Technology in Society 75 (2023) 102377

Contents lists available at ScienceDirect

Technology in Society

journal homepage: www.elsevier.com/locate/techsoc

Societal acceptance of urban drones: A scoping literature review

Ning Wang [a,b,*], Nico Mutzner [a,c], Karl Blanchet [b]

[a] Digital Society Initiative, University of Zurich, Rämistrasse 69, 8001 Zurich, Switzerland
[b] Geneva Center of Humanitarian Studies, University of Geneva, Boulevard du Pont-d'Arve 28, 1205 Geneva, Switzerland
[c] Department of Sociology, University of Zurich, Andreasstrasse 15, 8050 Zurich, Switzerland

ARTICLE INFO

Keywords:
Drones
Ethics
Societal acceptance
Technology governance
Value sensitive innovation

ABSTRACT

The use of drones (or Unmanned Aerial Vehicles) in urban areas has emerged rapidly in the last decade, and continues to expand at an accelerating pace. Alongside the emergent uses of high-impact technology in both public and private sectors, political debates about the potential risks and challenges have arisen, encompassing diverse perspectives and attitudes about the ethical, legal, social, and regulatory implications of introducing and integrating new technology in society. This scoping review offers an assessment of the societal acceptance factors of urban drones discussed in the current academic literature. We used a hybrid approach including quantitative landscape mapping and qualitative content analysis of the selected articles to inductively develop a typology of acceptance factors associated with urban use of drones. This review illuminates areas that have been the focus of attention within the current body of knowledge (e.g., visual and noise pollution of drones), sketches the evolution of the relevant discussions over time (e.g., a focus on the safety of the drone technology toward safety of the cargo it carries and security of the data it collects), and points to areas that have received less considerations (e.g., media appropriation and social group influence). It can, thus, help situate the topic of societal acceptance of urban drones in specific contexts, and orient future research on promoting value sensitive innovation in society more broadly.

1. Introduction

The development and deployment of high-impact technology, such as robotics and autonomous systems, touch upon a set of pressing ethical, legal, social, and political issues. It is important to create a knowledge base on this topic, and to develop normative frameworks and governance tools to support the introduction and integration of it in society. Currently, however, there is a lack of empirical knowledge on the perceptions about, and attitudes towards, the use of such technology at scale in urban settings, where humans, machines, sensors, and data co-exist and co-evolve. This epistemological lacuna further suggests a lack of awareness of the implications around its acceptability, where issues pertaining to access and equity, benefit sharing, harm and risk, consent, and allocation of public resources, etc., may be overlooked [1,2].

Taking drones used in urban contexts as an exemplar, we conducted a scoping review of the academic literature [3,4]. Our objective was to provide a comprehensive overview of how public perceptions associated with urban drones are discussed in the scientific articles. In particular, we were interested in identifying potential "blind spots" in the ongoing debate, for instance, a possibly exaggerated focus on noise that may distract the debate from other equally, if not more, important aspects. Two previous literature reviews existed in this subject area [5,6], each of which differed notably from the present study in terms of both scope and thematic focus, as well as methodology. In comparison, our study employed a more comprehensive and inclusive methodological approach throughout the review process. Moreover, unlike the earlier reviews, we explicitly concentrated on the actors involved in urban drone operations and related services, offering a macro-level analysis that included themes and clusters of broader societal implications.

It is important to highlight that this scoping review is situated in a larger research project comprising the present literature study, mixed-method empirical studies of both experts and public perceptions, experimental co-creation and evaluation of acceptance factors, and governance tool development and dissemination. Within this context, the literature review contributes to inform the current discourse and research, provide insights about prevailing perspectives and attitudes, and indicate potential knowledge gaps regarding societal acceptance of emerging technology more broadly.

* Corresponding author. Digital Society Initiative, University of Zurich, Rämistrasse 69, 8001 Zurich, Switzerland.
E-mail address: ning.wang@uzh.ch (N. Wang).

https://doi.org/10.1016/j.techsoc.2023.102377
Received 27 May 2023; Received in revised form 11 September 2023; Accepted 17 September 2023
Available online 5 October 2023

2. Methods

This scoping review followed the methodology introduced by Arksey and O'Malley [7]. Our review protocol was developed with the support of two librarians with expertise in social sciences and engineering. Prior to the final data collection, the review protocol was pilot-tested and calibrated to ensure its validity and applicability (see 2.3.).

2.1. Research question and search terms

The research question guiding our scoping review was "*What is known about societal acceptance factors regarding using drones in urban environments?*". The three key conceptual pointers in our review, hence, were "drones", "societal acceptance", and "urban", which were defined as follows:

The term "**drones**" referred to Unmanned Aerial Vehicles (UAVs) that are, in most cases, electrically powered aircrafts of small size, supported by on-board systems to fly without an on-board pilot, having a limited flight range and duration, and exhibit different levels of automation.[1] Generally, such small drones have a number of remarkable socio-economic impacts. For instance, images collected by drones can fill a gap between expensive, weather-dependent, and low-resolution images provided by satellites, or car-based images limited to human-level perspectives and the accessibility of roads [8]. Thanks to their high versality and easy maneuverability [9–11], small drones have been rapidly deployed and steadily scaled up on a wide spectrum of civilian applications over the last decade [12].

By "**societal acceptance**", we first leveraged on a baseline definition by scholars of technology acceptance, which is described as "a favorable or positive response, including intention, behavior and use relating to a proposed or in-situ technology or socio-technical system, by members of a given social unit (country or region, community or town, household or organization)" [13]. We further adopted a three-dimensional approach proposed by colleagues to highlight the spheres and layers of considerations included in societal acceptance [14], including.

1) *Socio-political acceptance*: refers to the broadest level of acceptance of a given technology by the public, key stakeholders, and policymakers.
2) *Community acceptance*: refers to specific acceptance of implementations of a technology, including projects and services by local stakeholders, such as community residents and local authorities.
3) *Market acceptance*: refers to acceptance by market players on the supply side, and by consumers on the demand side.

With respect to "**urban**", we utilized the World Bank's approach [15] to broadly describe it on the basis of population size, population density, concentration of administrative bodies and infrastructure, and presence of diverse livelihood and income generation activities.[2] Accordingly, an urban area is characterized by high population density, a concentration of administrative structures (e.g., government offices) and public services (e.g., hospitals and banks), and a diverse forms of income generation activities (i.e., unlike rural areas with a substantive reliance on agricultural production). To be comprehensive, we also included the so-called "peri-urban" areas in our review scope, which are typically characterized by a proximate location at the outskirt of an urban area, and a mix of rural and urban livelihoods [15]. Accordingly, if an area in question fits some, even if not all, of the basic characteristics, it was considered in scope in our review.

Finally, to clarify the meaning of "**societal acceptance of urban use of drones**" in concrete terms, we applied three evaluation criteria: (1) the use or operation of drones is carried out in urban contexts, including both public and private users or operators; (2) the applications of drone use are of civilian nature, i.e., non-military, such as for recreational, journalist, inspection, delivery, or public safety purposes; and (3) the use cases identified are generally aimed at promoting public values or generating the public good, even if operated by commercial entities.

2.2. Identifying relevant studies

Aligned with this broad understanding of the three central notions, we included a search string on "drones" validated by prior studies [2], and tested different combinations of primary search terms starting with a set of more extensive keywords. Next, a snowballing procedure was used to identify supplementary papers pertinent to our initial selection. Subsequently, we refined our search terms to yield a greater number of relevant studies. Finally, we included these secondary and tertiary search terms to assess their impact on the search results, using the approach of systematic inclusion of single terms. Table 1 shows the resulting search strings using the "AND" function. The use of these strings was adapted to the specificities of the selected databases.

To keep the literature search meaningful and manageable, we designed a set of parameters to help refine the search [16]. First, different types of publications were included. We searched for articles, book chapters, books (*Scopus*[3] only), conference proceedings, and early access[4] articles (*Web of Science*[5] only). We excluded abstracts related to conference presentations, book reviews, and PhD dissertations. The exclusion criteria outlined in Table 2 were calibrated through pilot testing.

A structured screening strategy was used involving both inductive screening via search engine and associated websites, as well as deductive identification of relevant articles in academic databases (see 2.3.). Three academic databases were searched: *Scopus*, *Web of Science,* and *Google Scholar*.[6] Our pilot test pointed to the need to adapt the search strategy in *Google Scholar* due to the high volume of search results – a consequence of the fact that the search logic in *Google Scholar* is full-text

Table 1
Search strings used in the database searches.

Central Notion	Search String
Drones	drone* OR "unmanned aerial vehicle*" OR "unmanned aerial system*" OR "UAV*" OR "UAS*"
Societal	good OR ethic* OR benefi* OR risk OR impact OR implicat* OR ramification OR mitigat* OR purpos*
Acceptance	concern OR considerat* OR accept* OR perce* OR attitude OR opinion OR prefer* OR belie*
Urban Use	public OR soci* OR civi* OR mobil* OR commerc*

[1] In addition to UAVs, drones are also known as "unmanned aerial/aircraft systems (UASs)", "remotely piloted aircrafts (RPAs)", or "remotely piloted aircraft systems (RPASs)". There are various types of drones in terms of mechanical structures, e.g., fixed-wing, rotary-wing, and multi-copters, etc. Depending on the level of automation, remote pilots can be included to control the vehicles from small to great distances.

[2] According to the scholarship of Urban Studies, the term "urban" is an interdisciplinary concept of fairly high level of abstraction and complexity. The proper foci of Urban Studies are the urban process and community phenomena as they are affected by this process, including inter-organizational and integrative relationships and mechanisms associated with neighbourhoods, municipalities, and ecological areas.

[3] Scopus (Elsevier's abstract and citation database): https://www.scopus.com/search/form.uri?display=basic.

[4] Clarivate: https://clarivate.com/blog/whats-next-for-jcr-defining-early-access/.

[5] Web of Science (a citation database provided by Clarivate Analytics): https://apps.webofknowledge.com/WOS_GeneralSearch_input.do?product=WOS&search_mode=GeneralSearch.

[6] Google Scholar: https://scholar.google.com/.

Table 2
Exclusion criteria for article screening.

Central Notion	Exclusion Criteria (A-J)
Drones	A. "Drone" is mentioned but the article is clearly out of scope (e.g., about insects, neuroscience, molecular biology, non-flying robotic systems, etc.).
	B. Focus is on purely technological aspects of drones or the robotic technology (e.g., sensors, flight control, flight planning, etc.).
	C. The article discusses societal aspects of robotics or of technology in general, but not specifically referring to drones.
Societal Acceptance	D. "Societal acceptance" or related search terms are mentioned as keywords or in the Abstracts, but the main text of the article does not discuss these aspects in a substantive manner.
	E. Focus of the article is on civilian use of drones, but without explicitly addressing public values, attitudes, or perspectives about such use (e.g., pure economic focus on drones as a nascent business case of urban air mobility solutions).
	F. The article is relevant to societal acceptance of drones but focuses mainly on the perceptions or opinions of technical experts and not the public.
Urban Use	G. "Urban" or related search terms are mentioned as keywords or in the Abstracts, but the article itself does not discuss drone applications used in urban contexts.
	H. Focus of the article is on urban planning or urban studies in general, with no substantial relevance to the use of drones in that context (e.g., ground-based mobility solution, smart city planning, etc.)
Technical Criteria	I. No Abstract or full text is available for further assessment.
	J. Other technical criteria(e.g., text is too short, full text is not in English).

and, in addition, reveals citations of relevant texts.

Only publications in English were included. The search was set to begin in 2010, based on the findings of an earlier literature review on the topic of humanitarian use of drones conducted by the first author in 2021 [2]. Furthermore, existing literature reviews on attitudes towards drones [5,6,17–20], as well as our own pilot test search, indicated that almost no papers referring to societal acceptance of urban drones were published before 2010 (see 3.1.2.).

2.3. Selection of articles

The official search, selection, and screening were conducted during October 2022–January 2023, following two preparatory stages of test search and pilot search undertaken in August–September 2022. Fig. 1 provides an overview of the official process including numbers of articles removed and retained, according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework [21].

The searches included two academic databases *Scopus* and *Web of Science*, and one search engine *Google Scholar*. For the former, the results yielded were merged and duplicates removed. For the latter, the first 100 entries of the original search sorted by "relevance" were merged with the database set. All three sets were then merged, and duplicates removed.

All articles found underwent a **first-round screening** based on title, a **second-round screening** based on abstract, and a **third-round screening** based on the full-text, following the exclusion criteria outlined in Table 2. The aim of the screening was to classify each paper either as eligible to be included for content analysis, or to be attributed to one of the ten exclusion criteria. The screening process was conducted by the second author and, whenever there was uncertainty about whether to include an article in the final set, the first author was engaged for a discussion until consensus was reached between the two reviewers.

In the first-round screening, the most frequent exclusion criteria used were A-C (see Table 2), whereby a large number of technical papers were excluded. The second-round screening leveraged mostly on the exclusion criteria D, G, and I, with reference to other criteria more generally. In the third-round screening, papers lacking an explicit focus on societal acceptance towards drones (E), or not sufficiently addressing perceptions of the public (F), or lacking a clearly defined application in the urban setting (H), were excluded. Some papers were also excluded due to technical reasons, such as missing full text (J). At the end of the three rounds of screening, a final set of 96 articles were retained for content analysis (full list of articles see Appendix 1).

2.4. Charting and analyzing the data

Starting from the second-round screening, a data charting process was purposefully undertaken. Specific themes were devised and organized in a data extraction table, resulting in the following three clusters.

1) **Bibliometric information** (about the articles): article type and source, publication time.
2) **Contextual information** (about the studies described in the articles): study methodology, type of data collected, geographic location of study.
3) **Substantive information** (about the drone applications discussed in the articles): entity involved in drone application, domain area of drone application, thematic clusters concerning drone acceptance.

To identify the most relevant societal acceptance factors discussed in the selected articles, we used a conventional **content analysis** approach, whereby researchers develop inductive categorizations of the matters of concern, without applying pre-conceived conceptions [22]. The content analysis was organized based on a bottom-up identification of thematic categories. To be comprehensive, we took an inclusive approach to interpret "societal acceptance", taking into account references to all three dimensions of acceptance illustrated in 2.1 (according at least to the respective authors of the selected articles). To ensure the rigorousness of the coding and content analysis methods of this review, we adopted an iterative approach in our coding strategy, whereby codes were derived from themes within the sampled articles, similar to the approach used by Komasová [5].

Specifically, a step-by-step coding protocol was developed by the first and second authors, which involved iterative cycles of coding, theme identification, and peer reviews. The coding process was conducted in three phases: initial open coding, axial coding to develop overarching categories, and selective coding for final theme identification. To further ensure comprehensive and unbiased coding results, the second author included all potential codes identified in the initial review of the texts. This exhaustive list of codes served as the basis for a series of peer reviews between the first and second authors to critically examine each code, thereby reducing the potential for subjective or biased omissions of themes. Codes were then carefully evaluated, verified, merged, or excluded based on in-depth discussions between the first and second authors, further enhancing the objectivity of the categorizations. As an additional validation mechanism, the third author provided independent feedback on the categorizations, resulting in the conclusion of the coding process.

2.5. Consultation

Finally, the typology was discussed among a small group of experts in May 2023 in Switzerland. These experts included scholars with expertise in robotics and engineering, technology ethics, social psychology, law, and cybersecurity. Additionally, practitioners from the regulatory authority and the local administration also provided inputs. We incorporated feedback obtained from this consultation process into the revision of the typology (see 3.3.3.).

3. Results

The presentation of results in this section includes descriptive analysis and thematic analysis [3,4]. The **descriptive analysis** includes both

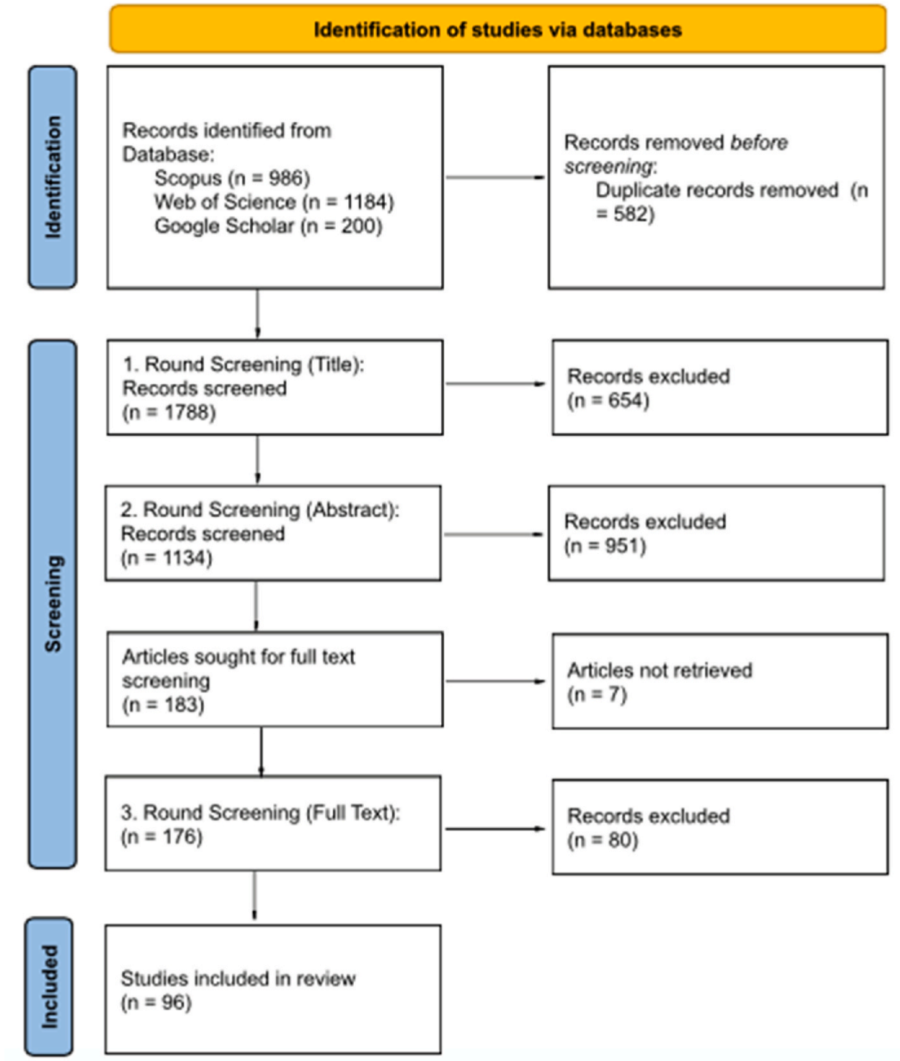

Fig. 1. PRISMA flow chart outlining the search and selection process.

bibliometric and contextual information – the former referring to the articles (see 3.1) and the latter referring to the studies described in the articles (see 3.2). The **thematic analysis** included more specific aspects regarding societal acceptance of urban drones emerged from the literature – including who used drones, why drones were used, and what factors were the matters of concerns to the authors of the articles (see 3.4).

3.1. Bibliometric information – articles

Generally, there was a large amount of technically oriented articles in our early samples, followed with articles lacking sufficient or substantive social aspects in the discussions. These led to the exclusion of a substantial part of the articles – from the initial set of 1788 to the final set of 96 – amounting to 95 % (see Fig. 1). While this distribution reflected a natural pattern considering the rapid development of the drone technology, the inherent imbalance between technical studies and social studies drew our attention to the potential biases it may imply.

3.1.1. Article type and source

Among the final set of 96 articles, the majority (75 %) was journal articles, followed with conference papers (22 %), and other types of publications (3 %), such as a data brief [23], a book chapter [24], and a technical report [25]. The selected articles appeared in 70 different journals, books, and conferences, spanning across disciplines and domain areas. Of those, 10 journals and conference proceedings published two or more articles on this topic (the rest either with only one article or without journal affiliation, e.g., one data brief and one technical report). While this showed a wide breadth of publication outlets that concern themselves with the topic, the scientific journal *Technology in Society* published most frequently articles within this area of research. It also covered the most breadth of studies ranging from literature reviews [6,19] to experiments [26] to surveys [5,27–29], and to discourse and media analysis [30,31]. Fig. 2 offers a general impression of the journals in which two or more of the selected articles were published (full table of journals see Appendix 2).

3.1.2. Publication time

The statistics showed a general increase of articles published since 2015, with a higher number in the final set towards 2022 (nearly 21 %). This trend was consistent with the results shown in our pilot test and throughout the three rounds of screening. We observed a slight drop in 2020 and a quick pick-up in 2021. This, to some extent, reflected an initial interruption of the COVID-19 pandemic for scientific publications. Meanwhile, the pandemic itself also inspired innovative use of drones in health emergency contexts and fueled further research about it [32–34]. Fig. 3 illustrates the comparative result of publication time between the initial and the final sets of articles.

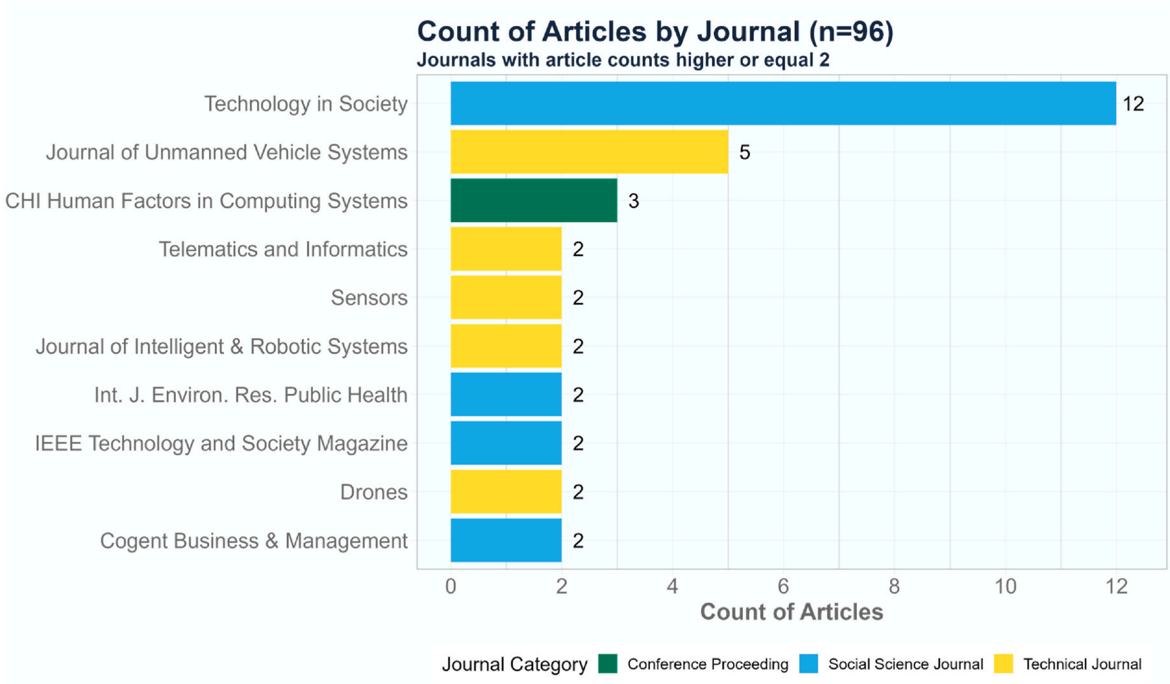

Fig. 2. Count of articles by journal (n = 96).

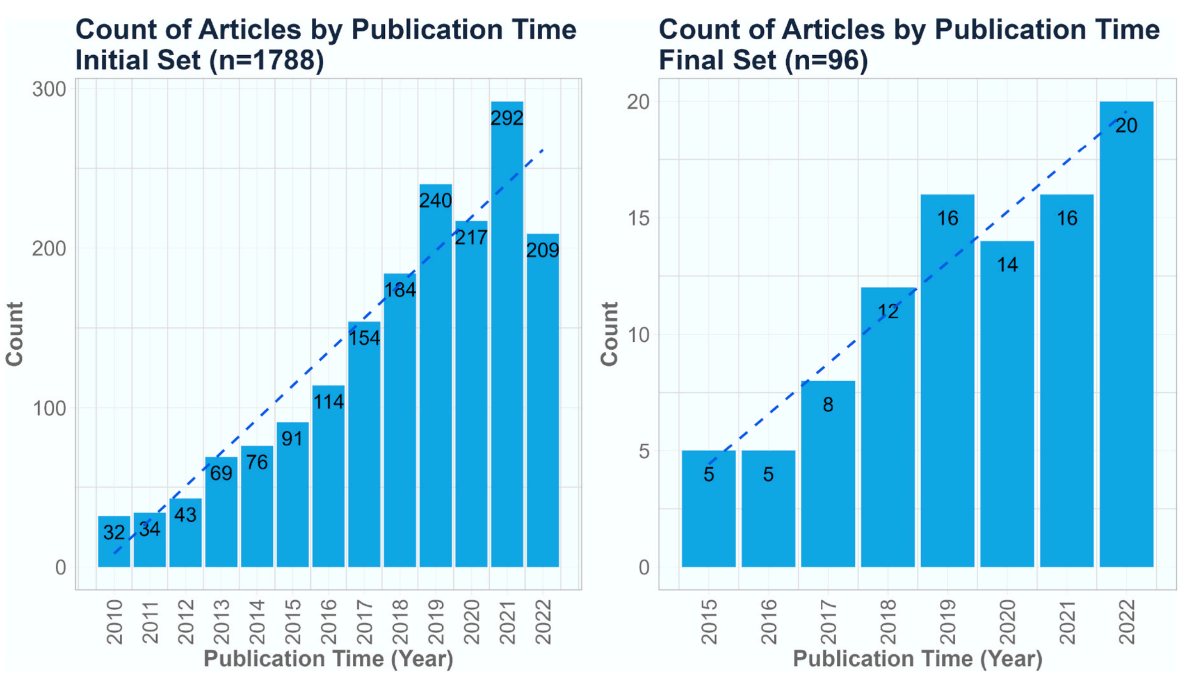

Fig. 3. Comparison of count of articles by publication time.

3.2. Contextual information – studies

Overall, we noticed a strong quantitative focus in studying public perceptions, amounting to 52 % of the total set of articles, which could be explained by the heavy reliance on surveys (see Figs. 4–5). While the deployment of quantitative methods offset the concern of a lack of new data gathered in existing knowledge, we found that qualitative methods supplemented such efforts with a broader literature base and more fine-grained data [31,33,35–39]. Additionally, while an overwhelming percentage of studies within this review relied on primary data, reaching 82 %, some articles opted for re-use of larger data sets [29,40–42]. For example, a few studies employed mixed sample groups including industry members, citizens, first responders and others [43], which provided valuable insights into perception contrasts between different groups of society.

3.2.1. Study methodology

In terms of research methodology, over 53 % of the studies were of quantitative nature, followed with qualitative method (nearly 21 %) and mixed methods (nearly 18 %), as well as literature reviews (over 7 %). The high frequency of using quantitative method to gauge public perceptions could be attributed to the fact that 51 out of 96 articles were

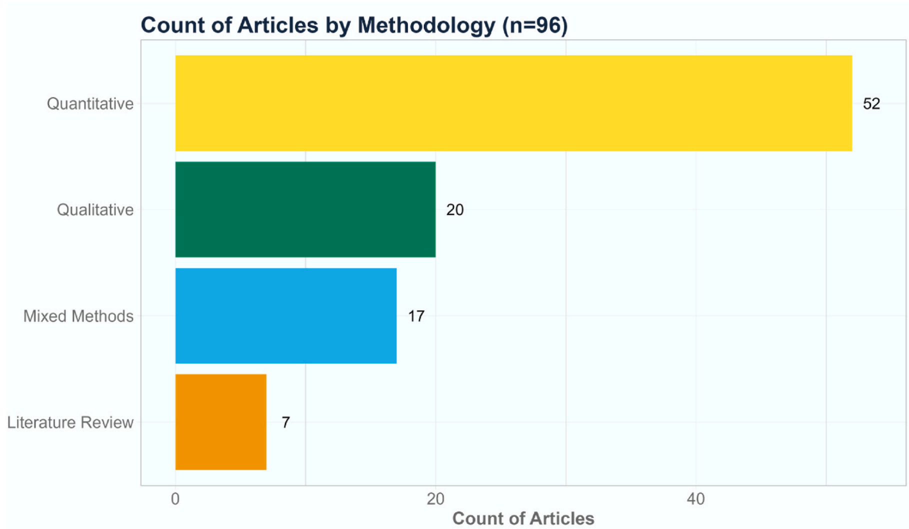

Fig. 4. Count of articles by methodology (n = 96).

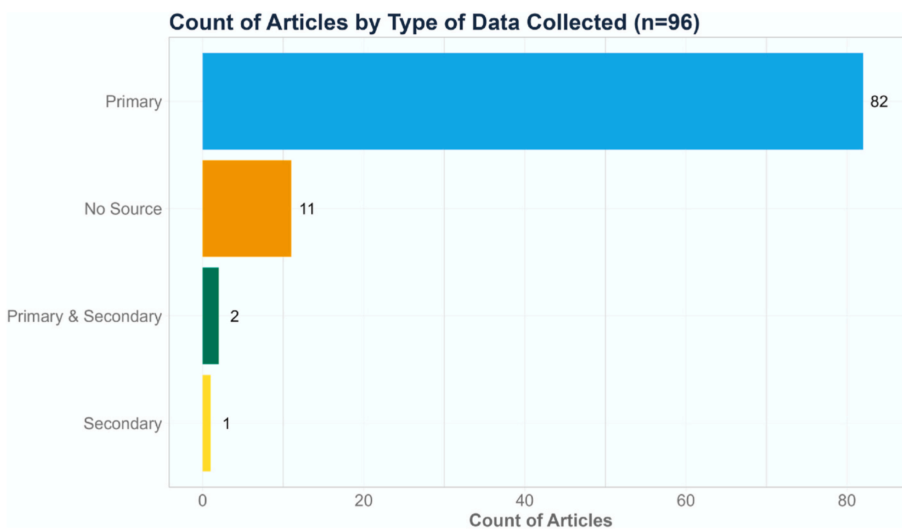

Fig. 5. Count of articles by type of data collected (n = 96).

surveys (e.g., online surveys [44], vignette surveys [45], or market research surveys [46]). This indicated a potential over-reliance on a single methodology in studying societal acceptance of technology which, although understandably a preferred approach given the measurability of data, lacked nuanced insights into the qualitative accounts which other articles could reveal (e.g., semi-structured interviews [35,47], discourse analysis [31], focus groups [36,37], or theoretical discussions [31,33,35–38,47]). Additionally, there were seven literature reviews that also focused on perceptions and attitudes towards drones in different areas [2,5,6,18–20]. This offered us an opportunity to compare findings and evaluate relevance against existing work to help identify gaps and inform further research. Fig. 4 illustrates the distribution of study methods.

3.2.2. *Type of data collected*

As a result of the above chosen methodology, the data collected in the studies sourced from surveys, interviews, text mining, and other data-gathering methods. The type of data referred mainly to the characteristics of data, such as primary or secondary data, the study population, and the sample size. Here, we observed a strong reliance on primary data which, again, could be explained by the heavy reliance on surveys in the studies. Some studies employed focus groups [5,36,37, 48–50], while others took place in multiple population settings including drone users, drone developers, experts, the general public [39, 43,51–53], and students [26,54–58]. While many of the surveys took place online, some studies involved nationally representative samples with the sample sizes of up to 3'000 [40,41]. Fig. 5 outlines the main characteristics of data of the selected articles.

3.2.3. *Geographic location of study*

With respect to the location where the studies were conducted, two scenarios were relevant to our review: (1) with identifiable locations (consisting of 82 articles), including either a specific location on which the study focused, e.g., case studies [27,39,59–63], or a specific location from where the raw data were collected, e.g., surveys [64,65], or experiments [26,54]; and (2) no identifiable location (consisting of 14 articles), e.g., literature reviews [5,6,18,19,19,20,66]. Among the 82 location-specific articles, 34 articles referred to the USA – a country of not only a high concentration of interests to the involved researchers, but also with a high level of awareness about public perceptions around urban drones.[7] Fig. 6 indicates the geographic location of the studies on drone applications reported by the selected articles.

3.3. Substantive information – drones

This section focuses more on the actual applications of, and concerns about, drone use and includes thematic framing and categorization of these topics. Importantly, themes and categories within this part of the review can overlap (applicable to Figs. 7–10). For example, a single paper can talk about both commercial and governmental entities, describe drone use for both emergency situations as well as delivery, and be situated within both research and public health domains.

3.3.1. Entity involved in drone application

Broadly speaking, entities involved in drone applications may include four main groups: (1) **private persons** for recreational usage, e.g., photography or hobby; (2) **private entities** for commercial usage, e.g., warehouse inspection or consumer goods delivery; (3) **public institutions** for public safety or law enforcement usage, e.g., boarder control or firefighting; (4) **scientific institutions** for research usage, e.g., meteomatical measurement, or environmental monitoring.

Our review suggested, somewhat unsurprisingly, that the level of societal acceptance of urban drones rely largely on who deploys the drones. According to the selected articles, commercial entities (e.g., offering food delivery services [65] or commercial flight services [67]) and public institutions (e.g., police [68] or emergency service providers [69]) were the two main stakeholder groups involved in urban drone applications, whereas recreational drone users were almost half as prevalent (e.g., hobbyists [52]), and scientific drone users only made up a small fraction overall. It could be discerned that much of the discussion about public perceptions of drones is revolved around applications of either commercial or public values, compared to more neutral applications. This seemed representative of reality where industry members and governmental authorities tended to be the leading forces driving or hindering the scaling of urban drones [1]. Fig. 7 offers a statistical insight on the involved stakeholders.

3.3.2. Domain area of drone application

From the perspective of ***function of drones***, there may be three main areas of applications (1) **imagery collection**, including aerial images (e.g., mapping) and footages (e.g., journalism); (2) **air mobility**, including transportation of both goods (e.g., cargo delivery) and humans (e.g., air taxi); and (3) **robotic medium/platform**, including attaching sensing systems such as lidar for inspection and monitoring purposes (e.g., search and rescue), enabling additional applications for industrial purposes (e.g., precision agriculture), and facilitating other scientific, social, or artistic activities (e.g., light shows).

Here, we observed a balanced distribution between applications of imagery collection (e.g., surveillance [70] or aerial mapping [60]) and transportation (e.g., small cargo delivery [23] or transportation of humans [67]), which were identically represented in the literature as the two main areas of application. Additionally, four articles discussed an emergent drone use as a robotic medium/platform, which has gained gradual popularity in recent years [54,71–73]. While nearly 90 % of the selected articles focused on specific drone applications, 11 articles discussed the drone technology as a more general concept. In particular, these included seven articles concerning the perceptions about specific technical aspects of drones, such as noise [74–77] or design [56,78,79], as well as four articles concerning both the technical and the social dimensions of drones [30,37,49,80]. Fig. 8 is a visual representation of the application areas of drones from the function perspective, including the aforementioned three drone application areas and a fourth category of general drone use.

From the perspective of ***purpose of drone use***, there may be eight main sectors concerned: (1) **emergency**: including natural disaster, search and rescue missions, firefighting, etc.; (2) **public health**: including routine medical delivery, pandemic outbreak control, public health surveillance, etc.; (3) **public safety and security**: including public infrastructure inspection, boarder control surveillance, crime monitoring, law enforcement, etc.; (4) **agriculture**: including precision farming, pesticide spread, crop monitoring, etc., in peri-urban areas; (5) **industry and services**: including construction or warehouse inspection, consumer goods delivery, transportation of goods or humans, etc.; (6) **research**: including environmental monitoring, earth observation, wildlife management, ecological measurement, etc.; (7) **journalism**: including filmmaking, media production of events, sports and exhibitions, artistic performance of drone light shows, etc.; (8) **recreation**: including hobbies, outdoor explorations, companionship, etc.

According to the statistics found in our review, drones were most frequently used for the purpose of the so-called "last mile delivery" (e.g., food delivery drones [65]), followed with surveillance (e.g., border patrol [40]), search and rescue missions (e.g., finding missing victims [81]), and recreational activities (e.g., photography and videography [52]). Delivery drones seemed to have pre-occupied much of the public discourse with a focus on the economic aspects, such as the willingness to adopt drone delivery services by private industry [58,82–86]. While warfare drones were excluded from our review, surveillance drones remained controversial in the current context [87]. Additionally, emergency drones used in search and rescue missions appeared often in the studies as generating the public good [38]. Fig. 9 illustrates the application areas of drones from the perspective of purpose of use.

Here, three observations were noteworthy: (1) Agriculture drones seemed to attract broad attentions, especially during the earlier rounds of screening in our review. The numbers, however, quickly dropped due to the fact that these applications tended to be deployed more frequently in rural areas and were accordingly excluded from our study (unless the application areas were clearly defined as peri-urban areas). (2) Drones used to assist health emergency, such as the recent COVID-19 pandemic, were not particularly overwhelming, contrary to what popular media has portrayed the situation to be. (3) An outlier application was the use of drones as personal guides, companions, or assistants, where the focus was more on the direct interactions between the persons/users and the drones deployed by/for them. These applications suggested a slightly different perspective regarding how drones were perceived by society at large. Fig. 10 outlines the distribution of application areas according to both the function and the purpose of drone use.

3.3.3. Thematic clusters concerning drone acceptance

The most critical part of data charting in our review was the thematic clustering of acceptance factors emerged from the selected articles. As aforementioned, the insights gained throughout the entire screening process led to the extraction of key themes, using an inductive iterative approach [3]. This resulted in a typology comprising the most important topics discussed in the articles concerning societal acceptance of urban drones. Table 3 provides an overview of this typology (counts of each theme see Appendix 3).

4. Discussions

Drones have been increasingly used in urban settings to support public affairs and private interests in recent years. Accordingly, publications on public perceptions about drone applications in these contexts have been steadily growing, including articles published in academic outlets. To help unpack the nuances of public attitudes towards urban drones, a more intricate understanding about citizens' perceptions is needed, with respect particularly to areas where attention has not been

[7] Due to the high relevance to the larger research project, Switzerland was initially included in the list in earlier rounds of screening, but no papers were eventually retained after the last round of full-text screening.

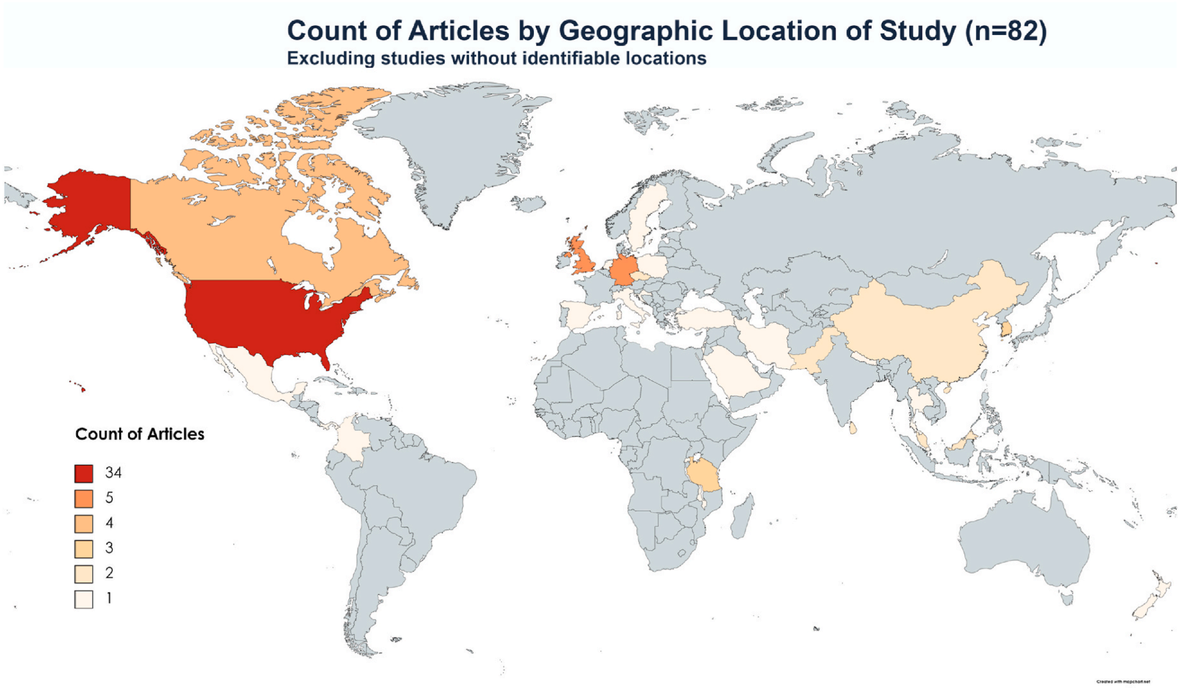

Fig. 6. Count of articles by geographic location of study (n = 82).

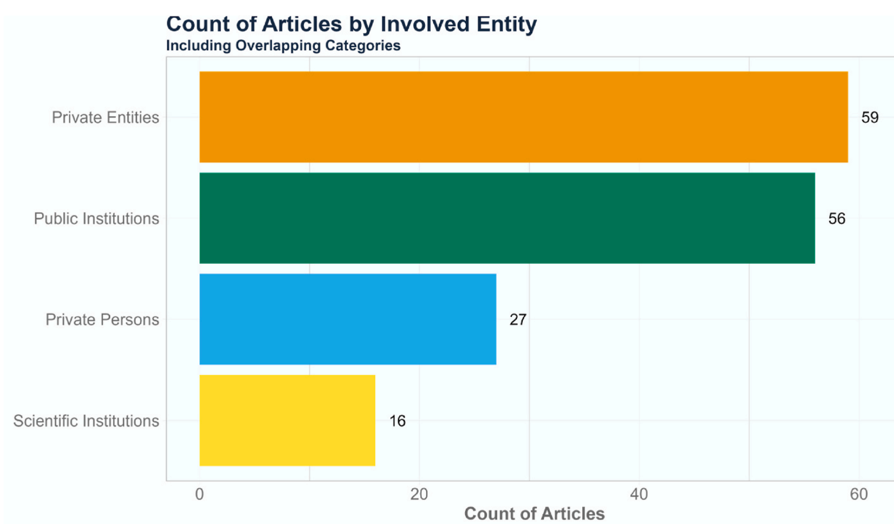

Fig. 7. Count of articles by involved entity (n = 96).

sufficiently paid, such as novel applications (e.g., drone companions), impact on quality of life (e.g., visual and noise pollution), media appropriation (e.g., value-laden narratives and social norm-setting), and social group influence (e.g., emotive responses to peers). This section consists of detailed discussions on factors affecting societal acceptance of urban drones revolved around the above identified thematic clusters.

4.1. Technical factors

With respect to thematic clusters, the technical aspects affecting public perceptions included, firstly, different levels of autonomation and human control [24,38,45,46]. While the level of automation was reported to depend on specific applications, e.g., emergency drones tended to be more automated than recreational drones [81], the public was concerned with automated drones failing in heavy weather conditions or other unpredictable situations [64]. From the aerodynamics perspective, drone proximity to humans and flight patterns seemed to have an influence on public perceptions [54,88]. In terms of aesthetics and design, suggestions were made to improve public trust through visual characteristics [67], including color [26,79], animal likeness [79,89], or marking drones with recording equipment in a clearly identifiable fashion (e.g., emitting signals while recording [56]). These general perception patterns were further influenced by the fact that knowledge and awareness of specific drone applications could differ [23,41,90], which led to the overall increased or decreased level of societal acceptance.

Additionally, one unique feature of drones of particular relevance to public perception was its noise emission. Unsurprisingly, significant considerations about drone noise were found within this review, where the public seemed to be deeply troubled with the annoyance caused by

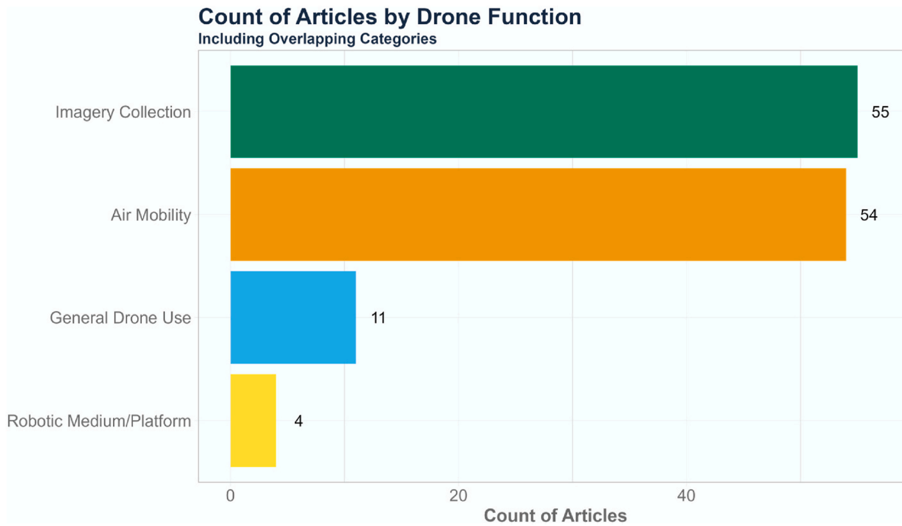

Fig. 8. Count of articles by drone function (n = 96).

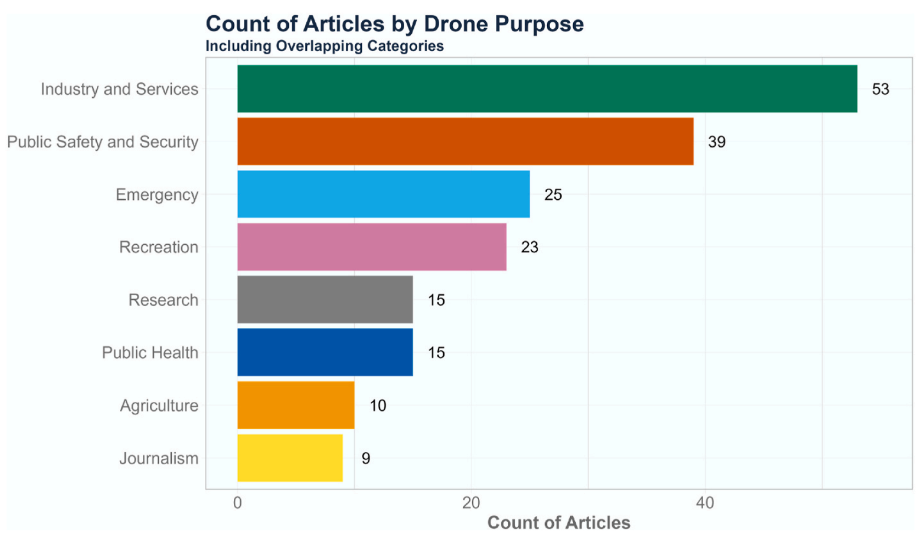

Fig. 9. Count of articles by drone purpose (n = 96).

drones in populated areas, such as the urban setting [5,17,40,76,77]. This included both general noise pollution [6,18,28,36,50,52,91], and their impacts on specific aspects such as social communication [92]. Importantly, literature on noise showed that different drones emit different noise profiles, which could therefore elicit different responses from humans [74,76,77]. However, a general lack of regulation effectively governing drone noise was observed within this review, whereby the exiting certification measures were perceived as not reflecting the complexity of noise emission of drones [17].

4.2. Operational factors

On the operational front, we found an array of applications of urban drones within this review [5,20,25,28,41,48,52,67,73,93,94]. On the one hand, the variety of applications showed the promise of the capability and usefulness of drones, and on the other hand, it accentuated the time criticality of understanding the myriad ways in which drones may be perceived according to their specific engagements with society [20,35]. A number of articles stressed this point by demonstrating the inadequacy of assessing drone perceptions beyond specific use contexts [6,23,41,48,67,87,90]. Currently, prevailing perceptions according to the purpose of drone use focused mainly on areas such as surveillance [95], search and rescue missions [6], or law enforcement and public safety [27], which tended to have broader societal impacts. Unsurprisingly, drones perceived as generating the public good, such as emergency drones [61], medical drones [36,69], research drones [48], drones used for urban planning [60] or for populations with special needs such as visual impairment [71], were rated much higher in terms of public acceptance [25,45,46,67,69], in comparison with less publicly salient use cases, such as commercial applications [82] or recreational applications [20].

Apart from applications, institutions or individuals involved in drone use were considered having a direct impact on public trust [5,25,39,75,78,81,96]. For example, the public became critical of data collection practices when governmental institutions using drones to surveil or monitor citizens [5,33,80,97]. The public seemed equally wary of commercial institutions using drones for, e.g., consumer goods delivery where concerns about safety and security were prevalent [24,39,56,60,96], or residential area surveying where the fear for privacy promptly emerged [34,53,73,82,98]. On the other hand, use of drones by research institutions garnered higher level of acceptance due to the perceived benefits to society at large [20,48,50,93]. By contrast, private individuals engaged with leisure activities using drones, such as filming [20], were perceived negatively either as intrusion to the public space

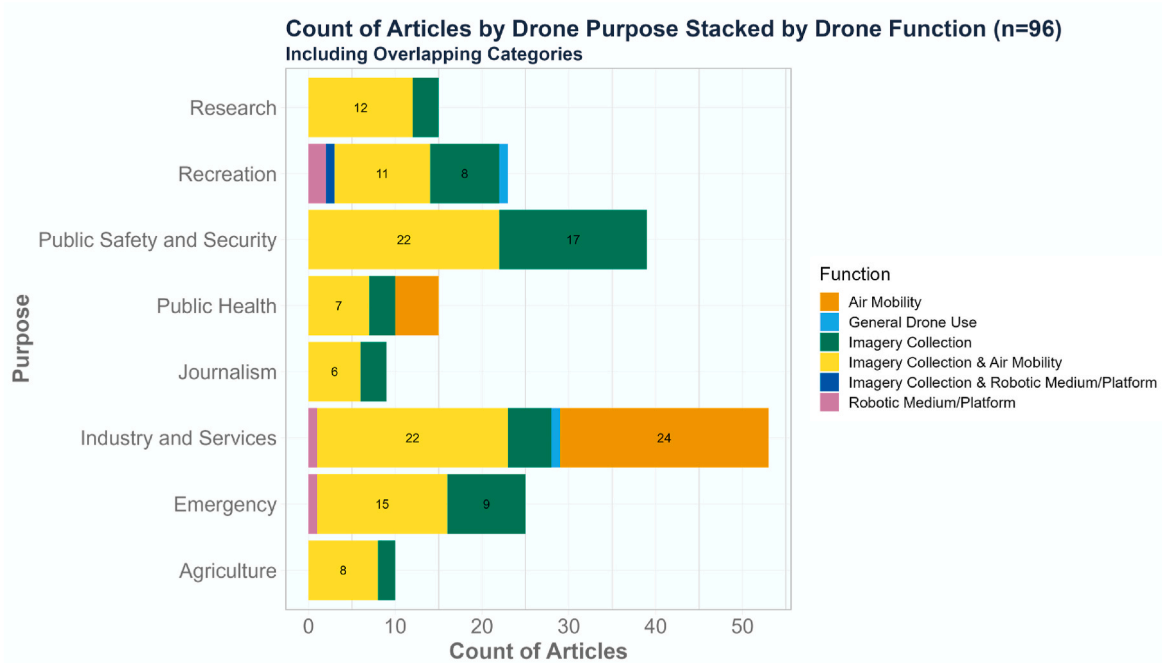

Fig. 10. Count of articles by drone purpose stacked by drone function (n = 96).

Table 3
Thematic classification of societal acceptance factors associated with urban drones.

Cluster	Theme
Technical Factors	Levels of Autonomy Technical Risk Noise Aerodynamics & Design
Operational Factors	Application Type, Purpose & Location Dual-use & Mis-use Trust, Accountability, Integrity & Transparency
Regulatory Factors	Privacy Safety & Security Aviation
Economic Factors	Technical Performance & Usefulness Intention to Adopt the Technology Related Infrastructure & Services
Impact Factors	Environmental Impacts Health Impacts Quality of Life Impacts
Personal Factors	Socio-Economic Status (SES) Emotional & Psychological Readiness Technical Knowledge & Competency
External Factors	Media Appropriation & Public Communication Peer & Social Group Influence Information Source & Influence Technical Terminology

[31,35,56,70,96], or as source of visual and noise pollution [27,44,64]. While it may be common sense that public attitudes towards new technology are largely associated with who uses it and how much trust is placed on those actors, it is important to acknowledge that such trust may be rooted in, or sourced from, accountability of the involved entities – or lack of it thereof [6,18,52,56,66], liability of their actions [5,18,31,43,91,99], transparency of their intentions [24,33,45,47,50,68,71,78,100], as well as care and benefits they could bring to the public [48,93]. Thus, understanding how trust can be improved when deploying drones at scale is critical to increase the legitimacy and acceptance of specific applications.

One distinctive feature of drones that has been historically attracting the public's attentions is the potential risk of mis-use or dual-use of the technology [101]. Considering the fact that the accessibility to drones is relatively high including off-the-shelf markets [12,66], while the accountability of drone manufacturers and operators can be rather low, drones do enable the possibilities of ill-intended usages [53]. The public, hence, were seriously concerned with drones being deployed for nefarious activities, which have not only happened in the past [102–104], but are continuously posing threats especially during warfare and conflicts [105–108]. Within this review, examples raised in the selected articles included the transportation of illicit goods [5,6,28,29,33,42], the use for attacks with the intention of injuring people [6,24,31,33,42,56], or the blatant use by terrorists [5,28,36,44,50,89,109]. The situation became more complicated when the media portrays drones in value-laden narratives, which played a key role in framing the public's mind in specific ways [45]. The increased focus on the security aspects of drones, coupled with the lack of knowledge about the competence of drone operators as well as regulators [59,83,93] – or the communication of these aspects thereof, led the public sentiments about drones to continuously focus on mis-use or dual-use, even when discussing about the so-called "good" drones [12].

4.3. Regulatory factors

In general, regulations were conceived by the public as central, as they could serve to curb other concerns about drone applications and potentially improve acceptance. Among others, privacy concerns were the most expressed factors, which appeared in 65 % of the selected articles. The public seemed to feel genuinely uneasy about any potential or perceived infringement of privacy, in both public spaces such as parks [75,89,110] and private arenas such as homes [6,41,50,52,60,61,71,75,81]. Autonomous systems like drones open up new avenues to collect different types of data, ranging from geolocation data gathered from previously inaccessible areas [78] to personal data captured through delivery services [34,53,73,82,98], posing the risks of compromising individuals' privacy. The public was, hence, alarmed that this may be abused with or without their informed consent [53,56,96,97]. Situated in the broader context of today's increased attention on personal data and its usage, drones used for surveillance and monitoring purposes appeared to be a conspicuous concern of the public [5,6,33,37,46,52,97]. Additionally, the concept of privacy can be obscured by other dimensions of public acceptance identified within this review. For instance, a lack of trust, transparency, regulation, and technical knowledge may create the so-called "chilling effects", leading to tensions between legitimacy of drone use and perceived privacy threats [20,44,66,68,87,90,99]. It follows that increasing public awareness about what drones are used for [37,70,78], and implementing regulatory measures such as licensing, can help ensure liability for privacy infringements [5,64]. Here, the importance of proactive public communication before, during, and after the implementation process surfaced from the proposed solutions to address privacy issues [70,91,96].

Next to privacy were the factors of safety and security, referring to an array of risks posed by not only drones themselves, but also the cargo they carry and the data they collect. Broadly, the public worried primarily about drone malfunctions caused by mechanical or human errors [6,28,29,33,36,44,56], and unpredictable factors such as weather conditions [89], which may cause both damages to properties [25,28,31,42,44,60,78,91,98,109,111,112] and injuries to humans [6,28,29,31,42,56,73,98,99,112,113]. In addition to safety caused directly by the drones, the public was also concerned about cargo safety [6,28,29,31,34,42,52,83,91,96,98], especially in terms of the so-called "dangerous goods", such as lab samples that may be infectious [34]. Further, closely related to the privacy aspect, there was an increased concern about cybersecurity related to drone data, given that drones may be stolen or mishandled [51] and drone data including sensitive ones such as patient data may be hacked [18,28,31,47,52,58,66,78,89,91,111,114]. These concerns were perceived as key in understanding the risk perceptions of the public and should be addressed across the diverse spectrum of drone applications [5,6,44,50,66]. As some articles noted, data protection regulations applicable to drones [66], and measures to enhance drone liability [18,31,43,91,99,109], would help convey a sense of confidence to the public, leading to improved acceptance. Interestingly, drones are also perceived by some as safety enhancing mechanisms, for example, to reduce crimes [113], protect first responders [50], and ensure public safety [50]. Although the latter was still overshadowed by the former in the mind of the public, it did bring a positive light to the debate about public attitudes.

The connection between public perceptions and regulatory factors was also manifest in aviation policy, airspace management, and specific drone certification and approval measures. Regulations responding to citizens' expectations – or conversely the lack of it – were deemed to have direct impact on the public's attitudes towards urban drones [5,6,17,30,31,47,50,62,66]. While existing aviation policies were referred to in the selected articles, such as the Federal Authority of Aviation (FAA) regulations [35,56,68,90] and the U-Space regulatory package [43], there was noticeable criticism on how aviation authorities should establish more comprehensive and up-to-date drone regulations in specific areas [30,44,81]. For example, it was observed that although drones were no longer a novel technology today, regulatory gaps persisted in areas such as drone noise [6,17,31,47,66] or airspace integration [62].

It was also suggested that the regulatory aspects could converge. For instance, by creating no-fly zones over private spaces [56,82,90,113], privacy could be protected; similarly, by regulating pilot accountability and traceability [6,53,78], safety and security could be ensured. Such considerations aligned with active areas of current policy debates, such as the implementation of a remote identification system in the newly proposed changes by the FAA of the USA, aiming to increase safety and accountability of drone operations [115]. With respect to drone certification and approval, whereas non-users generally favored stricter measures [17,31,48,67], manufacturers and operators alike argued that the existing regulations already overburdened technology development which, in turn, hindered research and innovation [36,53,116]. This was especially relevant regarding useful applications such as companion drones [71] or emergency drones [111], which could be granted faster approval allowing for more flexibility [33]. Again, these diverging perceptions highlighted the importance of discussing drones within the context of specific usage, as well as the significance of public communication to keep different groups of society informed and updated on a regular basis.

4.4. Economic factors

Regarding the economic dimensions about public perceptions, a strong commercial focus emerged from the selected articles within this review, which were mostly concerned with the acceptance of delivery, inspection, or other commercial services that the drone industry currently focused on. Unlike non-commercial applications such as drones used in development programs in Tanzania [60] or Malawi [63], where the effectiveness of drones in assisting local governments to cope with disasters or crises were shown, the perceived economic factors around commercial drones used in urban areas varied among the public [46,64,67,81]. Here, the most frequently discussed aspects centered around consumer benefits [27,30,34,36,43,51,83,85,86] and operation optimization [111]. Specifically, these included faster delivery time [26,34,36,50,58,59,73,85,91,92,98,112], cheaper transportation [117], higher cost-efficiency in missions [18,43,66,96], better costs reduction of required manpower [52,113], and easier accessibility to certain areas such as crop monitoring [50], or to certain products such as emergency medicines [86,96,98].

While the improvements of productivity and time-saving were generally perceived positively by the public [59], negative associations towards drone deliveries were also found. Examples included incomplete package deliveries [83,98], deliveries going to the wrong locations [28,29,91,98], or the limited size of payload that drones could carry [36]. Perceptions about the usefulness of other drone applications than delivery varied greatly [73], where recognized benefits were closely related to the purpose and reliability of drone use [50]. For instance, multi-purpose use of drones combining commercial services with public services, such as weather data collection while delivering consumer goods, was positively perceived [50]. Clearly, the perceptions about the technical performance of drones culminated in the public's technological readiness and willingness to adopt the technology [59,65,82,84–86]. This may serve as a proving ground on how economic interests of commercial and private actors can affect the overall level of societal acceptance of new technology, suggesting comprehensive and prudent reflections when the so-called business models will be conceived.

4.5. Impact factors

Three thematic clusters of impacts emerged from the selected articles showed relevance to the consequences of different use of drones, namely, environmental, health, and quality of life aspects. Within this review, there was a plethora of impacts discussed, encompassing both personal as well as wider societal considerations. From the environmental standpoint, positive impacts of drone use were discussed in light of sustainability [17,36,58,59,85,98], and specifically pollution reduction [5,18,34,43,92]. Yet, drones were also reported to potentially disrupt animal wellbeing, causing negative safety and health implications to fellow species such as birds co-living with humans [18,43,56,89,91,99,111].

From the health perspective, three dimensions were categorized including physical, mental, and general health effects. Physical health concerns were raised around human safety, covering a wide scope of matters ranging from injuries or death caused by drone accidents [6,28,29,31,42,43,56,73,76,98,99,112,113], bodily harms caused by drone falling [24,27,44], and damages to bystanders caused by kinetic energy, drone propellers, or drone packages [5,91]. Mental health concerns exemplified the long-term exposure to drone noise leading to sleep disturbance, mood alterations, depression and anxiety, and other adversarial chronical health problems [6,17,18,28,36,50,52,91].

Regarding the overall quality of life, the discussions opened up wider influences of drones on individuals. Key points raised here included the visual pollution of the sky [6,18,29,42,43,46,50,52], the fear of losing peaceful public spaces [36,109], disruption to social interactions due to drone movements [6,36,88], as well as interference with leisure activities due to drone noises [43,92]. Moreover, as with many other technologies, the public was worried about the impact of drones on job markets, specifically, the perceived danger of job loss [6,28,36,46,89]. It is worth noting that, within this diverse portfolio of impact factors related to public attitudes, perceived benefits and disadvantages brought by drones to social, environmental, health, or economic domains could overlap [52], which warrants further unpacking when assessing public acceptance of new technology in this regard.

4.6. Personal factors

As aforementioned, over half of the articles within this review used surveys to examine public perceptions, personal characteristics were used in this context as control variables to understand attitudes. On a base level, socio-economic status (SES) including age, gender, ethnicity, income, education, and occupation appeared to have an impact on how drones were perceived [27,93,97]. According to the studies, males in general showed a more positive attitudes towards drones than females [20,28,97], and younger people than older people as well as higher education level than lower education levels [20]. Studies also found that political orientation could influence perceptions on drones, with respect to both the liberal-conservative spectrum [23,87], and the general political worldviews and ideology [94,113,118,119]. For example, one study indicated that for surveillance purposes, conservatives appeared to be more supportive of deploying drones to monitor minority neighborhoods (e.g., where a concertation of African-American residents were present), whereas liberals appeared less so [113,119].

Interestingly, both positive and negative emotions associated to drones were reported in current literature. Descriptions included, in a positive light, intrigue [36], anticipation, joy, surprise, and attraction [32], fun and happiness [65], desirability [34,83], wonder and sense of adventure [25,57,59], and comfort [63]; and in a negative light, fear [6,24,32,44,59,63], mood alteration [92], sense of appalment and disgust [36], sadness and anger [32], feeling of being watched [56], etc. Relatedly, lifestyle preferences seemed to play a role. For example, drone delivery was perceived by some as compatible with their personal shopping habits [23,34,59,65,82,83,85,86,98], and was felt as fun, enjoyable, and even trendy and novelty-seeking [65,84]. These somewhat emotionally loaded perceptions indicated how the public was primarily concerned with their immediate feelings when seeing, hearing, or engaging with drones, which warrants them to be investigated further from a broader socio-psychological perspective.

Further, prior knowledge on technology could mitigate certain concerns about drones leading to better acceptance [20,25,27,56,67,90,97]. For instance, people who were familiar with drones or who had experiences in drone operations showed a lower level of privacy concerns [81,90], whereas a lower level of technological literacy or an apprehensive attitude towards technology could lead to higher level of risk perceptions [47,58]. This is also reflected in the perception gaps between users and non-users of drones, whereby the latter showed more concerns about drone accidents [5,81]. This highlighted the importance of managing risk perceptions on the basis of public understanding of technology in general and of drones in particular [63,116]. It also suggested that when considering upscaling drone operations in certain areas or among certain groups, it would be crucial to understand the specific demographics of the target populations, and how the particular needs of those populations as well as the sub-groups within them should be addressed in their own rights. It is worth noting that, while many studies included certain personal factors in their studies, only a few explicitly addressed how such factors may affect societal acceptance. This "blind spot" manifests a knowledge gap which calls for nuanced investigation to fully understand the dynamics of acceptance factors.

4.7. External factors

While personal characteristics were more inward-looking, the external factors affecting public perceptions were independent of individual preferences. According to the selected articles, the public understanding of drones was partly formed through the source of mass media [28,34,67,83]. For example, the media filled an important information gap, where the knowledge about drones was lacking from official sources such as authorities and key stakeholders, and was instead provided by media such as news [53] and popular shows [50]. Moreover, the ways in which drones were depicted by the media also largely influenced how drones were perceived [20,35,57]. The subtle difference in media narratives between generating benefits (e.g., saving life) and minimizing harms (e.g., preventing death) appeared to be significantly affecting public perceptions and thereby societal acceptance [38,45].

Further, the terminologies used to describe drones, such as "green technology" or "killer robots" or even the mere usage of the word "drones", coupled with the public's general sentiments towards media [118], led the public perceptions inevitably associated with fundamental values such as trustworthiness, accountability, biases, and transparency, etc. [35,38,45]. In this sense, shifting the primary source of knowledge about drones from media outlets towards regulatory authorities and scientific institutions could support public awareness-raising. For example, drones may not need to be framed in a dichotomic tone of "good" or "bad", but instead, a wider spectrum of applications and a more nuanced categorization of benefits and risks could be shown to the public, which could lead to a better-informed society. The provision of knowledge through media and peers is key in increasing public understanding of drones, and consequently their acceptance of the implementation of such technology.

Another external factor was the social settings surrounding the use and implementation of drones, as they could affect how people form their views on drones through the general influence of peers and social groups [57]. For example, the use of drones could be perceived as "trend-setting" and the drone users as "visionary", which could lead certain groups of citizens to be motivated to adopt drones to impress others [65,84]. This was especially true for "early adopters", who drove the emergence of technology and its adaption, and spread the word of it through mouth-to-mouth communication [86]. This may have particular relevance to urban settings, in which large social networks exist and frequent social exchanges could take place. Placing attitudes towards technology within their specific social settings can, thus, help understand how perceptions are formed and transformed, and how they can be guided through the accurate provision of knowledge about the technology. Within the current review, the external factors contained the least represented themes across existing literature, indicating another "blind spot" in the broad drone acceptance research. Enhancing the understanding of these factors is thus needed to help uncover the subtilties of societal acceptance.

4.8. Thematic classification

Based on the above observations and analyses, and as a first attempt, we benchmarked the scope of public concerns related to urban drones with the key acceptance factors. Table 4 below is an illustration of the scope of these factors. We acknowledged that this classification does not capture all subtleties associated with the richness and depth of public perceptions and, therefore, cannot be considered comprehensive with respect to all matters discussed in the selected articles. Nevertheless, we deem it appropriate and sufficient to map out where the relevant issues lie.

5. Limitations

Through an inductive process, we identified a set of societal

Table 4
Thematic classification of societal acceptance factors and scope associated with urban drones.

Cluster	Theme	Scope
Technical Factors	Levels of Autonomy	Human control & oversight, type & level of automation, responsiveness in unpredictable situations.
	Technical Risk	Technical mal-function, drone crash, influence of unpredictable factors (weather conditions).
	Noise	General noise pollution, environmental & health impacts, different noise profiles, noise measurement.
	Aerodynamics & Design	General technical characteristics (kinetic energy, propellers, battery, payload capacity, flight patterns), general visual characteristics (aesthetic, color, animal-like appearance).
Operational Factors	Application Type, Purpose & Location	Promotion of public values, transparency of mission goals & implementation plan, operation area & involved institutions, distinction of geographic location (residential, industrial, recreational, public, private).
	Dual-use & Mis-use	Terrorist attack, transportation of illicit goods, surveillance, positive dual-use (combined public interests), active public communication about use cases.
	Trust, Accountability, Integrity & Transparency	Trustworthiness of the technology, legitimacy of involved institutions, operator accountability & integrity, regulators competence & knowledge, public trust towards specific applications, public engagement in decision-making processes, general liability issues.
Regulatory Factors	Privacy	Data protection, the right to information, consent, opt-in/opt-out, chilling effects, liability issues.
	Safety & Security	Human injury, property damage, cargo safety, cybersecurity, drone theft, safety & security insurance.
	Aviation	Inadequate/unclear regulations, regulatory gaps, registration, certification & approval processes, implementation of existing legislation, no-fly zones, U-Space airspaces.
Economic Factors	Technical Performance & Usefulness	Mechanical & personnel cost reduction, operational cost-effectiveness, performance reliability, usefulness to local population, multi-purpose capacity.
	Intention to Adopt the Technology	General public perception, worldview & ideology, overall benefits to society & individuals, personal interest & experience, impact on labor market & work relations.
	Related Infrastructure & Services	Accessibility & ease of use, software optimization, volume of operation at scale, real-time digital tools to increase transparency.
Impact Factors	Environmental Impacts	Sustainability & emissions, disruption & safety of wildlife, visual pollution, airspace management.
	Health Impacts	Physical impacts (physical injury & damage, threat to bodily harm), mental impacts (anxiety & stress, annoyance & anger, disgust & depression), general ill-health concerns about long-term exposure (sleep disturbance, poorer performance capacity, feeling of being watched).
	Quality of Life Impacts	Personal lifestyle preferences, public space management, social interaction, leisure activities.
Personal Factors	Socio-Economic Status (SES)	Age, gender, ethnicity, residence type, education, occupation, income level, political affiliation, etc.
	Emotional & Psychological Readiness	Technological proximity (apprehensive about technology), negative emotions (anxiety, fear, shock & frustrations), positive emotion (wonder & inspiration, attraction & desirability, joy & fun, comfort & assurance).
	Technical Knowledge & Competency	Technological literacy, prior knowledge, technical familiarity & awareness, overall competency & capability of understanding new technology.
External Factors	Media Appropriation & Public Communication	Influential narratives ("early adopter", "trend setter"), personal characteristics (novelty, vigilance, openness, venturesomeness), sentiments of fundamental values (trust & trustworthiness, accountability, transparency).
	Peer & Social Influence	Benefits to specific groups of society (visually impaired people), emotive responses (engagement & participation), social norm setting ("live-saving", "green tech").
	Information Source & Influence	Mass media, entrainment sector, commercial lobbying, word-of-mouth.
	Technical Terminology	Confusing terminology (UAV, UAS, RPA, RPAS, drone), value-laden framing ("killer robots", "good drones").

acceptance factors related to urban use of drones. Broadly, these considerations reflect core societal concerns in areas such as regulatory and impact factors, which allowed us to further clarify places of emphasis in the literature. Although the rigor of this review was supported by the consultation with academic librarians, refinements of the protocol based on test and pilot searches, blinded search, selection and screening of articles by two reviewers, and the expert consultation to receive feedback on provisional findings, we acknowledged several limitations associated with this review.

First, it was challenging to create boundary definitions for the concept of "urban" and to operationalize it in our search and selection process. We adopted a more inclusive approach to this concept by including peri-urban contexts. Consequently, application areas such as agriculture were included in the review results, which helped shed light on this important area in spite of the overall urban focus of the review. Second, our search for the concept of "societal acceptance" used broad terms related to acceptance. As a result, we might not have identified papers focused on specific areas of considerations, e.g., issues of justice, if they were not indexed in relation to these broader categories. Third, while we employed conscientiously sentinel articles and snowballing in the pilot phase for search term optimization, such a procedure was not implemented in the subsequent processes. This was because the final search strings emerged from the pilot phase were purposefully extensive and robust to sufficiently cover relevant articles for this review. Forth, while our search and selection identified a wide range of considerations related to perceptions about different drone applications, purely expert opinions without explicitly referring to the public were not included in the current work (subsequent studies of own researcher focusing on expert opinions are ongoing). Fifth, we limited our search to sources written in English for two reasons: over 90 % of the articles identified during the pilot search were in English, also it was the common language at a proficiency level among all involved researchers. We noted the possibility that additional relevant articles were published in other languages, but were not identified based on this search parameter.

Last but not least, it is worth noting that, similar to experiences of Levac et al. (2010), we observed a general lack of defined theories to inform approaches of studies in the current context. The few theoretical frameworks used in the studies appeared to be mainly in the field of Economics and Management, and often with identical conceptual approaches. Some examples of theoretical framings appeared in the articles included Human-Computer/Robot-Interaction (HCI/HRI), Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), Perceived Usefulness (PU), Perceived Ease to Use (PEU), Social Impact Assessment (SIA), Knowledge, Attitude, and Practice (KAP). While detailed descriptions of theoretical framings did not seem to be systematically undertaken by the involved authors, we recognized the added value of engaging analyses with conceptual frameworks to capture the disciplinary affiliations of studies. While this was not a limitation of our review *per se*, but more of a limitation of the original articles selected in our review, we considered it a relevant point to note – it could be worthwhile for researchers working on this topic to explore further in future studies.

6. Conclusion

While the science and engineering of robotics is well developed in the past decades [8,120–122], drones have only recently become a research topic in ethics, law, and social sciences [12,66,123–126]. This scoping review presented a portrait of the expanding literature on this topic from 2010 through to the end of 2022, focusing on how societal acceptance of urban drones were understood and conceptualized across academic literature sources. Conceptually, our work offered a unique perspective in exploring societal acceptance of urban drones, thereby extending the insights provided by the existing literature. Methodologically, our work showed a wide range of data generation, with both qualitative and quantitative methods being used in different contexts. We highlighted the importance of ensuring such practices to be further expanded, as mixed methods and varied sources of data collection could add greater values to complement the existing body of knowledge.

While pointing to key areas of concerns where most consensus across the literature existed, such as the technical, operational, and regulatory factors, our study also demonstrated competing visions within these clusters regarding the broader societal implications of urban drones across a wide spectrum of applications and stakeholders. Two thematic clusters emerged from the literature drew particular attention of ours, namely, the personal and external factors, which currently lack scholarly insights and, thus, warrant further investigations in future research on these topics. While the focus of this study was to map the breadth of the literature, rather than delving into specific themes and form comparative analyses of them, we acknowledged that more detailed reviews about potential overlaps and discrepancies of specific themes may contribute to the depth and subtleties of the topic.

On a broader level, the review's findings could also be situated within the rise of the value-based innovation movement, which emerged just prior to the time period of this review, and which has led to a growing body of literature in its own right [127–130]. This includes a variety of scholarly work critically examining the ethical issues associated with innovation practices, processes and products [131–136], as well as efforts to develop ethics guidance for innovation projects [2,12,47,137]. The findings of this review shed light on what explicit and implicit societal acceptance factors related to urban use of drones are present, and how these factors are being articulated and interpreted, in the existing academic literature. It can, thus, contribute to orienting work on innovation and society, including the development of governance frameworks and guidance tools that are value-sensitive and context-specific.

Authors' contributions

Ning Wang: Conceptualization, Methodology, Writing – Original Draft, Reviewing and Editing, Supervision, Project Management, Funding Acquisition; **Nico Mutzner**: Investigation, Data Curation, Analysis, Validation, Visualization, Writing – Reviewing and Editing.; **Karl Blanchet**: Writing – Reviewing and Editing, Supervision, Project Management, Funding Acquisition.

Funding

This work was supported by a joint grant from the University of Zurich and the University of Geneva, who generously funded our research project "*Societal Acceptance of Drones in Urban Switzerland (SADUS)*".

Data availability

Data will be made available on request.

Acknowledgements

In developing the ideas presented in this paper, the authors received insightful feedback from Ms. Lizzie Sparrow and Mr. Paul Cooke (Cambridge University Libraries, United Kingdom), to whom we are immensely indebted. We are also grateful to PD. Dr. Markus Christen (University of Zurich, Switzerland), whose constructive feedback for both the larger research project and this study helped us improve the manuscript. We finally thank Ms. Samira Marty for her assistance in pilot-testing the review protocol, and Mr. Strahinja Popović for his feedback on the visualization of the review results.

Appendix 1. Collection of Selected Articles

Publication Type	Publication Year	Author(s)	Article Title
Journal Article	2018	PytlikZillig L.M., Duncan B., Elbaum S., Detweiler C.	A drone by any other name: Purposes, end-user trustworthiness, and framing, but not terminology, affect public support for drones
Journal Article	2021	Torija, Antonio J.; Clark, Charlotte	A Psychoacoustic Approach to Building Knowledge about Human Response to Noise of Unmanned Aerial Vehicles
Journal Article	2021	Zhang, Yuerong; Kamargianni, Maria	A review on the factors influencing the adoption of new mobility technologies and services: autonomous vehicle, drone, micromobility and mobility as a service

(*continued on next page*)

(*continued*)

Publication Type	Publication Year	Author(s)	Article Title
Journal Article	2022	Sabino, Hullysses; Almeida, Rodrigo V. S.; de Moraes, Lucas Baptista; da Silva, Walber Paschoal; Guerra, Raphael; Malcher, Carlos; Passos, Diego; Passos, Fernanda G. O.	A systematic literature review on the main factors for public acceptance of drones
Journal Article	2022	Kähler S.T., Abben T., Luna-Rodriguez A., Tomat M., Jacobsen T.	An assessment of the acceptance and aesthetics of UAVs and helicopters through an experiment and a survey
Conference Paper	2019	Khan, Md Nafiz Hasan; Neustaedter, Carman	An Exploratory Study of the Use of Drones for Assisting Firefighters During Emergency Situations
Conference Paper	2021	Nicholls R.K., Torija Martinez A.J.	An investigation into human response to unmanned aerial vehicle noise
Conference Paper	2015	Zhang, Guangda; Liang, Hai-Ning; Yue, Yong	An investigation of the use of robots in public spaces
Journal Article	2017	Kwon, Heeyeul; Kim, Jieun; Park, Yongtae	Applying LSA text mining technique in envisioning social impacts of emerging technologies: The case of drone technology
Journal Article	2019	Rosenfeld, Ariel	Are drivers ready for traffic enforcement drones?
Journal Article	2022	Alluhaidan, Ala Saleh	Artificial intelligence for public perception of drones as a tool for telecommunication technologies
Journal Article	2017	Sakiyama, Mari; Miethe, Terance D.; Lieberman, Joel D.; Heen, Miliaikeala S. J.; Tuttle, Olivia	Big hover or big brother? Public attitudes about drone usage in domestic policing activities
Journal Article	2022	Annan, Esther; Guo, Jinghui; Angulo-Molina, Aracely; Yaacob, Wan Fairos Wan; Aghamohammadi, Nasrin; Guetterman, Timothy C.; Yavasoglu, Sare Ilknur; Bardosh, Kevin; Dom, Nazri Che; Zhao, Bingxin; Lopez-Lemus, Uriel A.; Khan, Latifur; Nguyen, Uyen-Sa D. T.; Haque, Ubydul	Community acceptability of dengue fever surveillance using unmanned aerial vehicles: A cross-sectional study in Malaysia, Mexico, and Turkey
Journal Article	2021	Ivosevic, Jurica; Ganic, Emir; Petosic, Antonio; Radisic, Tomislav	Comparative UAV Noise-Impact Assessments through Survey and Noise Measurements
JournalArticle	2019	Zwickle, Adam; Farber, Hillary B.; Hamm, Joseph A.	Comparing public concern and support for drone regulation to the current legal framework
Journal Article	2022	Hardy, Andy; Proctor, Mark; MacCallum, Cathryn; Shawe, John; Abdalla, Safia; Ali, Rajab; Abdalla, Salha; Oakes, Gregory; Rosu, Laura; Worrall, Eve	Conditional trust: Community perceptions of drone use in malaria control in Zanzibar
Conference Paper	2015	Kerasidou X., Büscher M., Liegl M.	Don't drone? Negotiating ethics of RPAS in emergency response
JournalArticle	2019	Sanfridsson, J.; Sparrevik, J.; Hollenberg, J.; Nordberg, P.; Djarv, T.; Ringh, M.; Svensson, L.; Forsberg, S.; Nord, A.; Andersson-Hagiwara, M.; Claesson, A.	Drone delivery of an automated external defibrillator - a mixed method simulation study of bystander experience
JournalArticle	2021	Martins, Bruno Oliveira; Lavallee, Chantal; Silkoset, Andrea	Drone Use for COVID-19 Related Problems: Techno-solutionism and its Societal Implications
JournalArticle	2020	Sedig, K.; Seaton, M. B.; Drennan, I. R.; Cheskes, S.; Dainty, K·N.	Drones are a great idea! What is an AED? novel insights from a qualitative study on public perception of using drones to deliver automatic external defibrillators
JournalArticle	2020	Kellermann, Robin; Fischer, Liliann	Drones for parcel and passenger transport: A qualitative exploration of public acceptance
Book Chapter & Conference Paper	2017	Lidynia, Chantal; Philipsen, Ralf; Ziefle, Martina	Droning on About Drones-Acceptance of and Perceived Barriers to Drones in Civil Usage Contexts
Journal Article	2020	Torija, Antonio J.; Li, Zhengguang; Self, Rod H.	Effects of a hovering unmanned aerial vehicle on urban soundscapes perception
Journal Article	2018	Kong, Hwayeon; Biocca, Frank; Lee, Taeyang; Park, Kihyuk; Rhee, Jeonghoon	Effects of Human Connection through Social Drones and Perceived Safety
Conference Paper	2021	Garzia, Fabio; Borghini, Francesco; Castagnolo, Antonello; Lombardi, Mara; Ramalingam, Soodamani	Emotional analysis of safeness and risk perception of drones during the COVID-19 pandemic in Italy
Journal Article	2021	Wang, Ning; Christen, Markus; Hunt, Matthew	Ethical Considerations Associated with Humanitarian Drones: A Scoping Literature Review
Journal Article	2018	Gevaert, Caroline M.; Sliuzas, Richard; Persello, Claudio; Vosselman, George	Evaluating the Societal Impact of Using Drones to Support Urban Upgrading Projects
Conference Paper	2018	Rifan, Rafhan; Adikariwattage, Varuna	Evaluation of Regulatory Gap in UAS Operations in Sri Lanka
Journal Article	2021	Hwang, Jinsoo; Kim, Jinkyung Jenny	Expected benefits with using drone food delivery services: its impacts on attitude and behavioral intentions
Conference Paper	2020	Ariyasena, Erangi P.; Manawadu, Udaka A.; Abeyratne, Kasun R.; De Silva, P. Ravindra S.	Exploring a Ground-Air Personal Space in Human-Drone Interactions
Journal Article	2022	Valencia-Arias, Alejandro; Andrea Rodriguez-Correa, Paula; Camilo Patino-Vanegas, Juan; Benjumea-Arias, Martha; de la Cruz-Vargas, Jhony; Moreno-Lopez, Gustavo	Factors Associated with the Adoption of Drones for Product Delivery in the Context of the COVID-19 Pandemic in Medellin, Colombia
Journal Article	2021	Belmonte, Lidia M.; Garcia, Arturo S.; Morales, Rafael; de la Vara, Jose Luis; Lopez de la Rosa, Francisco; Fernandez-Caballero, Antonio	Feeling of Safety and Comfort towards a Socially Assistive Unmanned Aerial Vehicle That Monitors People in a Virtual Home
Conference Paper	2020	Lai, Mei-Chiao; Liu, Dan; Tsay, Wu-Der	Functional Deployment of Drone Logistics
Journal Article	2022	Yamin, Lee J.; Cauchard, Jessica R.	Generative Adversarial Networks and Data Clustering for Likable Drone Design
Conference Paper	2018	Martin, Lynne; Homola, Jeffrey; Omar, Faisal; Ramirez, Cesar; Jobe, Kimberly	Giving the public a perspective into Unmanned Aircraft Systems' operations
Conference Paper	2020	Coulter, Corina; Haring, Kerstin S.	Good Choices: Technological and Ethical Considerations to Increase Trust in UASs
Journal Article	2019	Walther, Janell; PytlikZillig, Lisa; Detweiler, Carrick; Houston, Adam	How people make sense of drones used for atmospheric science (and other purposes): hopes, concerns, and recommendations
Conference Paper	2019	Oltvoort, Anne; de Vries, Peter; van Rompay, Thomas; Rosen, Dale	I Am the Eye in the Sky - Can You Read My Mind? How to Address Public Concerns Towards Drone Use
Journal Article	2022	Serafinelli, Elisa	Imagining the social future of drones

(*continued on next page*)

(*continued*)

Publication Type	Publication Year	Author(s)	Article Title
Journal Article	2022	Cetin, Ender; Cano, Alicia; Deransy, Robin; Tres, Sergi; Barrado, Cristina	Implementing Mitigations for Improving Societal Acceptance of Urban Air Mobility
Journal Article	2022	Torija, Antonio J.; Nicholls, Rory K.	Investigation of Metrics for Assessing Human Response to Drone Noise
Conference Paper	2018	Soto, Mauro Avila; Funk, Markus	Look, a guidance drone! Assessing the Social Acceptability of Companion Drones for Blind Travelers in Public Spaces
Journal Article	2018	Keller, J; Adjekum, DK; Alabi, BNT; …	Measuring public utilization perception potential of unmanned aircraft systems
Journal Article	2016	Winter, Scott R.; Rice, Stephen; Tamilselvan, Gajapriya; Tokarski, Russell	Mission-based citizen views on UAV usage and privacy: an affective perspective
Journal Article	2020	Komasova, Sarah; Tesar, Jakub; Soukup, Petr	Perception of drone related risks in Czech society
Journal Article	2016	Saulnier, Alana; Thompson, Scott N.	Police UAV use: institutional realities and public perceptions
Journal Article	2021	Komasova, Sarah	Possible Inspiration: Drone-Related Literature and its Potential for Public Perception Research
Conference Paper	2017	Yao, Yaxing; Xia, Huichuan; Huang, Yun; Wang, Yang	Privacy Mechanisms for Drones: Perceptions of Drone Controllers and Bystanders
Journal Article	2021	Tan, Lynn Kai Lin; Lim, Beng Chong; Park, Guihyun; Low, Kin Huat; Yeo, Victor Chuan Seng	Public acceptance of drone applications in a highly urbanized environment
Journal Article	2019	Aydin, Burchan	Public acceptance of drones: Knowledge, attitudes, and practice
Journal Article	2022	Smith, A; Dickinson, JE; Marsden, G; Cherrett, T; …	Public acceptance of the use of drones for logistics: The state of play and moving towards more informed debate
Data Brief	2020	Miethe, TD; Lieberman, JD; Sakiyama, M; Troshynski, EI	Public attitudes about aerial drone activities: Results of a national survey
JournalArticle	2022	Li, Jamy; Janabi-Sharifi, Farrokh	Public Opinion About the Benefit, Risk, and Acceptance of Aerial Manipulation Systems
Journal Article	2018	Rice, Stephen; Tamilselvan, Gajapriya; Winter, Scott R.; Milner, Mattie N.; Anania, Emily C.; Sperlak, Lauren; Marte, Daniel A.	Public perception of UAS privacy concerns: a gender comparison
Journal Article	2015	Clothier, Reece A.; Greer, Dominique A.; Greer, Duncan G.; Mehta, Amisha M.	Risk Perception and the Public Acceptance of Drones
Conference Paper	2017	Chang, Victoria; Chundury, Pramod; Chetty, Marshini	Spiders in the Sky: User Perceptions of Drones, Privacy, and Security
Journal Article	2020	Eiβfeldt H., Vogelpohl V., Stolz M., Papenfuβ A., Biella M., Belz J., Kügler D.	The acceptance of civil drones in Germany
Conference Paper	2019	Macias, Miguel; Barrado, Cristina; Pastor, Enric; Royo, Pablo	The Future of Drones and their Public Acceptance
Conference Paper	2018	Lidynia, Chantal; Philipsen, Ralf; Ziefle, Martina	The Sky's (Not) the Limit - Influence of Expertise and Privacy Disposition on the Use of Multicopters
Journal Article	2019	Nelson, Jake R.; Grubesic, Tony H.; Wallace, Danielle; Chamberlain, Alyssa W.	The View from Above: A Survey of the Public's Perception of Unmanned Aerial Vehicles and Privacy
Journal Article	2015	Thompson, Scott; Bracken-Roche, Ciara	Understanding public opinion of UAVs in Canada: A 2014 analysis of survey data and its policy implications
Journal Article	2019	Ogilvie, Shaun; McCarthy, Alaric; Allen, Will; Grant, Andrea; Mark-Shadbolt, Melanie; Pawson, Steve; Richardson, Brian; Strand, Tara; Langer, E. R. (Lisa); Marzano, Mariella	Unmanned Aerial Vehicles and Biosecurity: Enabling Participatory-Design to Help Address Social Licence to Operate Issues
Conference Paper	2022	Barr H.M., Smitherman R.C., Mesmer B., Weger K., Bossuyt D.V., Semmens R., Tenhundfeld N.L.	Use, Acceptance, and Adoption of Automated Systems with Intrinsic and Extrinsic Motivation Based Incentive Mechanisms
Technical Report	2016	Eichleay, M; Mercer, S; Murashani, J; Evens, E	Using unmanned aerial vehicles for development: perspectives from Citizens and Government Officials in Tanzania
JournalArticle	2020	Wang, Ning	We Live on Hope …: Ethical Considerations of Humanitarian Use of Drones in Post-Disaster Nepal …
Journal Article	2017	Markowitz, Ezra M.; Nisbet, Matthew C.; Danylchuk, J.; Engelbourg, Seth I.	What's That Buzzing Noise? Public Opinion on the Use of Drones for Conservation Science
Journal Article	2022	Ganjipour, Houmaan; Edrisi, Ali	Applying the integrated model to understanding online buyers' intention to adopt delivery drones in Iran
Conference Paper	2022	Famula, Jurgen; Pittman, Daniel E.; Haring, Kerstin S.	Building Trust with a Mobile Application for Last-Mile Commercial Drone Delivery
Journal Article	2019	Khan, Rabeel; Tausif, Sadaf; Malik, Ahmed Javed	Consumer acceptance of delivery drones in urban areas
JournalArticle	2021	Leon, Steven; Chen, Charlie; Ratcliffe, Aaron	Consumers' perceptions of last mile drone delivery
Journal Article	2022	Osakwe, Christian Nedu; Hudik, Marek; Riha, David; Stros, Michael; Ramayah, T.	Critical factors characterizing consumers' intentions to use drones for last-mile delivery: Does delivery risk matter?
JournalArticle	2018	Yoo, Wonsang; Yu, Eun; Jung, Jaemin	Drone delivery: Factors affecting the public's attitude and intention to adopt
Journal Article	2020	Callanan, Jesse; Ghassemi, Payam; DiMartino, James; Dhameliya, Maulikkumar; Stocking, Christina; Nouh, Mostafa; Chowdhury, Souma	Ergonomic Impact of Multi-rotor Unmanned Aerial Vehicle Noise in Warehouse Environments
Journal Article	2018	de Miguel Molina, Maria; Santamarina Campos, Virginia; Carabal Montagud, Ma Angeles; de Miguel Molina, Blanca	Ethics for civil indoor drones: A qualitative analysis
Conference Paper	2017	Yao, Yaxing; Xia, Huichuan; Huang, Yun; Wang, Yang	Free to Fly in Public Spaces: Drone Controllers' Privacy Perceptions and Practices
Journal Article	2021	Graham, Amanda; Kutzli, Haylee; Kulig, Teresa C.; Cullen, Francis T.	Invasion of the Drones: A New Frontier for Victimization
Journal Article	2021	Hwang, Jinsoo; Kim, Jinkyung Jenny; Lee, Kwang-Woo	Investigating consumer innovativeness in the context of drone food delivery services: Its impact on attitude and behavioral intentions
Conference Paper	2021	Wang, Ning	Killing Two Birds with One Stone ? A Case Study of Development Use of Drones
Journal Article	2016	Freeman, PK; Freeland, RS	Media framing the reception of unmanned aerial vehicles in the United States of America

(*continued on next page*)

(*continued*)

Publication Type	Publication Year	Author(s)	Article Title
Journal Article	2019	Ahsan, Kamran; Irshad, Sana; Khan, Muhammad Abid; Ullah, Sana; Iqbal, Sarwat; Saeed, Muhammad; Ahmed, Sohaib; Rehman, Osama	Mobile-Controlled UAVs for Audio Delivery Service and Payload Tracking Solution
Journal Article	2019	Anania, Emily C.; Rice, Stephen; Pierce, Matthew; Winter, Scott R.; Capps, John; Walters, Nathan W.; Milner, Mattie N.	Public support for police drone missions depends on political affiliation and neighborhood demographics
Journal Article	2019	Zhu, Xun	Segmenting the public's risk beliefs about drone delivery: A belief system approach
Journal Article	2021	Chen, Yu-Che; Huang, Chenyu	Smart Data-Driven Policy on Unmanned Aircraft Systems (UAS): Analysis of Drone Users in US Cities
Journal Article	2020	Crampton, Jeremy W.; Hoover, Kara C.; Smith, Harrison; Graham, Steve; Berbesque, J. Colette	Smart Festivals? Security and Freedom for Well-Being in Urban Smart Spaces
Journal Article	2022	Buko, Jacek; Bulsa, Marek; Makowski, Adam	Spatial Premises and Key Conditions for the Use of UAVs for Delivery of Items on the Example of the Polish Courier and Postal Services Market
Journal Article	2020	Duncan, Megan; Culver, Kathleen Bartzen	Technologies, Ethics and Journalism's Relationship with the Public
Journal Article	2019	Milner, Mattie N.; Rice, Stephen; Winter, Scott R.; Anania, Emily C.	The effect of political affiliation on support for police drone monitoring in the United States
Journal Article	2015	Sandbrook, Chris	The social implications of using drones for biodiversity conservation
Journal Article	2016	Rao, Bharat; Gopi, Ashwin Goutham; Maione, Romana	The societal impact of commercial drones
Journal Article	2018	Heen, Miliaikeala S. J.; Lieberman, Joel D.; Miethe, Terance D.	The thin blue line meets the big blue sky: perceptions of police legitimacy and public attitudes towards aerial drones
Journal Article	2022	Jasim, Noor Islam; Kasim, Hairoladenan; Mahmoud, Moamin A.	Towards the Development of Smart and Sustainable Transportation System for Foodservice Industry: Modelling Factors Influencing Customer's Intention to Adopt Drone Food Delivery (DFD) Services
Journal Article	2019	Nelson, Jake; Gorichanaz, Tim	Trust as an ethical value in emerging technology governance: The case of drone regulation
Journal Article	2022	Xie, Wei; Chen, Charlie; Sithipolvanichgul, Juthamon	Understanding e-commerce customer behaviors to use drone delivery services: A privacy calculus view
Journal Article	2020	Zhu, Xun; Pasch, Timothy J.; Bergstrom, Aaron	Understanding the structure of risk belief systems concerning drone delivery: A network analysis
Conference Paper	2017	Mittendorf, Christoph; Franzmann, Daniel; Ostermann, Uwe	Why Would Customers Engage in Drone Deliveries?
Journal Article	2022	Chen, Charlie; Leon, Steve; Ractham, Peter	Will customers adopt last-mile drone delivery services? An analysis of drone delivery in the emerging market economy

Appendix 2. List and Counts of Identified Journals

Journal	Count
Technology in Society	12
Journal of Unmanned Vehicle Systems	5
International Journal of Environmental Research and Public Health	3
Drones	2
Sensors	2
Telematics and Informatics	2
Cogent Business & Management	2
IEEE Technology and Society Magazine	2
Journal of Intelligent & Robotic Systems	2
Technovation	1
Science & Society	1
Criminal Justice Studies	1
Deviant Behavior	1
Smart Cities	1
Ambio	1
Transportation Research Part D: Transport and Environment	1
Energies	1
Risk Analysis	1
Forests	1
Security Journal volume	1
Glob Policy.	1
Technological Forecasting and Social Change	1
IEEE Access	1
Transport Reviews	1
Annals of the American Association of Geographers	1
Convergence: The International Journal of Research into New Media Technologies	1
IEEE Transactions on Human-Machine Systems	1
Resuscitation Plus	1
International Journal of Aviation, Aeronautics, and Aerospace	1
Scand J Trauma Resusc Emerg Med	1
International Journal of Consumer Studies	1
Science and Engineering Ethics	1
International Journal of Logistics Research and Applications	1
CEAS Aeronautical Journal volume	1
International Journal of Micro Air Vehicles	1

(*continued on next page*)

(*continued*)

Journal	Count
Sustainability	1
Journal of Hospitality and Tourism Technology	1
Advances in Human-Computer Interaction	1
Behavioral Sciences & the Law	1
Computational Intelligence	1
Accident Analysis & Prevention	1
Transportation Letters	1
BioScience	1
Travel Medicine and Infectious Disease	1
Journal of Urban Technology	1
International Journal of Geo-Information	1
Media and Communication	1
Policing: An International Journal	1
Journal of Retailing and Consumer Services	1

Appendix 3. Count of Acceptance Factor Themes & Clusters

Cluster	Theme	Count Theme	Count Cluster
Technical Factors	Levels of Autonomy	12	63
	Technical Risk	9	
	Noise	23	
	Aerodynamics & Design	19	
Operational Factors	Application Type, Purpose & Location	38	120
	Dual-use & Mis-use	24	
	Trust, Accountability, Integrity & Transparency	58	
Regulatory Factors	Privacy	63	166
	Safety & Security	62	
	Aviation	41	
Economic Factors	Technical Performance & Usefulness	62	97
	Intention to Adopt the Technology	28	
	Related Infrastructure & Services	7	
Impact Factors	Environmental Impacts	23	75
	Health Impacts	27	
	Quality of Life Impacts	25	
Personal Factors	Socio-Economic Status (SES)	38	90
	Emotional & Psychological Readiness	24	
	Technical Knowledge & Competency	28	
External Factors	Media Appropriation & Public Communication	6	22
	Peer & Social Influence	5	
	Information Source & Influence	9	
	Technical Terminology	2	

References

[1] EASA, Study on the Societal Acceptance of Urban Air Mobility in Europe, 2021 [Online]. Available: https://www.easa.europa.eu/en/full-report-study-societal-acceptance-urban-air-mobility-europe. (Accessed 27 April 2023).

[2] N. Wang, M. Christen, M. Hunt, Ethical considerations associated with “humanitarian drones”: a scoping literature review, Sci. Eng. Ethics 27 (4) (2021) 51, https://doi.org/10.1007/s11948-021-00327-4.

[3] D. Levac, H. Colquhoun, K.K. O’Brien, Scoping studies: advancing the methodology, Implement. Sci. 5 (1) (2010) 69, https://doi.org/10.1186/1748-5908-5-69.

[4] M.D.J. Peters, C.M. Godfrey, H. Khalil, P. McInerney, D. Parker, C.B. Soares, Guidance for conducting systematic scoping reviews, Int. J. Evid. Base. Healthc. 13 (3) (2015) 141–146, https://doi.org/10.1097/XEB.0000000000000050.

[5] S. Komasova, Possible inspiration: drone-related literature and its potential for public perception research, J. Intell. Rob. Syst. 103 (3) (2021), https://doi.org/10.1007/s10846-021-01498-9.

[6] H. Sabino, et al., A systematic literature review on the main factors for public acceptance of drones, Technol. Soc. 71 (2022), https://doi.org/10.1016/j.techsoc.2022.102097.

[7] H. Arksey, L. O’Malley, Scoping studies: towards a methodological framework, Int. J. Soc. Res. Methodol. 8 (1) (2005) 19–32, https://doi.org/10.1080/1364557032000119616.

[8] D. Floreano, R. Wood, Science, technology and the future of small autonomous drones, Nature 521 (7553) (2015) 460–466, https://doi.org/10.1038/nature14542.

[9] M. Blösch, S. Weiss, D. Scaramuzza, R. Siegwart, Vision based MAV navigation in unknown and unstructured environments, in: 2010 IEEE International Conference on Robotics and Automation, 2010, pp. 21–28, https://doi.org/10.1109/ROBOT.2010.5509920.

[10] A. Fotouhi, M. Ding, M. Hassan, Understanding autonomous drone maneuverability for Internet of Things applications, in: 2017 IEEE 18th International Symposium on A World of Wireless, Mobile and Multimedia Networks (WoWMoM), 2017, pp. 1–6, https://doi.org/10.1109/WoWMoM.2017.7974336.

[11] V. Kangunde, R.S. Jamisola, E.K. Theophilus, A review on drones controlled in real-time, Int. J. Dyn. Control 9 (4) (2021) 1832–1846, https://doi.org/10.1007/s40435-020-00737-5.

[12] N. Wang, M. Christen, M. Hunt, N. Biller-Andorno, Supporting value sensitivity in the humanitarian use of drones through an ethics assessment framework, Int. Rev. Red Cross 104 (919) (2022) 1397–1428, https://doi.org/10.1017/S1816383121000989.

[13] P. Upham, C. Oltra, À. Boso, Towards a cross-paradigmatic framework of the social acceptance of energy systems, Energy Res. Social Sci. 8 (2015) 100–112, https://doi.org/10.1016/j.erss.2015.05.003.

[14] R. Wüstenhagen, M. Wolsink, M.J. Bürer, Social acceptance of renewable energy innovation: an introduction to the concept, Energy Pol. 35 (5) (2007) 2683–2691, https://doi.org/10.1016/j.enpol.2006.12.001.

[15] C. Deuskar, What does “urban” mean?, 2015. https://blogs.worldbank.org/sustainablecities/what-does-urban-mean. (Accessed 27 April 2023).

[16] D. Gough, J. Thomas, S. Oliver, Clarifying differences between review designs and methods, Syst. Rev. 1 (1) (2012) 28, https://doi.org/10.1186/2046-4053-1-28.

[17] A. Torija, C. Clark, A psychoacoustic approach to building knowledge about human response to noise of unmanned aerial vehicles, Int. J. Environ. Res. Publ. Health 18 (2) (2021), https://doi.org/10.3390/ijerph18020682.

[18] E. Cetin, A. Cano, R. Deransy, S. Tres, C. Barrado, Implementing mitigations for improving societal acceptance of urban air mobility, DRONES 6 (2) (2022), https://doi.org/10.3390/drones6020028.

[19] A. Smith, J. Dickinson, G. Marsden, T. Cherrett, Technol. …, no. Query date: 2022-10-14 11:34:24, 'Public acceptance of the use of drones for logistics: The state of play and moving towards more informed debate' (2022) [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0160791X22000240.

[20] Y. Zhang and M. Kamargianni, 'A review on the factors influencing the adoption of new mobility technologies and services: autonomous vehicle, drone, micromobility and mobility as a service', Transport Rev., doi: 10.1080/01441647.2022.2119297..

[21] M.J. Page, et al., The PRISMA 2020 statement: an updated guideline for reporting systematic reviews, BMJ 372 (2021) n71, https://doi.org/10.1136/bmj.n71.

[22] H.-F. Hsieh, S.E. Shannon, Three approaches to qualitative content analysis, Qual. Health Res. 15 (9) (2005) 1277–1288, https://doi.org/10.1177/1049732305276687.

[23] T. Miethe, J. Lieberman, M. Sakiyama, E. Troshynski, Public Attitudes about Aerial Drone Activities: Results of a National Survey. ncvc.dspacedirect.Org, 2020 [Online]. Available: https://ncvc.dspacedirect.org/handle/20.500.11990/3448.

[24] C. Lidynia, R. Philipsen, M. Ziefle, in: J. Chen (Ed.), 'The Sky's (Not) the Limit - Influence of Expertise and Privacy Disposition on the Use of Multicopters', Presented at the ADVANCES IN HUMAN FACTORS IN ROBOTS and UNMANNED SYSTEMS, 2018, pp. 270–281, https://doi.org/10.1007/978-3-319-60384-1_26.

[25] M. Eichleay, S. Mercer, J. Murashani, E. Evens, Query date: 2022-10-14 11:34:24, 'Using unmanned aerial vehicles for development: perspectives from Citizens and Government Officials in Tanzania', Durh. USA ICT Works (2016) [Online]. Available: https://www.updwg.org/wp-content/uploads/2019/08/UAV-public-perceptions-tanzania.pdf.

[26] S.T. Kähler, T. Abben, A. Luna-Rodriguez, M. Tomat, T. Jacobsen, An assessment of the acceptance and aesthetics of UAVs and helicopters through an experiment and a survey, Technol. Soc. 71 (102096) (2022), 102096.

[27] L.K. Lin Tan, B.C. Lim, G. Park, K.H. Low, V.C. Seng Yeo, Public acceptance of drone applications in a highly urbanized environment, Technol. Soc. 64 (2021), 101462, https://doi.org/10.1016/j.techsoc.2020.101462.

[28] B. Aydin, 'Public Acceptance of Drones: Knowledge, Attitudes, and Practice', Technology in Society, Elsevier, 2019, https://doi.org/10.1016/j.techsoc.2019.101180.

[29] X. Zhu, T. Pasch, A. Bergstrom, Understanding the structure of risk belief systems concerning drone delivery: a network analysis, Technol. Soc. 62 (2020), https://doi.org/10.1016/j.techsoc.2020.101262.

[30] P. Freeman, R. Freeland, Media framing the reception of unmanned aerial vehicles in the United States of America, no. Query date: 2022-10-14 11:34:24, Technol. Soc. (2016) [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0160791X15300269.

[31] B. Rao, A. Gopi, R. Maione, The societal impact of commercial drones, Technol. Soc. 45 (2016) 83–90, https://doi.org/10.1016/j.techsoc.2016.02.009.

[32] F. Garzia, F. Borghini, A. Castagnolo, M. Lombardi, S. Ramalingam, IEEE, 'Emotional Analysis of Safeness and Risk Perception of Drones during the COVID-19 Pandemic in Italy', Presented at the 2021 INTERNATIONAL CARNAHAN CONFERENCE on SECURITY TECHNOLOGY (ICCST), 2021.

[33] B. Martins, C. Lavallee, A. Silkoset, Drone use for COVID-19 related problems: techno-solutionism and its societal implications, Glob. POLICY 12 (5) (2021) 603–612, https://doi.org/10.1111/1758-5899.13007.

[34] A. Valencia-Arias, P.A. Rodríguez-Correa, J.C. Patiño-Vanegas, M. Benjumea-Arias, J. De La Cruz-Vargas, G. Moreno-López, Factors associated with the adoption of drones for product delivery in the context of the COVID-19 pandemic in medellín, Colombia, Drones 6 (9) (2022), https://doi.org/10.3390/drones6090225. Art. no. 9.

[35] Y. Yao, H. Xia, Y. Huang, Y. Wang, ACM, in: 'Free to Fly in Public Spaces: Drone Controllers' Privacy Perceptions and Practices', Presented at the PROCEEDINGS of the 2017 ACM SIGCHI CONFERENCE on HUMAN FACTORS IN COMPUTING SYSTEMS (CHI'17), 2017, pp. 6789–6793, https://doi.org/10.1145/3025453.3026049.

[36] R. Kellermann, L. Fischer, Drones for parcel and passenger transport: a qualitative exploration of public acceptance, Sociol. TECNOCIENCIA 10 (2) (2020) 106–138, https://doi.org/10.24197/st.2.2020.106-138.

[37] L. Martin, J. Homola, F. Omar, C. Ramirez, K. Jobe, Giving the public a perspective into unmanned aircraft systems' operations, in: 2018 IEEE/AIAA 37th Digital Avionics Systems Conference (DASC), 2018, pp. 1–7, https://doi.org/10.1109/DASC.2018.8569521.

[38] X. Kerasidou, M. Büscher, M. Liegl, 'Don't Drone? Negotiating Ethics of RPAS in Emergency Response', in: International Conference on Information Systems for Crisis Response and Management, 2015 presented at the, https://www.semanticscholar.org/paper/Don't-Drone-Negotiating-Ethics-of-RPAS-in-Emergency-Kerasidou-B%C3%BCscher/a0020f28dded4996a4a4b8ddcb980b63cbc885f8. (Accessed 19 April 2023).

[39] N. Wang, '" We Live on Hope…": Ethical Considerations of Humanitarian Use of Drones in Post-Disaster Nepal', no. Query date: 2022-10-14 11:34:24, IEEE Technol. Soc. Mag., 2020 [Online]. Available: https://ieeexplore.ieee.org/abstract/document/9199335/.

[40] A. Saulnier, S. Thompson, Police UAV use: institutional realities and public perceptions, Polic. An Int. J. Police Strategies Manag. 39 (4) (2016) 680–693, https://doi.org/10.1108/PIJPSM-11-2015-0136.

[41] S. Thompson, C. Bracken-Roche, Understanding public opinion of UAVs in Canada: a 2014 analysis of survey data and its policy implications, J. Unmanned Veh. Syst. 3 (4) (2015) 156–175, https://doi.org/10.1139/juvs-2015-0025.

[42] X. Zhu, Segmenting the public's risk beliefs about drone delivery: a belief system approach, Telematics Inf. 40 (2019) 27–40, https://doi.org/10.1016/j.tele.2019.05.007.

[43] M. Macias, C. Barrado, E. Pastor, P. Royo, IEEE, The future of drones and their public acceptance, in: Presented at the 2019 IEEE/AIAA 38TH DIGITAL AVIONICS SYSTEMS CONFERENCE (DASC), 2019.

[44] A. Rosenfeld, Are drivers ready for traffic enforcement drones? Accid. Anal. Prev. 122 (2019) 199–206, https://doi.org/10.1016/j.aap.2018.10.006.

[45] L.M. PytlikZillig, B. Duncan, S. Elbaum, C. Detweiler, A drone by any other name: purposes, end-user trustworthiness, and framing, but not terminology, affect public support for drones, IEEE Technol. Soc. Mag. 37 (1) (2018) 80–91, https://doi.org/10.1109/MTS.2018.2795121.

[46] R. Clothier, D. Greer, D. Greer, A. Mehta, Risk perception and the public acceptance of drones, Risk Anal. 35 (6) (2015) 1167–1183, https://doi.org/10.1111/risa.12330.

[47] N. Wang, '"We live on hope…": ethical considerations of humanitarian use of drones in post-disaster Nepal', IEEE Technol. Soc. Mag. 39 (3) (2020) 76–85, https://doi.org/10.1109/MTS.2020.3012332.

[48] A. Hardy, et al., Conditional trust: community perceptions of drone use in malaria control in Zanzibar, Technol. Soc. 68 (2022), https://doi.org/10.1016/j.techsoc.2022.101895.

[49] M. de Miguel Molina, V. Santamarina Campos, M.Á. Carabal Montagud, B. de Miguel Molina, Ethics for civil indoor drones: a qualitative analysis, Int. J. Micro Air Veh. 10 (4) (2018) 340–351, https://doi.org/10.1177/1756829318794004.

[50] J. Walther, L. PytlikZillig, C. Detweiler, How people make sense of drones used for atmospheric science (and other purposes): hopes, concerns, and recommendations, Veh. Syst. (2019), https://doi.org/10.1139/juvs-2019-0003. Query date: 2022-10-14 11:34:24.

[51] K. Ahsan, et al., Mobile-Controlled UAVs for audio delivery service and payload tracking solution, IEEE Access 7 (2019) 149672–149697, https://doi.org/10.1109/ACCESS.2019.2944262.

[52] S. Ogilvie, A. McCarthy, W. Allen, A. Grant, Unmanned aerial vehicles and biosecurity: enabling participatory-design to help address social licence to operate issues, Forests, no. Query date (2022). -10-14 11:34:24, 2019, [Online]. Available: https://www.mdpi.com/516570.

[53] E. Serafinelli, 'Imagining the social future of drones', Converg.- Int. J. Res. NEW MEDIA Technol., doi: 10.1177/13548565211054904..

[54] E. Ariyasena, U. Manawadu, K. Abeyratne, P. De Silva, 'Exploring a Ground-Air Personal Space in Human-Drone Interactions', in: Presented at the 2020 INTERNATIONAL CONFERENCE on IMAGE PROCESSING and ROBOTICS (ICIPROB 2020, B. Sudantha, 2020, https://doi.org/10.1109/ICIP48927.2020.9367352.

[55] H.M. Barr, et al., Use, acceptance, and adoption of automated systems with intrinsic and extrinsic motivation based incentive mechanisms, in: 2022 Systems and Information Engineering Design Symposium (SIEDS), 2022, pp. 298–303, https://doi.org/10.1109/SIEDS55548.2022.9799319.

[56] V. Chang, P. Chundury, M. Chetty, ACM, '"Spiders in the Sky": User Perceptions of Drones, Privacy, and Security', in: Presented at the PROCEEDINGS of the 2017 ACM SIGCHI CONFERENCE on HUMAN FACTORS IN COMPUTING SYSTEMS (CHI'17), 2017, pp. 6765–6776, https://doi.org/10.1145/3025453.3025632.

[57] N. Jasim, H. Kasim, M. Mahmoud, Towards the development of smart and sustainable transportation system for foodservice industry: modelling factors influencing customer's intention to adopt drone food delivery (DFD) services, Sustainability 14 (5) (2022), https://doi.org/10.3390/su14052852.

[58] W. Xie, C. Chen, J. Sithipolvanichgul, Understanding e-commerce customer behaviors to use drone delivery services: a privacy calculus view, COGENT Bus. Manag. 9 (1) (2022), https://doi.org/10.1080/23311975.2022.2102791.

[59] H. Ganjipour and A. Edrisi, 'Applying the integrated model to understanding online buyers' intention to adopt delivery drones in Iran', Transport. Lett. Int. J. Transport Res., doi: 10.1080/19427867.2022.2035130..

[60] C. Gevaert, R. Sliuzas, C. Persello, G. Vosselman, Evaluating the societal impact of using drones to support urban upgrading projects, ISPRS Int. J. Geo-Inf. 7 (3) (2018), https://doi.org/10.3390/ijgi7030091.

[61] R. Khan, S. Tausif, A. Malik, Consumer acceptance of delivery drones in urban areas, Int. J. Consum. Stud. 43 (1) (2019) 87–101, https://doi.org/10.1111/ijcs.12487.

[62] R. Rifan, V. Adikariwattage, Evaluation of regulatory gap in UAS operations in Sri Lanka, in: 2018 Moratuwa Engineering Research Conference (MERCon), 2018, pp. 408–413, https://doi.org/10.1109/MERCon.2018.8421959.

[63] N. Wang, Killing two birds with one stone"? A case study of development use of drones, in: 2020 IEEE International Symposium on Technology and Society (ISTAS), 2020, pp. 339–345, https://doi.org/10.1109/ISTAS50296.2020.9462187.

[64] G. Zhang, H. Liang, Y. Yue, IEEE, An investigation of the use of robots in public spaces, in: Presented at the 2015 IEEE INTERNATIONAL CONFERENCE on CYBER TECHNOLOGY IN AUTOMATION, CONTROL, and INTELLIGENT SYSTEMS (CYBER), 2015, pp. 850–855.

[65] J. Hwang, J. Kim, Expected benefits with using drone food delivery services: its impacts on attitude and behavioral intentions, J. Hosp. Tour. Technol. 12 (3) (2021) 593–606, https://doi.org/10.1108/JHTT-05-2020-0123.

[66] N. Wang, M. Christen, M. Hunt, Ethical considerations associated with "humanitarian drones": a scoping literature review, Sci. Eng. Ethics 27 (4) (2021), https://doi.org/10.1007/s11948-021-00327-4.

[67] J. Keller, D.K. Adjekum, B.N.T. Alabi, Measuring public utilization perception potential of unmanned aircraft systems, Int. J. (2018) [Online]. Available: https://commons.erau.edu/ijaaa/vol5/iss3/9/.

[68] S.R. Winter, S. Rice, G. Tamilselvan, Mission-based citizen views on UAV usage and privacy: an affective perspective, Veh. Syst. (2016), https://doi.org/10.1139/juvs-2015-0031.
[69] J. Sanfridsson, et al., Drone delivery of an automated external defibrillator - a mixed method simulation study of bystander experience, Scand. J. Trauma Resuscitation Emerg. Med. 27 (2019), https://doi.org/10.1186/s13049-019-0622-6.
[70] Y. Yao, H. Xia, Y. Huang, Y. Wang, ACM, Privacy mechanisms for drones: perceptions of drone controllers and bystanders, in: Presented at the PROCEEDINGS of the 2017 ACM SIGCHI CONFERENCE on HUMAN FACTORS IN COMPUTING SYSTEMS (CHI'17), 2017, pp. 6777–6788, https://doi.org/10.1145/3025453.3025907.
[71] M. Avila Soto, M. Funk, Look, a guidance drone! Assessing the social acceptability of companion drones for blind travelers in public spaces, in: Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility, , Association for Computing Machinery, New York, NY, USA, 2018, pp. 417–419, https://doi.org/10.1145/3234695.3241019. ASSETS '18.
[72] H. Kong, F. Biocca, T. Lee, K. Park, J. Rhee, Effects of human connection through social drones and perceived safety, Adv. Hum.-Comput. Interact. 2018 (2018), https://doi.org/10.1155/2018/9280581.
[73] J. Li, F. Janabi-Sharifi, Public opinion about the benefit, risk, and acceptance of aerial manipulation systems, Ieee Trans. Hum.-Mach. Syst. 52 (5) (2022) 1069–1085, https://doi.org/10.1109/THMS.2022.3164775.
[74] J. Callanan, et al., Ergonomic impact of multi-rotor unmanned aerial vehicle noise in warehouse environments, J. Intell. Rob. Syst. 100 (3–4) (2020) 1309–1323, https://doi.org/10.1007/s10846-020-01238-5.
[75] J. Nelson, T. Gorichanaz, Trust as an ethical value in emerging technology governance: the case of drone regulation, Technol. Soc. 59 (2019), https://doi.org/10.1016/j.techsoc.2019.04.007.
[76] R. Nicholls, A.T. Martinez, An investigation into the impact of unmanned aerial vehicles on soundscape perception in urban and rural environments, Internoise 263 (6) (2021) 577–588, https://doi.org/10.3397/IN-2021-1570.
[77] A. Torija, R. Nicholls, Investigation of metrics for assessing human response to drone noise, Int. J. Environ. Res. Publ. Health 19 (6) (2022), https://doi.org/10.3390/ijerph19063152.
[78] C. Coulter, K.S. Haring, Good choices: technological and ethical considerations to increase trust in UASs, in: 2020 International Conference on Unmanned Aircraft Systems (ICUAS), 2020, pp. 562–567, https://doi.org/10.1109/ICUAS48674.2020.9213978.
[79] L. Yamin, J. Cauchard, Generative adversarial networks and data clustering for likable drone design, Sensors 22 (17) (2022), https://doi.org/10.3390/s22176433.
[80] A. Graham, H. Kutzli, T. Kulig, F. Cullen, Invasion of the drones: a new frontier for victimization, Deviant Behav. 42 (3) (2021) 386–403, https://doi.org/10.1080/01639625.2019.1678973.
[81] C. Lidynia, R. Philipsen, M. Ziefle, in: P. SavageKnepshield, J. Chen (Eds.), 'Droning on about Drones-Acceptance of and Perceived Barriers to Drones in Civil Usage Contexts', Presented at the ADVANCES IN HUMAN FACTORS IN ROBOTS and UNMANNED SYSTEMS, 2017, pp. 317–329, https://doi.org/10.1007/978-3-319-41959-6_26.
[82] S. Leon, C. Chen, and A. Ratcliffe, 'Consumers' perceptions of last mile drone delivery', Int. J. Logist. Res. Appl., doi: 10.1080/13675567.2021.1957803..
[83] C. Osakwe, M. Hudik, D. Riha, M. Stros, T. Ramayah, Critical factors characterizing consumers' intentions to use drones for last-mile delivery: does delivery risk matter? J. Retailing Consum. Serv. 65 (2022) https://doi.org/10.1016/j.jretconser.2021.102865.
[84] J. Hwang, J. Kim, K. Lee, Investigating consumer innovativeness in the context of drone food delivery services: its impact on attitude and behavioral intentions, Technol. Forecast. Soc. Change 163 (2021), https://doi.org/10.1016/j.techfore.2020.120433.
[85] C. Mittendorf, D. Franzmann, U. Ostermann, Assoc informat syst, 'why would customers engage in drone deliveries?', in: Presented at the AMCIS 2017 PROCEEDINGS, 2017.
[86] C. Chen, S. Leon, P. Ractham, Will customers adopt last-mile drone delivery services? An analysis of drone delivery in the emerging market economy, COGENT Bus. Manag. 9 (1) (2022), https://doi.org/10.1080/23311975.2022.2074340.
[87] M. Sakiyama, T. Miethe, J. Lieberman, M. Heen, O. Tuttle, Big hover or big brother? Public attitudes about drone usage in domestic policing activities, Secur. J. 30 (4) (2017) 1027–1044, https://doi.org/10.1057/sj.2016.3.
[88] L. Belmonte, A. Garcia, R. Morales, J. de la Vara, F. de la Rosa, A. Fernandez-Caballero, Feeling of safety and comfort towards a socially assistive unmanned aerial vehicle that monitors people in a virtual home, Sensors 21 (3) (2021), https://doi.org/10.3390/s21030908.
[89] H. Kwon, J. Kim, Y. Park, Applying LSA text mining technique in envisioning social impacts of emerging technologies: the case of drone technology, Technovation 60–61 (2017) 15–28, https://doi.org/10.1016/j.technovation.2017.01.001.
[90] J. Nelson, T. Grubesic, D. Wallace, The view from above: a survey of the public's perception of unmanned aerial vehicles and privacy, J. Urban (2019), https://doi.org/10.1080/10630732.2018.1551106 no. Query date: 2022-10-14 11:34:24.
[91] J. Famula, D. Pittman, K. Haring, IEEE, Building trust with a mobile application for last-mile commercial drone delivery, in: Presented at the 2022 INTERNATIONAL CONFERENCE on UNMANNED AIRCRAFT SYSTEMS (ICUAS), 2022, pp. 462–467, https://doi.org/10.1109/ICUAS54217.2022.9836198.
[92] J. Ivosevic, E. Ganic, A. Petosic, T. Radisic, Comparative UAV noise-impact assessments through survey and noise measurements, Int. J. Environ. Res. Publ. Health 18 (12) (2021), https://doi.org/10.3390/ijerph18126202.
[93] A. Zwickle, H. Farber, J. Hamm, Comparing public concern and support for drone regulation to the current legal framework, Behav. Sci. Law 37 (1) (2019) 109–124, https://doi.org/10.1002/bsl.2357.
[94] E. Markowitz, M. Nisbet, J. Danylchuk, S. Engelbourg, 'What's that buzzing noise? Public opinion on the use of drones for conservation science', Bioscience 67 (4) (2017) 381–384, https://doi.org/10.1093/biosci/bix003.
[95] K. Sedig, M. Seaton, I. Drennan, S. Cheskes, K. Dainty, Drones are a great idea! What is an AED?" novel insights from a qualitative study on public perception of using drones to deliver automatic external defibrillators, Resusc. PLUS 4 (2020), https://doi.org/10.1016/j.resplu.2020.100033.
[96] A. Alluhaidan, 'Artificial intelligence for public perception of drones as a tool for telecommunication technologies', Comput. Intell., doi: 10.1111/coin.12507..
[97] S. Rice, G. Tamilselvan, S. Winter, Public perception of UAS privacy concerns: a gender comparison, Veh. Syst (2018), https://doi.org/10.1139/juvs-2017-0011 no. Query date: 2022-10-14 11:34:24.
[98] W. Yoo, E. Yu, J. Jung, Drone delivery: factors affecting the public's attitude and intention to adopt, Telematics Inf. 35 (6) (2018) 1687–1700, https://doi.org/10.1016/j.tele.2018.04.014.
[99] H. Eißfeldt, et al., The acceptance of civil drones in Germany, CEAS Aeronaut. J. 11 (3) (2020) 665–676, https://doi.org/10.1007/s13272-020-00447-w.
[100] A. Oltvoort, P. de Vries, T. van Rompay, D. Rosen, '"I Am the Eye in the Sky - Can You Read My Mind?" How to Address Public Concerns towards Drone Use', in: H. OinasKukkonen, K. Win, E. Karapanos, P. Karppinen, E. Kyza (Eds.), Presented at the PERSUASIVE TECHNOLOGY: DEVELOPMENT of PERSUASIVE and BEHAVIOR CHANGE SUPPORT SYSTEMS, PERSUASIVE 2019, 2019, pp. 103–114, https://doi.org/10.1007/978-3-030-17287-9_9.
[101] S. Ibrahim, Swiss army uses drone technology. Should we worry? SWI swissinfo.ch (2022). https://www.swissinfo.ch/eng/business/swiss-drone-technology-used-in-military–should-we-be-concerned–/47681636. (Accessed 27 April 2023).
[102] L. Hudson, C.S. Owens, M. Flannes, Drone warfare: blowback from the new American way of war, Middle East Pol. 18 (3) (2011) 122–132, https://doi.org/10.1111/j.1475-4967.2011.00502.x.
[103] P.B. Tiedemann Katherine, 'The Year of the Drone', Foreign Policy, 2010. https://foreignpolicy.com/2010/04/23/the-year-of-the-drone/. (Accessed 27 April 2023).
[104] J. Marcus, 'Drone Wars: Today's Weapon of Choice?', BBC News, 2015 [Online]. Available: https://www.bbc.com/news/world-34219417. (Accessed 27 April 2023).
[105] Tidy, Ukraine Rapidly Expanding its "Army of Drones" for Front Line, BBC News, 2023 [Online]. Available: https://www.bbc.com/news/technology-65389215. (Accessed 27 April 2023).
[106] D. Sabbagh, A. Mazhulin, '"They're starting to die": fears Ukraine's drone supremacy may soon be over', The Guardian, 2023 [Online]. Available: https://www.theguardian.com/world/2023/apr/10/in-war-there-are-no-emotions-ukraine-drone-squads-bakhmut. (Accessed 27 April 2023).
[107] A.D. Algarni, Drones in the Ukrainian War: Will They Be an Effective Weapon in Future Wars? International Institute for Iranian Studies, 2022 [Online]. Available: https://rasanah-iiis.org/english/centre-for-researches-and-studies/drones-in-the-ukrainian-war-will-they-be-an-effective-weapon-in-future-wars%ef%bf%bc/. (Accessed 27 April 2023).
[108] D. Kunertova, The war in Ukraine shows the game-changing effect of drones depends on the game, Bull. At. Sci. 79 (2) (2023) 95–102, https://doi.org/10.1080/00963402.2023.2178180.
[109] S. Komasova, J. Tesar, P. Soukup, Perception of drone related risks in Czech society, Technol. Soc. 61 (2020), https://doi.org/10.1016/j.techsoc.2020.101252.
[110] M. Heen, J. Lieberman, T. Miethe, The thin blue line meets the big blue sky: perceptions of police legitimacy and public attitudes towards aerial drones, Crim. Justice Stud. Crit. J. Crime Law Soc. (2018), https://doi.org/10.1080/1478601x.2017.1404463 no. Query date: 2022-10-14 11:34:24.
[111] Md N.H. Khan, C. Neustaedter, An exploratory study of the use of drones for assisting firefighters during emergency situations, in: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, New York, NY, USA, 2019, pp. 1–14, https://doi.org/10.1145/3290605.3300502. CHI '19.
[112] J. Buko, M. Bulsa, A. Makowski, Spatial premises and key conditions for the use of UAVs for delivery of Items on the example of the polish courier and postal services market, Energies 15 (4) (2022), https://doi.org/10.3390/en15041403.
[113] E.C. Anania, S. Rice, M. Pierce, S.R. Winter, J. Capps, 'Public Support for Police Drone Missions Depends on Political Affiliation and Neighborhood Demographics', Technology in, Elsevier, 2019 [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0160791X18301878.
[114] M. Lai, D. Liu, W. Tsay, 'Functional Deployment of Drone Logistics', in: T. Meen (Ed.), Presented at the PROCEEDINGS of the 2ND IEEE EURASIA CONFERENCE on BIOMEDICAL ENGINEERING, HEALTHCARE and SUSTAINABILITY 2020 (IEEE ECBIOS 2020): BIOMEDICAL ENGINEERING, HEALTHCARE and SUSTAINABILITY, 2020, pp. 1–4.
[115] FAA, UAS Remote Identification | Federal Aviation Administration, UAS Remote Identification, 2023. https://www.faa.gov/uas/getting_started/remote_id. (Accessed 1 September 2023).
[116] Y. Chen, C. Huang, Smart data-driven policy on unmanned aircraft systems (UAS): analysis of drone users in US cities, SMART CITIES 4 (1) (2021) 78–92, https://doi.org/10.3390/smartcities4010005.

[117] M.-C. Lai, D. Liu, W.-D. Tsay, Functional deployment of drone logistics, in: 2020 IEEE 2nd Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability (ECBIOS), 2020, pp. 1–4, https://doi.org/10.1109/ECBIOS50299.2020.9203635.
[118] M. Duncan, K. Culver, Technologies, ethics and journalism's relationship with the public, Media Commun. 8 (3) (2020) 101–111, https://doi.org/10.17645/mac.v8i3.3039.
[119] M. Milner, S. Rice, S. Winter, E. Anania, The effect of political affiliation on support for police drone monitoring in the United States, J. Unmanned Veh. Syst. 7 (2) (2019) 129–144, https://doi.org/10.1139/juvs-2018-0026.
[120] How to evolve autonomous robots: different approaches in evolutionary robotics, in: S. Nolfi, D. Floreano, O. Miglino, F. Mondada (Eds.), Artificial Life IV: Proceedings of the 4th International Workshop on Artificial Life, MIT Press, MA, 1994.
[121] D. Floreano, J. Urzelai, 'Evolutionary robots with on-line self-organization and behavioral fitness', Neural Netw. Off, J. Int. Neural Netw. Soc. 13 (4–5) (2000) 431–443, https://doi.org/10.1016/s0893-6080(00)00032-0.
[122] F. Mondada, et al., Swarm-bot: a new distributed robotic concept, Aut. Robots 17 (2) (2004) 193–221, https://doi.org/10.1023/B:AURO.0000033972.50769.1c.
[123] admin, The case against humanitarian drones, Open Canada (2012). https://opencanada.org/the-case-against-humanitarian-drones/. (Accessed 19 April 2023).
[124] K.B. Sandvik, K. Lohne, 'The Promise and Perils of "Disaster Drones"', Humanitarian Practice Network, 2013. https://odihpn.org/publication/the-promise-and-perils-of-disaster-drones/. (Accessed 19 April 2023).
[125] A. Choi-Fitzpatrick, Drones for good: technological innovations, social movements, and the state, no. Query date: 2022-10-14 11:34:24, J. Int. Aff. (2014) [Online]. Available: https://www.jstor.org/stable/24461704.
[126] K.B. Sandvik, K.L. Jacobsen, S.M. McDonald, Do no harm: a taxonomy of the challenges of humanitarian experimentation, Int. Rev. Red Cross (2017). http://international-review.icrc.org/articles/do-no-harm-taxonomy-challenges-humanitarian-experimentation. (Accessed 19 April 2023).
[127] I. van de Poel, Embedding values in artificial intelligence (AI) systems, Minds Mach. 30 (3) (2020) 385–409, https://doi.org/10.1007/s11023-020-09537-4.
[128] I. van de Poel, Design for value change, Ethics Inf. Technol. 23 (1) (2021) 27–31, https://doi.org/10.1007/s10676-018-9461-9.
[129] G. van de Kaa, J. Rezaei, B. Taebi, I. van de Poel, A. Kizhakenath, How to weigh values in value sensitive design: a best worst method approach for the case of smart metering, Sci. Eng. Ethics 26 (1) (2020) 475–494, https://doi.org/10.1007/s11948-019-00105-3.
[130] I. van de Poel, T. de Wildt, D. van Kooten Pássaro, COVID-19 and changing values, in: M.J. Dennis, G. Ishmaev, S. Umbrello, J. van den Hoven (Eds.), Values for a Post-Pandemic Future, Philosophy of Engineering and Technology, Springer International Publishing, Cham, 2022, pp. 23–58, https://doi.org/10.1007/978-3-031-08424-9_2.
[131] B. Taebi, M. van Asselt, I. van de Poel, Multilateral governance of technological risks; editors' overview 1, J. Risk Res. 25 (8) (2022) 941–944, https://doi.org/10.1080/13669877.2022.2104345.
[132] L. Cavalcante Siebert, et al., Meaningful human control: actionable properties for AI system development, AI Ethics 3 (1) (2023) 241–255, https://doi.org/10.1007/s43681-022-00167-3.
[133] A. van Wynsberghe, T. Comes, Drones in humanitarian contexts, robot ethics, and the human–robot interaction, Ethics Inf. Technol. 22 (1) (2020) 43–53, https://doi.org/10.1007/s10676-019-09514-1.
[134] R. Owen, M. Pansera, Responsible innovation and responsible research and innovation, in: Handbook on Science and Public Policy, Edward Elgar Publishing, 2019, pp. 26–48 [Online]. Available: https://www.elgaronline.com/display/edcoll/9781784715939/9781784715939.00010.xml. (Accessed 27 April 2023).
[135] P.J. Craigon, et al., Ethics by design: responsible research & innovation for AI in the food sector, J. Responsible Technol. 13 (2023), 100051, https://doi.org/10.1016/j.jrt.2022.100051.
[136] K.H. Keskinbora, Medical ethics considerations on artificial intelligence, J. Clin. Neurosci. 64 (2019) 277–282, https://doi.org/10.1016/j.jocn.2019.03.001.
[137] N. Wang, As it is africa, it is ok"? Ethical considerations of development use of drones for delivery in Malawi, IEEE Trans. Technol. Soc. 2 (1) (2021) 20–30, https://doi.org/10.1109/TTS.2021.3058669.