, Intervention, Comparison, and Outcome (PICO) model, a commonly used framework for defining research questions in systematic reviews, define the research question as the first phase of the PRISMA approach [49]. This methodology aids in making sure that the review question is precise and valuable, enhancing the review's quality and applicability [49].

3.2. Study Population

The study sources included research articles, papers, conference proceedings, and book chapters focused on the topic of interest (see Figure 1). These sources were chosen as they provided the field's most relevant and up-to-date information. A succinct explanation of paper inclusion and exclusion standards is a prerequisite for conducting the SLR [50]. There were 219 scientific articles found after the following article eligibility requirements were adopted: articles; without a set time frame, English language, and full-text availability. Articles that had nothing to do with unmanned aerial vehicles (UAVs) in safety and security were eliminated. The study identified total of 1789 records from databases and 30 from other sources. In sum, 398 records from databases were excluded before the screening stage. When the screening process was complete, 450 records were further excluded due to repetitions and irrelevancy. In the end, the study used a total of 47 records including 40 from databases and 7 from other sources (for more details, see the Figure 1 PRISMA diagram).

3.3. Database and Search Terms

The academic sources ScienceDirect, Web of Science by Clarivate Analytics, and Scopus by Elsevier served as the data sources. Scopus was chosen as it is the largest database of peer-reviewed articles; Web of Science was chosen due to its ability to access all journals that have been indexed with a determined impact factor of one in the Journal Citation Report (JCR) [51] and ScienceDirect was chosen due to the international scope's multidisciplinarity of studies and references. For Web of Science, we solely used the "type of documents" filter, selecting articles, reviews, and conference papers. The search criteria for the other databases were "Title, Keywords, and Abstract". Design and implement security, safety, and privacy design connected with "UAVs", "unmanned aerial vehicles", "UAVs in security", "UAVs in safety", "drones", and "UAVs in smart city/cities" were used as search criteria. It was hoped to include publications that used words and phrases that were grammatically different but had the same meaning as the suggested issue.

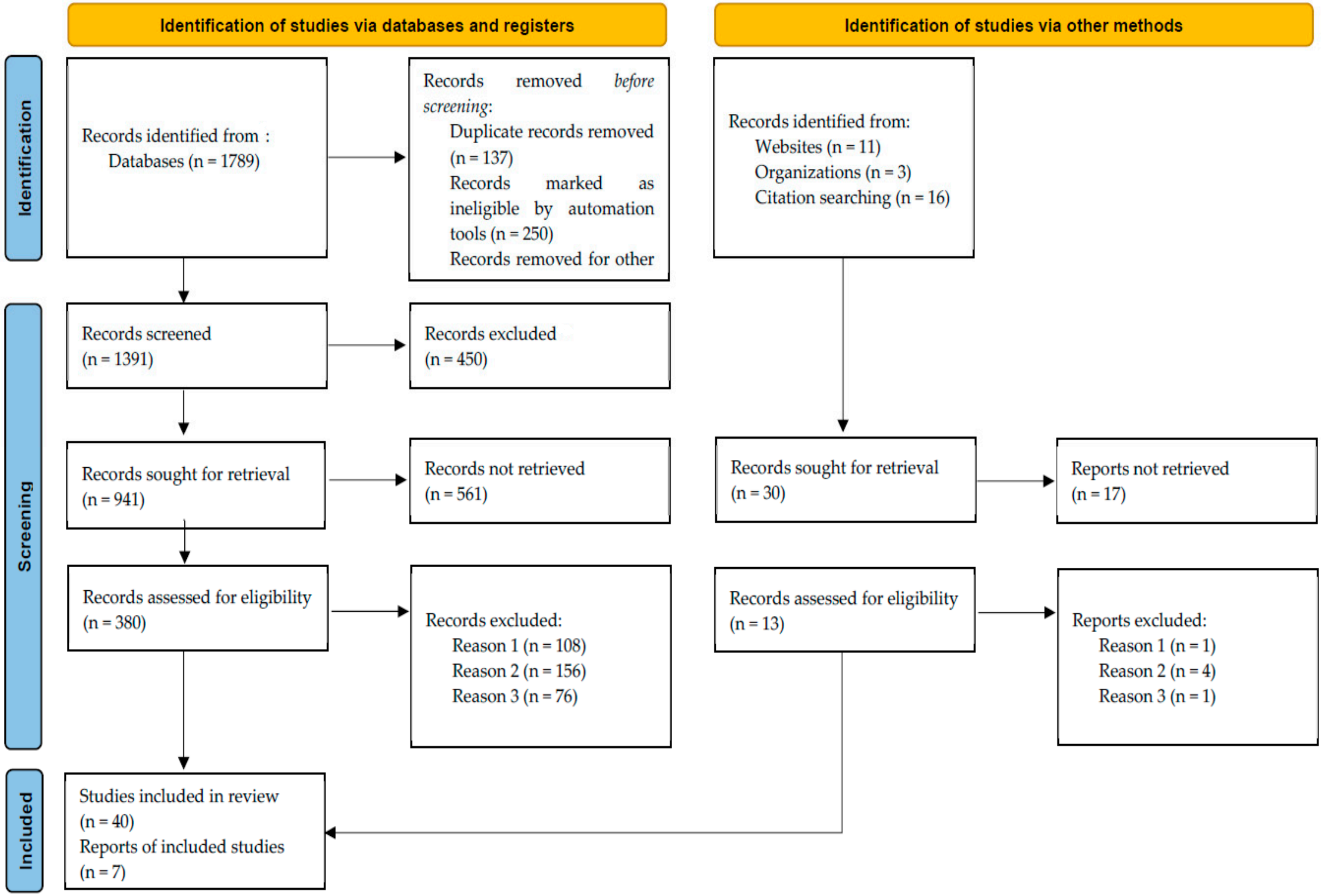

Figure 1. PRISMA Diagram.

3.4. Inclusion and Exclusion Criteria

Studies were included if they met the following criteria: (a) published in English; (b) focused on innovative solutions and strategies for implementing UAVs in smart city safety and security; or (c) presented original research, reviews, or case studies. Articles were excluded if they (1) were not available in full-text; (2) were published before 2012; (3) needed a clearer focus on the topic of interest.

3.5. Data Extraction

Data from the selected articles were extracted using a standardized data extraction form. Information collected included author(s), publication year, research method, innovative solutions, strategies, and outcomes. The quality of the included articles was assessed using a modified version of the Critical Appraisal Skills Programme (CASP) checklist [52]. This tool evaluated each study based on its relevance, validity, and reliability.

3.6. Data Synthesis and Reporting

The extracted data were synthesized using a thematic analysis approach [53,54]. This involved identifying common themes and patterns across the included studies. The findings were then reported in a structured manner, highlighting key insights and implications for the field. The criteria gave essential insights into choosing research topics, guiding descriptive and thematic analysis, and comprehending the significance and necessity of research in this region. Using themes allows the researcher to better grasp the problem being addressed by condensing a large amount of information into smaller, more manageable parts. The viewpoints and contexts of the research were discovered through descriptive and theme analysis after reading and evaluating the articles.

4. Results and Discussion

4.1. Descriptive Analysis

Table 4 offers an enlightening overview of various studies categorized based on their research methods, year of publication, citation count, and whether they are empirical or conceptual. A significant observation is the prevalent use of quantitative methods in 19 out of 47 analyzed studies (see Figure 2). This indicates a strong reliance on numerical data and statistical techniques to probe research questions in this field. Qualitative research, emphasizing understanding human behavior and the reasons behind such behavior, is the method chosen in 15 studies, signifying a significant interest in exploratory research. Descriptive and systematic literature reviews (SLR)/meta-analysis methods account for the remaining studies, with eight and five, respectively. These methods reflect the value of analyzing data and summarizing existing literature to conclude. The publication years for these studies are from 2012 to 2022, representing a decade of scholarly contributions. The division between empirical and conceptual studies is almost equal, with 25 empirical and 22 conceptual studies. This indicates a balanced approach between studies based on observation or experience and those based on ideas and theories. The number of citations these studies received varies, but it is a crucial metric as it reflects the impact and recognition of these studies within the academic community. Thus, interpreting the citation count can provide insights into the influence and relevance of these studies.

Table 4. Number of studies and year of publications for studies used in the review.

Research Method	Number of Studies
Quantitative	19
Qualitative	15
Descriptive	8
SLR/Meta-analysis	5

Number of Citations	Year of Publication	Empirical Studies	Conceptual Studies
Count 47	2012–2022	25	22

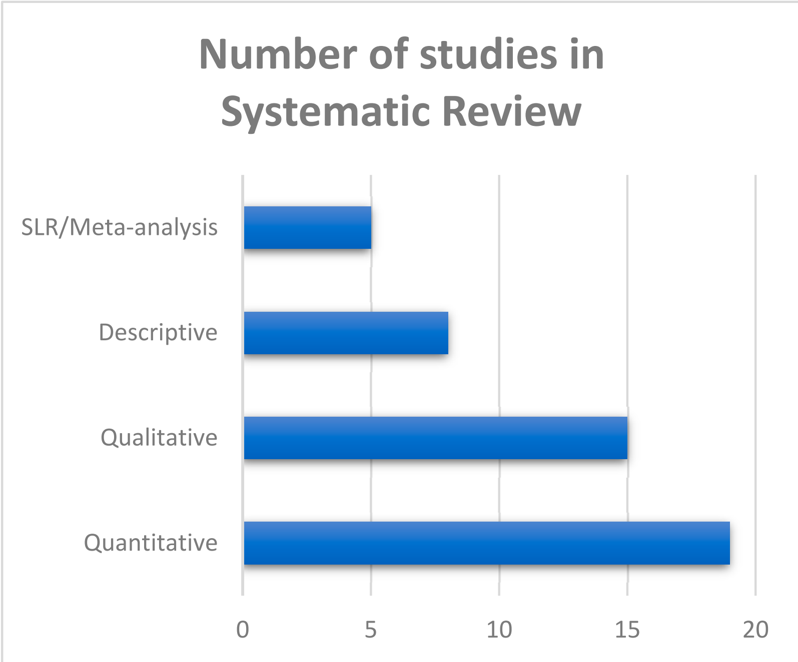

Figure 2. Number of studies.

4.2. Implementation of Unmanned Aerial Vehicles (UAVs) for Safety and Security

Table 5 provides a comprehensive view of the multifaceted application of Unmanned Aerial Vehicles (UAVs) in safety and security operations across diverse domains. From the collected data, several key trends and patterns emerge. One of the most prevalent themes is the utilization of UAVs in the context of smart cities. This application field has been the subject of seven studies, making it the most explored area. This popularity is attributed to UAVs' wide-ranging possibilities for urban areas. Smart cities integrate UAVs in various functions such as surveillance, traffic management, cybersecurity, digital forensics, and even in improving the overall 'smartness' of the city. The authors emphasize applications that improve the quality of urban life, suggesting that UAVs can play a pivotal role in the evolution of smart cities. The field of disaster management also emerges as a significant area of focus, albeit less explored than smart cities. The studies underscore the role of UAVs in damage assessment post-disaster scenarios and life-saving initiatives like the delivery of automated external defibrillators for out-of-hospital cardiac arrests. The flexibility and nimbleness of UAVs make them perfect candidates for accessing disaster-struck areas that may be challenging for humans to reach, thus increasing their value in disaster management.

Moreover, drone and UAV security concerns appear to be a recurrent theme in the studies, focusing on privacy issues, UAV attacks and neutralization techniques, and regulatory impacts on public safety. This theme indicates the growing recognition of the potential risks and challenges of using UAVs. The ethical implications of UAV use also surface in the studies, reinforcing the necessity for a balanced approach that respects civil liberties while taking advantage of UAVs' benefits. In particular, the use of UAVs for indoor surveillance and their privacy implications are discussed. Overall, the table illustrates the expanding role of UAVs in shaping the future of safety and security operations across various sectors. However, the findings also stress the importance of addressing the emerging challenges and ethical considerations associated with their widespread use.

Table 5. Implementation of Unmanned Aerial vehicles (UAVs) for safety and security.

Research Field	Number of Studies	Author's Names (APA Style)	Targeted Contexts
Smart Cities	7	Alqurashi et al. [42]; Alsamhi et al. [15]; Baig et al. [38]; Garge and Balakrishna [32]; El-Sayed et al. [41]; Ismagilova et al. [36]; Jain et al. [31]	Smart cities applications, cybersecurity and digital forensics, improving smartness, on-demand QoS enabler for multimedia applications, traffic-aware approach for enabling UAVs, security, privacy and risks, surveillance solution
Disaster Management	3	Calantropio et al. [9]; Claesson et al. [55]; Erdelj et al. [6]	Damage assessment in post-disaster scenarios, delivery of an automated external defibrillator for simulated out-of-hospital cardiac arrests, leveraging UAVs for disaster management
Drone and UAV Security	5	Cavoukian [21]; Chamola et al. [13]; Choudhary et al. [37]; Clarke and Moses [23]; Krichen et al. [30]	Privacy and drones, UAV attacks and neutralization techniques, internet of drones (IoD) threats, vulnerability, and security perspectives, Regulation of civilian drones' impacts on public safety, Security challenges for drone communications
Ethics of UAV use	2	de Miguel Molina et al. [39]; Finn and Wright [22]	Ethics of civil indoor drones, surveillance, ethics and privacy in civil applications
Construction and Infrastructure Monitoring	2	Israr et al. [29]; Yuan and Liu [10]	Inspection of construction sites, Rapid damage assessment in hurricanes
Transportation	2	Mualla et al. [34]; Outay et al. [20]	Transport with UAVs in future smart cities, Road safety, traffic and highway infrastructure management
Urban Environment Mapping	2	Kuru [18]; Majeed and Hwang [47]	Planning the future of smart cities with swarms of fully autonomous unmanned aerial vehicles, Coverage path planning algorithm for UAVs to cover spatially distributed regions in urban environments
Environmental Monitoring	2	Barbedo [2]; Sharma and Arya [17]	Use of unmanned aerial vehicles and imaging sensors for monitoring and assessing plant stresses, UAV based long range environment monitoring system
Gement	1	Erdelj et al. [6]	Using UAVs for disaster management
Drone Surveillance and Energy Efficiency	1	Jain et al. [31]	Smart city surveillance and energy efficiency in UAV technologies
Construction Sites Inspection	1	Israr et al. [29]	Utilizing IoT-enabled UAVs for construction sites inspection
Urban Environment Coverage Path Planning	1	Majeed and Hwang [47]	Planning of UAV coverage paths in urban environments
Structural Health Monitoring	1	Malekloo et al. [45]	Machine learning and structural health monitoring with UAVs
UAV Applications in Smart Cities	1	Mohamed et al. [19]	Discussing the applications of UAVs in future smart cities
UAV in Transport for Smart Cities	1	Mualla et al. [34]	Challenges of transport with UAVs in future smart cities
Air Quality Measurements	1	Villa et al. [11]	Small UAVs for air quality measurements
Emergency Response	1	Wankmüller et al. [44]	The use of drones in emergency response

Table 5. *Cont.*

Research Field	Number of Studies	Author's Names (APA Style)	Targeted Contexts
Street Environment Change Detection	1	Xiao et al. [14]	Mobile laser scanning for street environment change detection
Communications, Coordination, and Sensing in Drone Networks	2	Yanmaz et al. [7]	Communications, coordination, and sensing in drone networks
Rapid Damage Assessment	1	Yuan and Liu [10]	Integration of social media and UAVs for rapid damage assessment
Agricultural Monitoring	1	Zhang et al. [24]	Using UAV low-altitude remote sensing in agricultural monitoring in China

4.3. Key Challenges Associated with Deploying UAVs in Smart City Safety and Security

Figure 3 presents the key challenges of deploying UAVs in smart city safety and security. Each category's percentage is calculated based on the total number of studies (32) mentioned across the categories. Security and Cybersecurity Challenges, addressed in 10 studies, represent 31.25% of the total, underscoring the prominence of cybersecurity concerns in the UAV domain. This emphasizes the importance of developing robust cybersecurity measures, including protection from UAV attacks and ensuring secure communication. Regulatory challenges, discussed in seven studies (21.87% of the total), highlight the significance of creating and enforcing effective regulatory mechanisms for UAV usage. The prevalence of these issues underscores the need for new, comprehensive regulations that ensure public safety and address the specific needs of UAV operations in smart cities. Interoperability and standardization, covered in six studies, comprise 18.75% of the total. This reflects the importance of integrating UAVs seamlessly into existing IoT systems in smart cities and developing new standards for these emerging technologies.

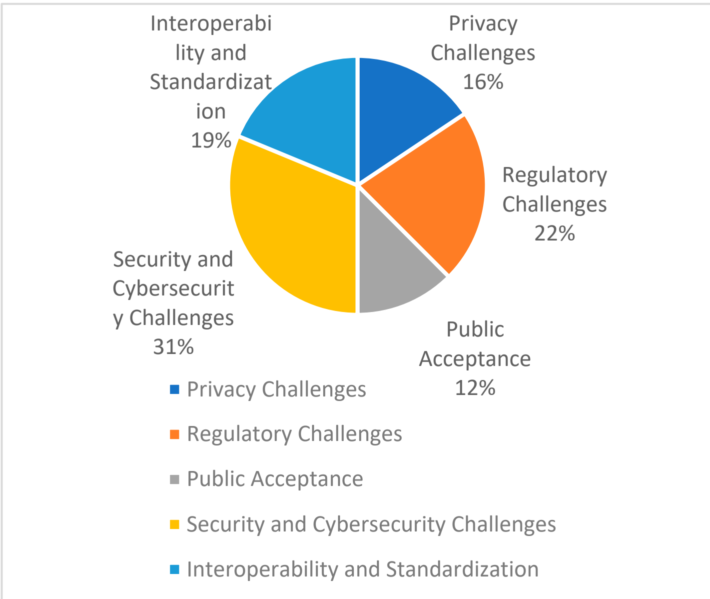

Figure 3. Key challenges associated with deploying UAVs in smart city safety and security.

On the other hand, privacy challenges addressed in five studies (15.62%), indicate the need to balance the use of UAVs with personal privacy. This suggests that privacy-respecting guidelines and technology are necessary to protect citizens' rights in smart cities. Finally, Public Acceptance, discussed in four studies (12.5%), emphasizes the importance of addressing public perceptions of UAVs, including ethical concerns and overall acceptance of these technologies in everyday life. Therefore, the findings indicate that successfully deploying UAVs in smart cities will require addressing several key challenges. The highest priority should be given to addressing Security and Cybersecurity Challenges [56], representing almost a third of all studies. Following this, Regulatory Challenges and Interoperability and Standardization are also vital areas to focus on, comprising 21.87% and 18.75%, respectively. However, the Privacy Challenges and the requirement for Public Acceptance should be considered, as these factors are crucial for maintaining public trust and ensuring the ethical use of UAVs in smart cities. Integrating UAVs into smart city infrastructure will necessitate a well-rounded approach addressing all these aspects.

4.4. Best Practices for Public Engagement and Stakeholder Involvement in Smart Cities

The findings in Table 6 provide the results of the best practices for public engagement and stakeholder involvement in the context of smart cities (Also see Figure 4). The most frequently referenced practices in the public engagement category point toward the need for effective communication and participation. The use of online platforms and social media is vital, which can be attributed to these tools' extensive reach and interactive nature. Furthermore, enabling public participation in decision-making ensures a broader range of perspectives is considered, leading to more inclusive and practical solutions. Holding public consultations or town hall meetings and including public feedback in the planning and execution phases reflect the importance of a continuous dialogue with citizens, who are the primary beneficiaries of smart city initiatives.

Table 6. Best practices for public engagement and stakeholder involvement in smart cities.

Category	Number of Studies	Best Practices
Public Engagement	16	1. Use of online platforms and social media for communication. 2. Encouraging public participation in decision-making processes. 3. Running awareness campaigns about smart city initiatives. 4. Holding public consultations or town hall meetings. 5. Including public feedback in planning and execution phases.
Stakeholder Involvement	17	1. Inclusion of stakeholders in planning and design stages. 2. Encouraging partnerships between government, industry, academia, and civil society. 3. Facilitating regular communication and collaboration among stakeholders. 4. Implementing transparency and openness in dealing with stakeholders. 5. Promoting the understanding of each stakeholder's roles and responsibilities. 6. Ensuring stakeholders have equal opportunities to contribute.

In addition, stakeholder involvement, meanwhile, is characterized by practices that promote inclusion, collaboration, and transparency. The most frequent recommendations revolve around involving stakeholders from the planning and design stages and maintaining a consistent line of communication among them. Partnerships across sectors—government, industry, academia, and civil society—are key to leveraging diverse expertise and resources. Transparency and openness in dealings with stakeholders build trust and promote active engagement. Understanding each stakeholder's roles and responsibilities and providing equal opportunities for contribution further foster a sense of shared ownership and accountability. Therefore, these findings underline the critical role of active public engagement and holistic stakeholder involvement in smart cities' successful planning, development, and operation. The vast majority of studies consider an open, collaborative, and inclusive approach essential, reflecting a broader shift in public governance towards more participatory models. These practices can guide policymakers and city administrators in implementing smart city projects, helping to ensure their initiatives are rooted in the needs and insights of those they serve.

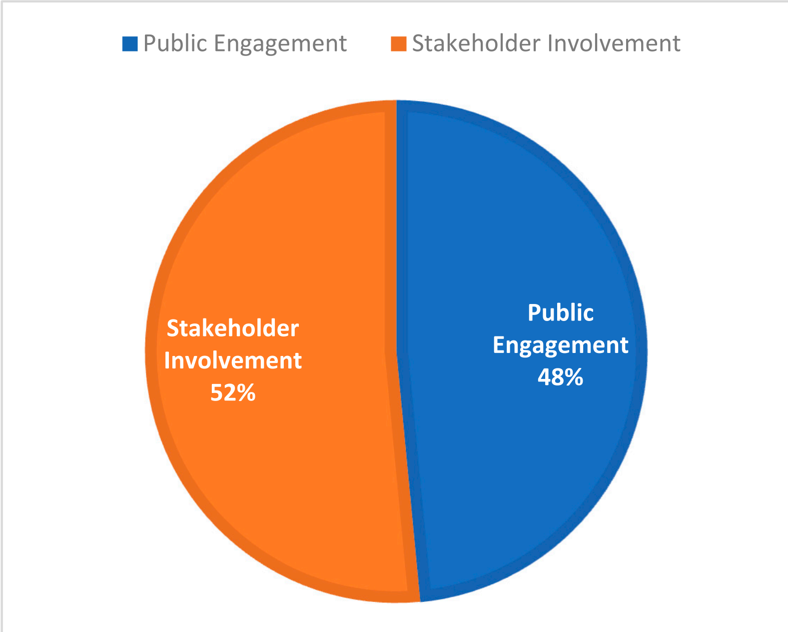

Figure 4. Best practices for smart cities.

4.5. Innovative Solutions and Strategies for Implementing UAVs in Smart City Safety and Security Applications

Table 7 presents a summary of research activity across several important domains related to Unmanned Aerial Vehicles (UAVs), the Internet of Things (IoT), Artificial Intelligence (AI), and related topics in the context of smart cities. The fields of study range from technical aspects like IoT integration in energy systems and AI in surveillance to broader societal considerations such as security, privacy, and ethics. The number of studies indicates the relative amount of research activity and interest in each area. As per this table, the area with the highest number of studies is "Security, privacy, and risks within smart cities" with five key references. This suggests a heightened focus on understanding and addressing the vulnerabilities and risks associated with deploying interconnected systems in smart cities, especially as our reliance on these systems for managing city infrastructure and services increases. The "Internet of Drones (IoD)" is also an emerging field, as indicated by the four studies conducted in this domain. As drones are becoming more commonplace, especially in delivery, surveillance, and traffic management applications, a comprehensive communication and control framework is vital. The integration of "IoT in electric power and energy systems" and the application of "AI techniques in smart city surveillance using UAVs" are active research areas, with two and three studies, respectively. These technologies are at the heart of many smart city applications, and continued research in these areas will likely yield innovations that improve the efficiency, safety, and sustainability of urban environments.

Cybersecurity and digital forensics and "Ethics for drones and UAVs" also receive attention, each with two studies referenced. These represent critical areas of concern as the proliferation of IoT, drones, and AI brings new challenges in ensuring data security and privacy and ethical issues related to surveillance, autonomy, and safety. Finally, Table 7 underscores the multidisciplinary nature of research in smart city development, encompassing technical, security, and ethical aspects. It is evident that while technologies like IoT, AI, and UAVs promise significant benefits for city management, their integration poses complex challenges that the research community is actively seeking to understand and address.

Table 7. Innovative solutions for implementing UAVs in smart city safety and security applications.

Innovative Solution	Number of Studies	Key References
Internet of Things (IoT) in electric power and energy systems	2	Israr et al. [29]; Sharma and Arya [17]
Artificial intelligence techniques in smart cities surveillance using UAVs	3	Jain et al. [31]; Thakur et al. [35]; Khan et al. [16]
Security, privacy, and risks within smart cities	5	Sookhak et al. [43]; Ismagilova et al. [36]; Baig et al. [38]; Krichen et al. [30]; Chamola et al. [13]
Internet of Drones (IoD)	4	Alqurashi et al. [42]; Choudhary et al. [37]; Mohamed et al. [19]; Alsamhi et al. [15]
Cybersecurity and digital forensics	2	Baig et al. [38]; Chamola et al. [13]
Ethics for drones and UAVs	2	de Miguel Molina et al. [39]; Finn and Wright [22]

Table 8 provides an overview of the innovative strategies for implementing Unmanned Aerial Vehicles (UAVs) in smart city safety and security applications. It is evident from the table that a diverse range of research topics and strategies are being pursued, focusing on integrating advanced technologies like IoT, AI, and machine learning with UAVs to enhance various facets of smart cities. The most researched topic pertains to addressing security and privacy challenges in smart cities, which include IoT, cloud computing, big data, and UAVs, signifying the importance of data security in our increasingly interconnected world. Other notable areas include IoT-UAV integration for energy systems, optimization techniques in civil UAV applications, and strategies to meet future challenges for smart cities, underlining the ongoing efforts to make smart cities more efficient, resilient, and secure. Despite the diversity of research topics, there is a common thread of focusing on real-time responses, predictive strategies, and proactive risk management, which are integral to smart cities' safe and successful operation.

Table 8. Innovative strategies for implementing UAVs in smart city safety and security applications.

Research Topics	Number of Studies	Innovative Strategies
Integration of IoT with UAVs for electric power and energy systems	3	Real-time monitoring, predictive maintenance, disaster management
AI in UAV surveillance systems	2	Object recognition, motion detection, anomaly detection
Smart city and UAV interaction framework	1	Addressing security, privacy, risk management, threat identification
Security perspectives of IoD	2	Secure communication protocols, threat detection, vulnerability assessment
Future challenges for smart cities	4	Cybersecurity strategies, digital forensics, protection of IoT, cloud computing, and UAVs
Ethical concerns in indoor drone use	1	Ethical guideline formulation, privacy protection, safety measures, autonomy control
Optimization in civil UAV applications	3	Routing optimization, scheduling strategies, payload allocation
Integrating UAVs into urban airspace	2	Traffic management strategies, UAV traffic integration, safety measures
Machine learning in UAV use cases	2	Traffic management algorithms, security protocols, environmental monitoring

Table 8. *Cont.*

Research Topics	Number of Studies	Innovative Strategies
Traffic-aware approach for UAV in smart cities	1	Minimizing traffic impact, improving safety, optimizing UAV flight paths
Security and privacy challenges in smart cities	5	Addressing IoT, cloud computing, big data, and UAVs vulnerabilities, proposing solutions
Usability evaluation of UAVs	2	Usability testing, user feedback collection, performance measurement

In summary, the practical implications of the study and research findings is derived from the enhanced knowledge resulting from the research findings for the implementation of Unmanned Aerial Vehicles (UAVs) in the Safety and Security of Smart Cities. The challenges discussed and the innovations as well as best strategies for implementation of Unmanned Aerial Vehicles (UAVs) in the Safety and Security of Smart Cities provide significant information and knowledge toward successful implementation of UAVs and subsequent realization of security and surveillance in smart cities.

4.6. Limitation of the Study

A major limitation of the study is the shortage of high-impact literatures. However, the researcher managed this limitation by focusing on a wide range of resources that are significant for the study and relevant to the research objectives

5. Conclusions

From the descriptive analysis, it is clear that integrating Unmanned Aerial Vehicles (UAVs) into smart city initiatives represents a multidimensional research field. The studies span a wide range of themes, including IoT and UAV integration, artificial intelligence in surveillance, the interaction framework between smart cities and UAVs, the security perspectives of the Internet of Drones (IoD), the challenges faced by smart cities regarding cybersecurity, and ethical considerations in drone use. The highest number of studies focus on addressing security and privacy issues within smart cities, indicating that these areas are of primary concern for researchers and policymakers. Another major research direction is the Internet of Drones (IoD), which illustrates the growing interest in the potential of drones to be networked and controlled remotely for various smart city applications.

The review of innovative strategies suggests that researchers are applying cutting-edge technologies to address the challenges of implementing UAVs in smart city environments. A common thread across the strategies is the emphasis on integrating advanced technologies like IoT, AI, and machine learning with UAVs, which is expected to enhance their capability to monitor, manage, and safeguard smart city infrastructures. In a nutshell, integrating IoT with UAVs provide flying gateways that allows UAVs to extend their coverage of terrestrial gateways in the exchange of data through the use of artificial intelligence and machine learning with systems, software, devices and communication networks for enhanced security and surveillance. Therefore, the focus on real-time responses, predictive strategies, and proactive risk management is vital to ensuring the safety and efficiency of smart cities. Furthermore, the ethical aspects of drone use and the need for user-friendly interfaces and controls are also being recognized, reflecting a comprehensive approach toward integrating UAVs into smart cities. Overall, the field is vibrant and rapidly evolving, promising exciting developments in the future.

Author Contributions: Conceptualization, K.A.-D. and N.F.; methodology, K.A.-D. and N.F.; investigation, K.A.-D. and N.F.; writing original draft preparation, K.A.-D.; writing—review and editing, N.F.; supervision, N.F. All authors have read and agreed to the published version of the manuscript.

Funding: Open Access funding provided by the Qatar National Library.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data can be shared up on request.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Neirotti, P.; De Marco, A.; Cagliano, A.C.; Mangano, G.; Scorrano, F. Current trends in Smart City initiatives: Some stylised facts. *Cities* **2014**, *38*, 25–36. [CrossRef]
2. Barbedo, J.G.A. A review on the use of unmanned aerial vehicles and imaging sensors for monitoring and assessing plant stresses. *Drones* **2019**, *3*, 40. [CrossRef]
3. Kummitha, R.K.R. Smart technologies for fighting pandemics: The techno-and human-driven approaches in controlling the virus transmission. *Gov. Inf. Q.* **2020**, *37*, 101481. [CrossRef] [PubMed]
4. Tonkin, T.N.; Midgley, N.G.; Graham, D.J.; Labadz, J.C. The potential of small unmanned aircraft systems and structure-from-motion for topographic surveys: A test of emerging integrated approaches at Cwm Idwal, North Wales. *Geomorphology* **2014**, *226*, 35–43. [CrossRef]
5. Gupta, L.; Jain, R.; Vaszkun, G. Survey of important issues in UAV communication networks. *IEEE Commun. Surv. Tutor.* **2015**, *18*, 1123–1152. [CrossRef]
6. Erdelj, M.; Natalizio, E.; Chowdhury, K.R.; Akyildiz, I.F. Help from the sky: Leveraging UAVs for disaster management. *IEEE Pervasive Comput.* **2017**, *16*, 24–32. [CrossRef]
7. Yanmaz, E.; Yahyanejad, S.; Rinner, B.; Hellwagner, H.; Bettstetter, C. Drone networks: Communications, coordination, and sensing. *Ad Hoc Netw.* **2018**, *68*, 1–15. [CrossRef]
8. Tiwari, A.; Dixit, A. Unmanned aerial vehicle and geospatial technology pushing the limits of development. *Am. J. Eng. Res.* **2015**, *4*, 16–21.
9. Calantropio, A.; Chiabrando, F.; Sammartano, G.; Spanò, A.; Losè, L.T. UAV strategies validation and remote sensing data for damage assessment in post-disaster scenarios. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2018**, *42*, 121–128. [CrossRef]
10. Yuan, F.; Liu, R. Integration of social media and unmanned aerial vehicles (UAVs) for rapid damage assessment in hurricane matthew. In *Construction Research Congress, 2018*; American Society of Civil Engineers: Reston, VA, USA, 2018. Available online: https://ascelibrary.org/doi/abs/10.1061/9780784481288.050 (accessed on 4 September 2023).
11. Villa, T.F.; Gonzalez, F.; Miljievic, B.; Ristovski, Z.D.; Morawska, L. An overview of small unmanned aerial vehicles for air quality measurements: Present applications and future prospectives. *Sensors* **2016**, *16*, 1072. [CrossRef]
12. Rhee, D.S.; Kim, Y.D.; Kang, B.; Kim, D. Applications of unmanned aerial vehicles in fluvial remote sensing: An overview of recent achievements. *KSCE J. Civ. Eng.* **2018**, *22*, 588–602. [CrossRef]
13. Chamola, V.; Kotesh, P.; Agarwal, A.; Gupta, N.; Guizani, M. A comprehensive review of unmanned aerial vehicle attacks and neutralization techniques. *Ad Hoc Netw.* **2021**, *111*, 102324. [CrossRef] [PubMed]
14. Xiao, W.; Vallet, B.; Brédif, M.; Paparoditis, N. Street environment change detection from mobile laser scanning point clouds. *ISPRS J. Photogramm. Remote Sens.* **2015**, *107*, 38–49. [CrossRef]
15. Alsamhi, S.H.; Ma, O.; Ansari, M.S.; Almalki, F.A. Survey on collaborative smart drones and internet of things for improving smartness of smart cities. *IEEE Access* **2019**, *7*, 128125–128152. [CrossRef]
16. Khan, M.A.; Alvi, B.A.; Safi, A.; Khan, I.U. Drones for good in smart cities: A review. In Proceedings of the International Conference on Electrical, Electronics, Computers, Communication, Mechanical and computing (EECCMC), Vaniyamabadi, India, 28–29 January 2018; pp. 1–6.
17. Sharma, R.; Arya, R. UAV based long range environment monitoring system with Industry 5.0 perspectives for smart city infrastructure. *Comput. Ind. Eng.* **2022**, *168*, 108066. [CrossRef]
18. Kuru, K. Planning the future of smart cities with swarms of fully autonomous unmanned aerial vehicles using a novel framework. *IEEE Access* **2021**, *9*, 6571–6595. [CrossRef]
19. Mohamed, N.; Al-Jaroodi, J.; Jawhar, I.; Idries, A.; Mohammed, F. Unmanned aerial vehicles applications in future smart cities. *Technol. Forecast. Soc. Chang.* **2020**, *153*, 119293. [CrossRef]
20. Outay, F.; Mengash, H.A.; Adnan, M. Applications of unmanned aerial vehicle (UAV) in road safety, traffic and highway infrastructure management: Recent advances and challenges. *Transp. Res. Part A Policy Pract.* **2020**, *141*, 116–129. [CrossRef]
21. Cavoukian, A. *Privacy and Drones: Unmanned Aerial Vehicles*; Information and Privacy Commissioner of Ontario: Toronto, ON, Canada, 2012; pp. 1–30.
22. Finn, R.L.; Wright, D. Unmanned aircraft systems: Surveillance, ethics and privacy in civil applications. *Comput. Law Secur. Rev.* **2012**, *28*, 184–194. [CrossRef]
23. Clarke, R.; Moses, L.B. The regulation of civilian drones' impacts on public safety. *Comput. Law Secur. Rev.* **2014**, *30*, 263–285. [CrossRef]
24. Zhang, H.; Wang, L.; Tian, T.; Yin, J. A review of unmanned aerial vehicle low-altitude remote sensing (UAV-LARS) use in agricultural monitoring in China. *Remote Sens.* **2021**, *13*, 1221. [CrossRef]

25. Rios, J.L.; Aweiss, A.S.; Jung, J.; Homola, J.; Johnson, M.; Johnson, R. Flight demonstration of unmanned aircraft system (UAS) traffic management (UTM) at technical capability level 4. In Proceedings of the AIAA AVIATION 2020 FORUM, Virtual Event, 15–19 June 2020; p. 2851.
26. Al Saadi, I.; Tarhuni, N.; Mesbah, M. Ground Level Mobile Signal Prediction Using Higher Altitude UAV Measurements and ANN. In *2022 32nd Conference of Open Innovations Association (FRUCT), Tampere, Finland, 9–11 November 2022*; IEEE: New York, NY, USA, 2022; pp. 15–21.
27. Yang, G.; Liu, J.; Zhao, C.; Li, Z.; Huang, Y.; Yu, H.; Yang, H. Unmanned aerial vehicle remote sensing for field-based crop phenotyping: Current status and perspectives. *Front. Plant Sci.* **2017**, *8*, 1111. [PubMed]
28. Karras, G.C.; Marantos, P.; Bechlioulis, C.P.; Kyriakopoulos, K.J. Unsupervised online system identification for underwater robotic vehicles. *IEEE J. Ocean. Eng.* **2018**, *44*, 642–663. [CrossRef]
29. Israr, A.; Abro, G.E.M.; Sadiq Ali Khan, M.; Farhan, M.; Bin Mohd Zulkifli, S.U.A. Internet of things (IoT)-Enabled unmanned aerial vehicles for the inspection of construction sites: A vision and future directions. *Math. Probl. Eng.* **2021**, *2021*, 9931112.
30. Krichen, M.; Adoni, W.Y.H.; Mihoub, A.; Alzahrani, M.Y.; Nahhal, T. Security Challenges for Drone Communications: Possible Threats, Attacks and Countermeasures. In Proceedings of the 2022 2nd International Conference of Smart Systems and Emerging Technologies (SMARTTECH), Riyadh, Saudi Arabia, 9–11 May 2022; pp. 184–189.
31. Jain, R.; Nagrath, P.; Thakur, N.; Saini, D.; Sharma, N.; Hemanth, D.J. Towards a smarter surveillance solution: The convergence of smart city and energy efficient unmanned aerial vehicle technologies. In *Development and Future of Internet of Drones (IoD): Insights, Trends and Road Ahead*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 109–140.
32. Garge, G.K.; Balakrishna, C. Unmanned aerial vehicles (UAVs) as on-demand QoS enabler for multimedia applications in smart cities. In Proceedings of the 2018 International Conference on Innovation and Intelligence for Informatics, Computing, and Technologies (3ICT), Sakhier, Bahrain, 18–20 November 2018; pp. 1–7.
33. Bedi, G.; Venayagamoorthy, G.K.; Singh, R.; Brooks, R.R.; Wang, K.C. Review of Internet of Things (IoT) in electric power and energy systems. *IEEE Internet Things J.* **2018**, *5*, 847–870.
34. Mualla, Y.; Najjar, A.; Galland, S.; Nicolle, C.; Tchappi, I.H.; Yasar, A.U.-H.; Främling, K. Between the Megalopolis and the Deep Blue Sky: Challenges of Transport with UAVs in Future Smart Cities. In Proceedings of the AAMAS, Montreal, QC, Canada, 13–17 July 2019; pp. 1649–1653.
35. Thakur, N.; Nagrath, P.; Jain, R.; Saini, D.; Sharma, N.; Hemanth, D.J. Artificial intelligence techniques in smart cities surveillance using UAVs: A survey. In *Machine Intelligence and Data Analytics for Sustainable Future Smart Cities*; Springer: Berlin/Heidelberg, Germany, 2021; pp. 329–353.
36. Ismagilova, E.; Hughes, L.; Rana, N.P.; Dwivedi, Y.K. Security, privacy and risks within smart cities: Literature review and development of a smart city interaction framework. *Inf. Syst. Front.* **2020**, *24*, 393–414.
37. Choudhary, G.; Sharma, V.; Gupta, T.; Kim, J.; You, I. Internet of drones (iod): Threats, vulnerability, and security perspectives. *arXiv* **2018**, arXiv:1808.00203.
38. Baig, Z.A.; Szewczyk, P.; Valli, C.; Rabadia, P.; Hannay, P.; Chernyshev, M.; Johnstone, M.; Kerai, P.; Ibrahim, A.; Sansurooah, K.; et al. Future challenges for smart cities: Cyber-security and digital forensics. *Digit. Investig.* **2017**, *22*, 3–13. [CrossRef]
39. de Miguel Molina, M.; Santamarina Campos, V.; Carabal Montagud, M.Á.; de Miguel Molina, B. Ethics for civil indoor drones: A qualitative analysis. *Int. J. Micro Air Veh.* **2018**, *10*, 340–351. [CrossRef]
40. Otto, A.; Agatz, N.; Campbell, J.; Golden, B.; Pesch, E. Optimization approaches for civil applications of unmanned aerial vehicles (UAVs) or aerial drones: A survey. *Networks* **2018**, *72*, 411–458.
41. El-Sayed, H.; Chaqfa, M.; Zeadally, S.; Puthal, D. A traffic-aware approach for enabling unmanned aerial vehicles (UAVs) in smart city scenarios. *IEEE Access* **2019**, *7*, 86297–86305.
42. Alqurashi, F.A.; Alsolami, F.; Abdel-Khalek, S.; Sayed Ali, E.; Saeed, R.A. Machine learning techniques in internet of UAVs for smart cities applications. *J. Intell. Fuzzy Syst.* **2022**, *42*, 3203–3226.
43. Sookhak, M.; Tang, H.; He, Y.; Yu, F.R. Security and privacy of smart cities: A survey, research issues and challenges. *IEEE Commun. Surv. Tutor.* **2018**, *21*, 1718–1743.
44. Wankmüller, C.; Kunovjanek, M.; Mayrgündter, S. Drones in emergency response–evidence from cross-border, multi-disciplinary usability tests. *Int. J. Disaster Risk Reduct.* **2021**, *65*, 102567.
45. Malekloo, A.; Ozer, E.; AlHamaydeh, M.; Girolami, M. Machine learning and structural health monitoring overview with emerging technology and high-dimensional data source highlights. *Struct. Health Monit.* **2022**, *21*, 1906–1955.
46. Hossain, M.; Hossain, M.A.; Sunny, F.A. A UAV-based traffic monitoring system for smart cities. In Proceedings of the 2019 International Conference on Sustainable Technologies for Industry 4.0 (STI), Dhaka, Bangladesh, 24–25 December 2019; pp. 1–6.
47. Majeed, A.; Hwang, S.O. A multi-objective coverage path planning algorithm for UAVs to cover spatially distributed regions in urban environments. *Aerospace* **2021**, *8*, 343.
48. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med.* **2009**, *6*, e1000097.
49. Schardt, C.; Adams, M.B.; Owens, T.; Keitz, S.; Fontelo, P. Utilization of the PICO framework to improve searching PubMed for clinical questions. *BMC Med. Inform. Decis. Making* **2007**, *7*, 1–6.
50. Gracias, J.S.; Parnell, G.S.; Specking, E.; Pohl, E.A.; Buchanan, R. Smart Cities: A Structured Literature Review. *Smart Cities* **2023**, *6*, 1719–1743.

51. Morioka, S.N.; de Carvalho, M.M. A systematic literature review towards a conceptual framework for integrating sustainability performance into business. *J. Clean. Prod.* **2016**, *136*, 134–146.
52. CASP. CASP Checklists. 2018. Available online: https://casp-uk.net/casp-tools-checklists/ (accessed on 4 September 2023).
53. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101.
54. Braun, V.; Clarke, V. Toward good practice in thematic analysis: Avoiding common problems and becoming a knowing researcher. *Int. J. Transgender Health* **2023**, *24*, 1–6.
55. Claesson, A.; Bäckman, A.; Ringh, M.; Svensson, L.; Nordberg, P.; Djärv, T.; Hollenberg, J. Time to delivery of an automated external defibrillator using a drone for simulated out-of-hospital cardiac arrests vs. emergency medical services. *JAMA* **2017**, *317*, 2332–2334. [PubMed]
56. Verhulsdonck, G.; Weible, J.L.; Helser, S.; Hajduk, N. Smart cities, playable cities, and cybersecurity: A systematic review. *Int. J. Hum.-Comput. Interact.* **2023**, *39*, 378–390.

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.