

# Urban Crowdsourcing Platforms across the World: A Systematic Review

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Urban crowdsourcing platforms are becoming increasingly important, especially considering the relevance of citizen-centricity in smart cities. This systematic review aims at analysing existing academic literature on urban crowdsourcing platforms to gather citizen-generated data, and shed light on the state of research and development of these tools. Studies describing data-gathering urban crowdsourcing platforms were selected following the PRISMA protocol, for a total of 30 studies, corresponding to 32 platforms. After analysing the studies at large, this review then proceeds to examine and catalogue the platforms, focusing on their location, purpose, and public data availability. While providing valuable information on existing platforms, the catalogue is subject to different types of bias, including a geographical one, which derive primarily from the chosen methodology to identify platforms worldwide. The paper also discusses the implications of such choices.

CCS Concepts: • **General and reference** → **Surveys and overviews**; • **Information systems** → **Collaborative and social computing systems and tools**; **Crowdsourcing**; • **Applied computing** → **Computing in government**.

Additional Key Words and Phrases: Urban Crowdsourcing, Citizen Sourcing

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## 1 INTRODUCTION

Crowdsourced data generated by citizens has become increasingly relevant for the development of so-called smart cities: data availability is paramount to the functioning of a city, and therefore platforms allowing to collect data generated by people represent a key element in the transition towards more citizen-centric cities [9]. The concepts of citizen sourcing and urban crowdsourcing are becoming particularly relevant for the public sector, as local, state, and national governments have promoted projects and made use of this kind of platforms in the past decade [27]. Citizen-generated data platforms can be very useful as part of the digital transformation of certain processes in cities, as they can be an efficient and effective way to gather urban data to ultimately improve citizen-oriented services [13].

However, both the notion of urban crowdsourcing and citizen sourcing are blurry, without having a unique definition. Hilgers and Ihl describe citizen sourcing as *"The design and configuration of a new relationship between*

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a government and its people, based on a set of emerging practices and principles applied from the private sector" [20], while Linders considers it to be "*Citizens' support of government to increase its responsiveness and effectiveness*" [26]. The domain of what can be referred to as urban crowdsourcing is quite broad, and encompasses a broad range of applications, including urban mobility, participatory budgeting, and urban reporting [33]. It is possible to classify urban crowdsourcing into two macro-areas: *citizen participation*, in which citizens take a more active role, proposing new ideas and projects for the city or taking part in participatory budgeting initiatives; and *data gathering*, whereby the main role of citizens is to communicate (more or less actively) certain types of data to the platform for various purposes. This paper will focus on the latter [39].

**The relevance of a literature review.** Having considered the importance of urban crowdsourcing in the context of the transition to smart cities, it is important to map existing research on the broader topic of data and crowdsourcing in the city. Several papers with this general goal exist in the literature. Niu and Silva [33] conducted a systematic review of studies concerning methods for data mining for crowdsourced data in urban contexts, highlighting both the diversity and heterogeneity of the crowdsourced data that can be used for different types of analyses (including tweets, images, and geographic information), as well as the broad range of applications that urban crowdsourcing can have. Costa and Teixeira [9] carried out another systematic review of the ways that applications for smart cities can be developed and empirically tested. Liao et al. [25] explored how crowdsourcing methods can be utilized for urban planning. Pereira et al. [35] analysed tools and initiatives to increase citizen participation in cities. Finally, Marzano et al. [29] conducted a review of studies describing crowdsourcing-based methods and initiatives for the purpose of urban mobility.

One aspect that remains open is the systematic examination of the existing scholarly research that directly describes *platforms for urban crowdsourcing*. The goals of this systematic review are to analyse studies directly concerning urban crowdsourcing platforms whose main purpose is data gathering (rather than increasing citizen participation); compile a catalogue of them; and conduct a comparative analysis around relevant dimensions, including geographic distribution, specific platform purposes, and availability of platform data for possible further use. The analysis also highlights a number of biases that researchers in the smart city domain need to be aware of. Overall, our review contributes to a more coherent understanding of the current state of affairs, reveals key trends in urban crowdsourcing platforms, and identifies topics of future interest.

The paper is organized as follows. Section 2 describes the methodology and sources used in the review. Section 3 presents our analysis of the literature from a study-centric perspective. Section 4 extends the analysis of the literature from a platform-centric perspective. Section 5 discusses limitations encountered as well as future directions. Section 6 offers final remarks.

## 2 METHODS AND SOURCES

### 2.1 Methodology and Study Identification

This systematic review follows the PRISMA Statement for systematic reviews [30], and it is entirely based on a database search. The scientific databases that have been considered are Elsevier's Scopus<sup>1</sup>, the Social Science Research Network (SSRN)<sup>2</sup>, Wiley Online Library<sup>3</sup>, ACM Digital Library<sup>4</sup>, and IEEE Xplore<sup>5</sup>. For the purpose of this analysis, solely peer-reviewed academic articles retrievable in academic databases have been taken into account. Mendeley<sup>6</sup> has additionally been used as software for the removal of duplicate articles. All records were retrieved in October 2021.

<sup>1</sup><https://www.scopus.com/>

<sup>2</sup><https://www.ssrn.com/>

<sup>3</sup><https://onlinelibrary.wiley.com/>

<sup>4</sup><https://dl.acm.org/>

<sup>5</sup><https://ieeexplore.ieee.org/>

<sup>6</sup><https://www.mendeley.com/>

Given that this article aims at analysing the current state of urban data gathering, urban crowdsourcing and citizen sourcing platforms in the world, for all the aforementioned databases a search has been performed using *data* and either *urban crowdsourcing* or *citizen sourcing* as filtering keywords. Subsequently, all the articles containing this combination of keywords in either their title or abstract have been retrieved for initial screening.

For a study to be selected for inclusion, the following eligibility criteria were used:

- (1) Be an academic and peer-reviewed article.
- (2) Be written in English.
- (3) Contain at least a short description of an urban crowdsourcing platform that would adhere to the eligibility criteria for platforms, which are described in Table 1.

<b>PLATFORM</b>	It is about (or it describes) a platform (at least one).
<b>IMPLEMENTED</b>	It has to be a permanent infrastructure, not an academic project or proposal.
<b>URBAN</b>	It is focused on one (or more) specific urban areas.
<b>LOCAL</b>	It is either managed or officially endorsed by a local government, or developed by a local organization with a strong relationship with a city.
<b>DATA GATHERING</b>	There needs to be the ability to generate reports from the gathered data; users need to be actively involved/informed of the data gathering procedure.

Table 1. Eligibility Criteria for Platforms

During the screening procedure, every article has been examined, and it has been checked whether it described a platform satisfying all the five criteria in Table 1. These criteria were applied sequentially, and will be explained and justified in more detail in section 2.2.

## 2.2 Eligibility Criteria for Platforms

Considering the broad diversity of platforms and applications that can be referred to as *urban crowdsourcing platforms*, it was necessary to define more strictly which kinds of platforms could be considered for this study. More specifically, it was important to identify aspects that could potentially lead to ambiguity regarding inclusion; these were identified as the following:

- (1) **Type and Purpose:** The first step consisted in defining what would count as a *citizen sourcing* or *urban crowdsourcing platform* for the purpose of this study. In fact, such definitions are not necessarily clear, as they could encompass city government’s websites incorporating basic data gathering (such as feedback and contact forms) and independent websites and apps with no connection whatsoever to a city. With respect to this point, it was also to be determined whether to include applications such as instant messaging apps or social networks that are used by city governments to connect with citizens. Moreover, it was also necessary to consider the scope of the platforms to be included, and whether to restrict the study to only certain scopes (such as mobility, urban reporting, citizen participation, or socialization).

Given the macro-level differentiation between citizen participation and data gathering platforms for urban crowdsourcing (see section 1), for the purpose of this paper we will only consider those whose main purpose is to obtain data generated by citizens (and citizens need to be voluntarily contributing to these data collection efforts). Hence, a platform will be eligible for this study if it permits to generate reports of the data obtained from citizens.

- (2) **Official Status and Link to the City:** Another important aspect to consider is the link that the platform should have with the city, and also how to define a city: whether it should be strictly a municipality or an urban area, and whether this area needs to exceed a certain population threshold. In any case, as argued by

Crooks et al., the peculiarity of urban crowdsourcing platforms is the way that they integrate with and complement the complex urban landscape, which includes physical, digital, and human aspects [10]. Given that this study solely focuses on platforms analysed in the academic literature, it was not deemed necessary to impose a minimum population. Nonetheless, only those platforms that have a specific connection to one or more cities (or urban areas) will be considered in the review, as the review is aimed to analyse *urban* crowdsourcing.

In addition to this, it is also necessary to define the official status of the platform, as it could be officially adopted or endorsed by the city government, or have no relationship with it whatsoever, i.e., without any specific connection to the local administration. In order to exclude those platforms not having any relationship with a specific city despite their urban nature (such as Waze, the mobility app), this review will only include platforms that are either adopted or endorsed by a local government, or that are developed by groups with a strong connection to the city (without necessarily having any official relations with the city administration).

- (3) **Nature and Current State of the Platform:** Finally, besides its purpose, it is also essential to consider the nature of the platform, and its creators: whether it is aimed at being a long-term infrastructure supported by the city, or a purely academic project with minimal features, such as a research prototype. For this review, platforms developed for purely academic and research purposes will be considered as out of the scope of the analysis. To be taken into account, platforms need to have been practically implemented and functioning, hence beta-tests and prototypes cannot be considered. Nonetheless, discontinued or dormant platforms may be included in the review, provided that they satisfy the other eligibility criteria.

### 2.3 Data Collection and Synthesis

Once the studies to be included in the review have been selected, it is necessary to extract the data for analysis. In this paper, two different analyses will be conducted: the first will cover directly the articles that have been identified, exploring how papers approach the analysis of the different platforms. Subsequently, there will be a second analysis, focusing on the identified platforms.

Besides collecting the basic bibliographical data on the papers and the platform(s) they describe, this review considers the approach that each of the articles adopts to analyse the platform, which is classified as either primarily **qualitative** or **quantitative**. Moreover, since for a study to be eligible for inclusion it is sufficient that it contains a short description of a platform abiding by the criteria in Table 1, studies are also divided in three categories, according to the relevance that the platform takes within each study, to discern whether (1) it is at the core of the study; (2) it describes the platform in one paragraph (or more); and (3) it describes it only briefly.

After this step, for each of the studies, the data on the platform is collected. These include the main characteristics indicated in Table 2.

Subsequently, the data collected from each of the studies and platforms will be aggregated, to extract general considerations and trends. Furthermore, one of the main objectives of this study is to compile a catalogue of urban crowdsourcing platforms featured in previous academic studies, which will be analysed in section 4.

## 3 RESULTS: STUDY-CENTRIC ANALYSIS

### 3.1 Study Selection

In this section, we consider the papers selected by following the PRISMA framework and methodology, described in section 2.1. Figure 1 shows the flowchart of all the records that have been identified, screened and selected during this process. After the initial database search with the keywords *urban crowdsourcing* OR *citizen sourcing*, AND *data*, a total of 1688 records have been identified. After the removal of duplicates, these were reduced to 1488, which were later screened. A further 1193 records have been excluded on the basis of their title and abstract

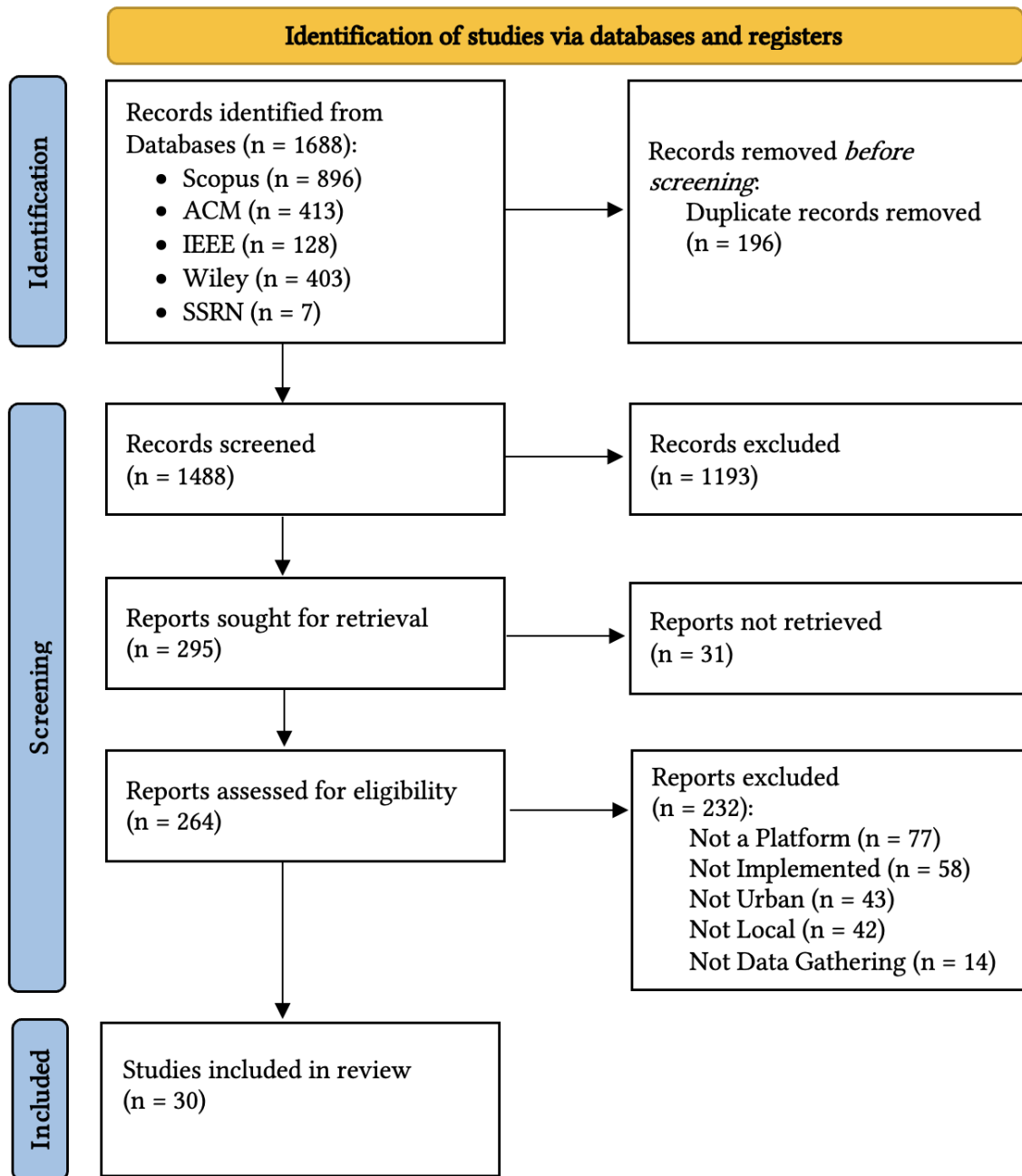


Fig. 1. Flow diagram of identification of eligible articles for review.

<b>Name</b>	Official name of the platform, in the original language (untranslated).
<b>Website</b>	URL to the official website.
<b>City</b>	City in which it is based. This strictly depends on the description as given by the study to which it corresponds.
<b>Country and Continent</b>	Country and continent, to identify the main location of each platform.
<b>Purpose</b>	Main purpose of the platform. Four main categories have been selected: Urban Reporting, Mapping, Mobility, and Other.
<b>Availability of Data</b>	This indicates whether it is possible to publicly access the data collected by the platform, and if so, how to access it.
<b>Format of the Data</b>	When it is possible to download the data, this corresponds to the format in which the datasets are obtained (e.g. JSON, CSV).
<b>Data Retrieval</b>	When the data can be downloaded, this indicates how it is possible to access the data, which is generally either via API or direct dataset download.
<b>License</b>	The license used to distribute the data - whether it is a proprietary dataset, part of the public domain, or distributed with an open data license.
<b>Privacy</b>	Information on whether or not any personal data from users are stored on the platform, and whether the datasets are publicly available.

Table 2. Data collected with respect to each platform mentioned in the selected studies.

as they did not satisfy the eligibility criteria, which led to 295 studies being sought for retrieval. Of these, 264 were actually retrieved. At this point, each article was checked to verify whether it was describing one or more eligible platforms. The exclusion criteria were applied sequentially, meaning that if an article did not describe any platform, it was immediately excluded, otherwise, the assessment went on, checking whether the platform had been actually implemented, and so on. Ultimately, 30 studies were selected for inclusion in this review, as can be seen in Figure 1. The full list of studies is included in Appendix I, Table 4.

### 3.2 Description and Analysis of Selected Studies

In this review, only peer-reviewed studies published in English have been considered. From a temporal point of view, articles span a decade, as can be seen in Figure 2, with the oldest one being written in 2011. This shows how the topic of urban crowdsourcing has been increasingly emerging in the past years, and especially since the mid-2010s. This increased academic interest in the area could be attributed to the increasing number of urban platforms worldwide.

As part of the eligibility criteria, each of the articles describes at least one urban crowdsourcing platform, but some articles describe or mention more than one platform. For example, Aguilera et al. [2] describe two different platforms in Spain, the Complaint and Suggestions portal of the city of Zaragoza, and the *Bicicas*, a mobility platform of the city of Castellón.

As mentioned in section 2.3, all articles are classified as *quantitative* or *qualitative*, depending on the main methodology used to describe and analyse the platform. A study is considered quantitative if it contains a detailed quantitative analysis of the platform, considering aggregate statistics and usage data; otherwise, the approach is classified as qualitative, meaning that the description or analysis of the platform is purely descriptive or qualitative – this can range from a short description to a longer analysis. Overall, 22 of the selected articles adopted a qualitative approach, while only 8 were quantitative analyses. This highlights a relative scarcity of peer-reviewed papers that contain in-depth quantitative analyses of urban crowdsourcing platforms.

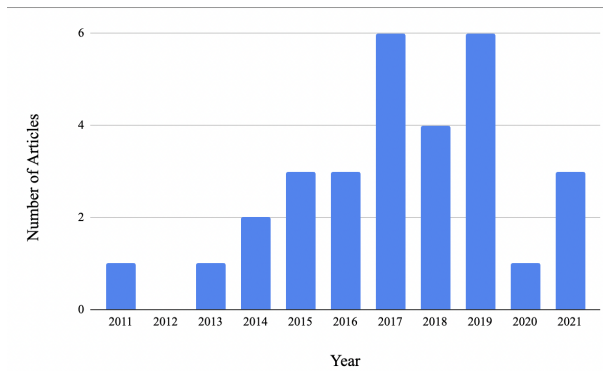


Fig. 2. Studies included in the review by year of publication (*number of platforms = 32*)

Subsequently, the studies were also divided into three other categories to highlight the relative importance that the platform(s) referred to by each article had with respect to the article itself:

- (1) **Articles whose primary focus is a platform:** These are the articles whose primary focus is the description and analysis of the platform itself, independently of the specific type of analysis that was conducted. In these cases, the name and purpose of the platform are clearly stated in the abstract. Overall, there are 15 of these articles in the sample, corresponding to exactly half of the total.
- (2) **Articles whose secondary focus is a platform:** In these cases, the primary focus of the study is not the description or analysis of the platform *per se*, but the platform is still an important and relevant part of the article. In these papers, at least one paragraph is dedicated to the described platform, which often acts as a case study or example from which other conclusions are drawn. A total of 11 articles belong to this group, making up 36% of the full sample.
- (3) **Articles mentioning a platform:** These are articles that only shortly describe a platform, using a few sentences, and usually as an example, or in the description of existing research. A total of 4 of the identified studies correspond to this group, i.e. 13% of the sample.

It is also possible to observe a connection between the relative importance of the platform and the type of analysis, as illustrated by Table 3. In fact, of the 8 studies that adopt a quantitative analysis, 6 are entirely about the platform that they are describing. This observation is also quite intuitive, as a quantitative analysis can be considerably more intensive and longer than a simple description of the platform. Similarly, this is the reason why all the studies that simply *mention* a platform are classified as adopting a qualitative approach.

	Primary Focus	Secondary Focus	Mentioning Platform
Qualitative	8	9	5
Quantitative	6	2	0

Table 3. Studies included in the review divided by the approach towards the platform (*number of articles = 30*)

Finally, it is also important to analyse the main thematic area on which each article is focused, especially in the case of the articles that are not centred on the description of the platform. Articles have been grouped into 5 main areas, which identify the main research goal of each publication. These are:

- (1) **Urban Crowdsourcing and Smart Cities:** These studies analyse the topic of urban crowdsourcing and smart cities at large. They are mainly about different aspects of the management of data at the urban level, explaining in different ways how a city can be improved with the help of urban crowdsourcing platforms.
- (2) **Urban Crowdsourcing Platform:** This refers to articles whose primary focus is a specific urban crowdsourcing platform, meaning that the article is mainly about the corresponding platform(s) included in Table 6.
- (3) **Urban Mobility:** The main topic of these papers is to describe strategies for improving mobility at the urban level, often with the use of digital tools and data models.
- (4) **Research Prototype:** These describe primarily a research prototype (i.e., an application that has been developed solely for academic purposes). Such platforms have not been considered in this study and are therefore not included in Table 6, as they are excluded by the eligibility criteria in table 1. Nonetheless, the articles have been taken as part of the analysis whenever they mention other platforms that do satisfy the eligibility criteria.
- (5) Then, there are other types of articles, with only one occurrence per thematic area, which have been labelled as *others*. These comprise urban planning, flood management, an analysis of noise, privacy and an ethnographic analysis.

The results of this analysis are also included in Appendix I, Table 4. Only 8 out of the 30 papers directly address the topic of an urban crowdsourcing platform as their core.

## 4 RESULTS - PLATFORM-CENTRIC ANALYSIS

### 4.1 Platforms from Selected Studies

We now move to the platform-centric analysis, which considers platforms described by and identified from the studies included in the review. The 30 studies mentioned in section 3.1 correspond to a total of 32 platforms, shown in Table 6 in Appendix II. All these platforms match the criteria explained in section 2.2, meaning that they are all permanent platforms with a strong connection to a specific city (either because of a city government's official endorsement, or because the platform is managed with a specific focus on a certain city), and aimed at obtaining citizen-generated data.

Most of these platforms are specific to a city, which gives them a strong local connotation. However, there are also certain platforms present in more cities; these have been included in the review, as they corresponded to the eligibility criteria. These platforms, such as FixMyStreet, have an international reach and might not be specific to one single city, but always have a relation with local authorities, making them satisfy the criteria. In these cases, multiple entries may be present for the same platform: one entry for the platform as a whole, which may be classified as an *international* platform, and one for each of the city-specific versions of the platform which are present in the selected studies. Therefore, the combination of platform and city is unique. In other words, the same platform can appear multiple times, in relation to multiple cities, and the same city might appear multiple times with different platforms – such as in the case of Boston, which appears two distinct times.

The platforms are then classified into one of four main categories, to identify their main scope. These are:

- (1) **Urban Reporting:** This category refers to those that allow users to report to the city administration or local authorities whether there are issues with the city that need to be addressed. Some examples are potholes, garbage, or broken public objects that need to be collected or fixed by the government.
- (2) **Mapping:** Platforms that fall into this group aim at creating maps with data generated and/or provided by the users. Maps can either be general-purpose maps, especially in cases where accurate and up-to-date maps are difficult to obtain or non-existent; or specific maps aimed at highlighting certain events or areas.
- (3) **Mobility:** This category refers to platforms aimed at using crowdsourced data to improve mobility within the city, either with public or private transportation.



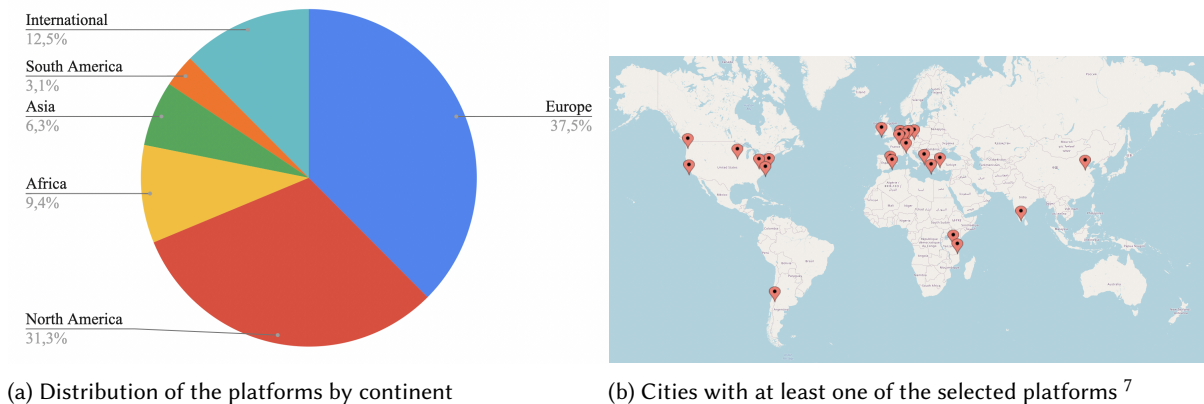


Fig. 3. Geographical distribution of platforms (*number of platforms = 32*)

(4) **Others:** All other platforms would fall into this category.

Finally, an important piece of information that has been considered is the availability of data to the public. This has been divided into three macro-categories: *Fully Available*, when all the data obtained by the platform can be freely accessed on the web; *Partly Available*, when the data can be obtained with limitations - in most cases this is because it is necessary to make a request to the platform owners or managers in order to access the data; and *Not Available*, when the data cannot be accessed by unauthorized individuals, and there is no specified procedure to inquire or ask for the data. This will be further discussed in section 4.4.

## 4.2 Geographical Distribution

We now proceed to analysing the platforms included in Table 6. As shown in Figure 3a, the platforms are very unevenly distributed geographically, as around 70% of all the platforms included in the studies are either in Europe or North America. In addition to this, around 10% of the platforms have been classified as *international*, meaning that they do not refer to any specific city, but are present in many countries spanning different continents; examples of these are the mapping and urban reporting platform Ushahidi, or SeeClickFix, also used for urban reporting. Therefore, there is a high level of geographic imbalance in this platform catalogue. While this could be in part an indicator of the fact that urban crowdsourcing platforms are more often developed in North America or Europe, it is also in part attributable to a selection bias derived from the fact that the platforms have been selected solely from academic studies written in English.

This imbalance can also be seen in Figure 3b, which shows all the cities in which there is at least one urban crowdsourcing platform identified from the studies. In fact, of all the platforms, 10 of them are based in the United States, corresponding to about 30% of the total, with 2 platforms in Boston. At the same time, only three platforms are based in Africa, two in Asia, and only one in South America. On the other hand, the geographical distribution of platforms within Europe is moderately more even.

## 4.3 Purpose of the Platform

As explained in section 4.1, all platforms were assigned to one or more of four macro-categories that indicate the main platform scope: urban reporting, mapping, mobility, and other.

As seen in Figure 4, the most popular category is that of **urban reporting**.

<sup>7</sup>Source for the map: <https://www.mapcustomizer.com/>

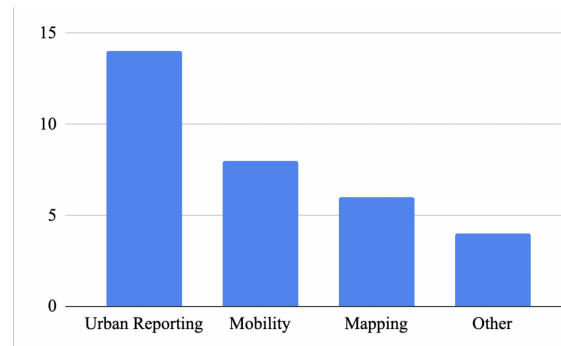


Fig. 4. Number of platforms for each of the purposes ( *number of platforms = 32* )

This is an indication of the relevance and popularity of urban reporting platforms, which create a direct connection between citizens and city government.

Some of these platforms are programmed and maintained by companies that provide the same platform to different city governments, such as *SeeClickFix* or *FixMyStreet*, while others are integrated within the main city website, like *Zaragoza Quejas y Sugerencias* (*Zaragoza Complaints and Suggestions*), or Vancouver's *311* service. In any case, a common characteristic of urban reporting platforms is that there is always a connection with the local government, an administrative office, or an official agency, so that the city can intervene to solve the problems that are reported by citizens.

A second group is that of **mapping platforms**, whose main goal is to utilize the provided data to generate or improve maps. Within this category, we can observe different types of platforms: Map Kibera and Dar Ramani Huria, based in Nairobi and Dar Es Salaam, respectively, aim at using citizen's volunteered geographic information to create maps of certain neighbourhoods that, because of irregular housing and poor official reporting, are poorly mapped in official maps. On the other hand, apps like Reusing Dublin or Hush City in Berlin, use data generated by users to map certain areas of particular interest within the city (such as vacant properties in the former case, or quiet areas in the latter).

A third category of platforms for **mobility**, whose main purpose is to improve mobility within the city. These are also of different types: for example, IBB CepTrafik in Istanbul uses citizens' data to provide the real-time state of traffic, while other platforms like Tiramisu Transit in Pittsburgh use the users' data to monitor the state of public transportation.

Finally, there are the platforms classified as **other**, which did not fit into the previous categories. The purposes of these platforms include flood management, smell detection, or noise detection.

One general consideration to make is that, in different forms, platforms from all the four aforementioned categories contain a geo-localization aspect: nearly the totality of the analysed platforms contain, to some extent, geographic information. For example, in the case of urban reporting, this corresponds to the location of the problem that needs to be solved, while in an application for smell detection like Smell Pittsburgh, the map is a fundamental component of the platform.

#### 4.4 Availability of Data

The public availability of data is another important aspect of urban crowdsourcing platforms, as publicly available datasets enable research, innovation, and transparency. Table 6 indicates to which extent the data is available, dividing platforms into three macro-categories:

- (1) For platforms with **fully available data**, all data generated by the users and gathered by the platform can be accessed online via the official website of the platform, or with the use of APIs. The formats in which the data can be obtained, accessed, or downloaded differ across platforms. In certain cases, such as in Budi Odgovoran, based in Podgorica, all data are accessible on the website, but not directly downloadable, so the data could be scraped from the website in order to be downloaded. Most platforms directly allow downloading a dataset or accessing it via API.
- (2) Platforms are categorized as having **partly available data** when the data generated by users is not entirely or directly accessible. In most cases (7 out of 10 of partially available data), this is because it is necessary to contact the platform managers in order to obtain access to the data or to the API keys necessary to download the data. This definition also applies to international platforms whereby each individual deployment has the right to administer the data independently, as in the case of Ushahidi or FixMyStreet. A different case is that of Dar Es Salaam-based Dar Ramani Huria, where the data is indicated as partly available because some of the download links were not functioning at the time of writing this review, meaning that it is necessary to contact the organization to access the data.
- (3) The rest of the platforms do not grant access to the data, and are labeled as having **not available data**. These can occur for two reasons: either the platform has been discontinued and the dataset is no longer available (such as in the case of BeCity), or the managers of the database do not allow for unauthorized individuals to download the data.

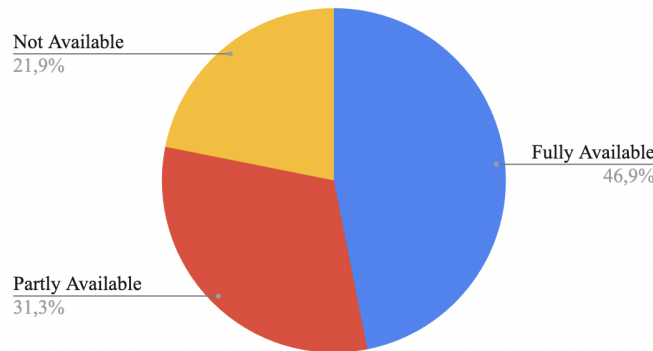


Fig. 5. Platforms divided into macro-categories by availability of data (*number of platforms = 32*)

As seen in Figure 5, close to half of the platforms fall within the category of Fully Available data, followed by those classified as containing partly available data. Table 6 includes detailed information on the availability of the data of each platform, including the links from which it is possible to access data. It also shows which data can be accessed via API and which can be downloaded, as well as the format of the data that can be downloaded.

A majority of the analysed applications allow obtaining JSON data, while other popular data formats are CSV and XML. Moreover, most platforms with publicly available data have APIs that can be used for queries.

#### 4.5 Licensing and Privacy

We can observe that the large majority of the platform managers have made the decision to distribute the data collected with open data licenses of different types, meaning that anybody can make use of the data under certain conditions. There are a few exceptions, which coincide with platforms that do not share their data publicly, and

which retain all the rights over the datasets, requiring any potential data user to sign confidentiality agreements to use the data, thereby preventing redistribution.

Finally, we notice that all the applications taken into consideration in this study have a strict privacy policy in the way that they handle personal data. It is noteworthy to point out a divide between platforms that store users' personal data for log purposes (even though these data are not publicly distributed, but only an anonymized version of the datasets is made available), while others do not store any personal data in the first place. Generally, larger and more well-established platforms will tend to store and process data such as the name, email address, and phone number of the users.

## 5 DISCUSSION

### 5.1 General Trends

Overall, while there is a certain diversity both across studies and platforms, there are certain characteristics that are commonly shared. First and foremost, the urban connotation is reflected in the fact that all the selected platforms rely, at least partly, on location and geographic data. This aspect highlights the strong link that exists between data-gathering urban crowdsourcing platforms and cities themselves, showing how they can generally be used as data sources for understanding the behaviour of citizens with respect to the urban context of interest to the platform/city. Therefore, considering that the majority of the selected platforms had all their data publicly available, these platforms offer a potentially significant data source for a broad range of applications, which could span from research on citizens' urban reporting habits to informing policymaking actors.

### 5.2 Limitations.

While this review has given insights into existing data-gathering urban crowdsourcing platforms, it has certain limitations. First, the only included platforms were those on which academic studies in English had been conducted. While this choice was useful to understand the current state of urban crowdsourcing academic research, it also introduces bias, which is particularly evident when looking at their geographical distribution. As described in section 4.2, the selected studies primarily referred to platforms based in cities in North America and Europe: this phenomenon is likely partly caused by a language bias, as only studies published in English were considered, thus possibly discarding papers that could have been included in the review but were written in a different language [24]. Language bias is particularly relevant for this research because of the importance of geo-localization of the platforms, which is directly related to culture and language. Furthermore, besides the inaccessibility of relevant research in different languages, there is also another problematic issue: the possible non-existence or scarcity of research on platforms in certain regions, compared to others.

Given the type of literature selection that was carried out, it is not possible to determine exactly why so few platforms were identified in Asia, Africa, and South America, although the results show that there might be lack of research, lack of research in English, or lack of urban crowdsourcing platforms in these regions, or a combination of these factors [17]. The inability to clearly establish the main drivers of the existing geographical bias is another limitation of the current analysis. In fact, the definition of urban crowdsourcing platform for data gathering that was adopted in this paper might not be relevant in certain countries, e.g., under authoritarian regimes, whereby there might be an absence or quasi-absence of data protection laws, leading to the possibility of government and other agents to exploit other user-generated data more freely, without the need for these platforms.

A further point relates to the selection of keywords for the identification of studies in scientific databases. Given that the concepts of citizen sourcing and urban crowdsourcing are relatively vaguely defined, and not all researchers utilize unequivocally these concepts in their work [32], this review might have possibly failed to identify a number of studies that would otherwise have satisfied the eligibility criteria for inclusion. This potential

limitation in the identification phase of the study selection process is related to the lack of clarity regarding the concept of *urban crowdsourcing*. Hence, it is not simple to determine a compact yet precise list of words that could be used for another database search, without having an exceedingly large number of results.

Finally, this review classified studies into the broad categories of *quantitative* and *qualitative*, or *primary focus on a platform*, *secondary focus on a platform*, and *mentioning a platform*. While this classification certainly simplified the process, grouping all articles into two and three categories tends to flatten them, possibly failing to capture certain nuances. This also applies to the second part of the analysis, which focused on the platforms themselves: trying to obtain some general characteristics that could be applied to all the entries might have resulted in oversimplification, therefore increasing the risk of overlooking potentially important aspects and features.

### 5.3 Directions for future work

First, as mentioned in the previous section, our analysis may have been limited by certain choices with respect to the selection of articles. Future work could broaden the systematic review so that a larger range of keywords is utilized to identify relevant studies from scientific databases, such that additional studies that do not directly refer to the concepts of *urban crowdsourcing* or *citizen sourcing* can be included in a review.

Second, this review analysed academic studies on platforms using citizen-generated data for cities, solely considering platforms that have been mentioned in academic and peer-reviewed studies. For future research, it would be desirable to expand the current catalogue of urban crowdsourcing platforms to include those that are not featured in academic papers, therefore constructing a larger, worldwide database of platforms. Needless to say, there are important complexities associated to this task, such as finding a method to systematize the search outside scientific databases, and to obtain information documented in a very diverse range of languages. A possible approach would be to launch a collaborative and dynamic database of urban crowdsourcing platforms that scholars from different areas of the world could contribute to. However, considering the limitations of current scholarly research and the discussion in section 5.2, it is likely that even such database would be subject to a representation bias. Nonetheless, even though it is unlikely that it would accurately reflect the state of urban crowdsourcing in the whole world, such expanded catalogue could be a useful tool for research and possibly the design and development of new platforms.

Third, it would also be possible to extend the research (both with respect to a systematic review and the creation of a catalogue database) to platforms whose main scope is not that of gathering data on and for the city, but that collect people's suggestions and ideas on the city, and that increase citizen engagement; those can be described as *citizen participation platforms*.

Fourth, the analysis in section 3.2 highlighted the need for more quantitative research based on crowdsourced data from existing urban platforms. This review showed how most of the studies tended to adopt a more descriptive, qualitative approach. In order to better assess the quality and variety of the data gathered, it could be useful to conduct more quantitative research on the analysed platforms.

Finally, an open topic in urban crowdsourcing research entails the definition of theoretical models and frameworks that could be used to better classify and analyse digital platforms within the urban context. The existence of such theoretical frameworks would help to identify (and reason about) currently under-explored elements of existing urban crowdsourcing platforms, and to envision how to conceptualize new platforms.

## 6 CONCLUSION

This systematic review investigated the state of research on existing urban crowdsourcing platforms for data-gathering, selecting a list of 30 studies with the PRISMA framework. After a study-centric analysis, which showed how most of the existing papers tend to be largely descriptive rather than quantitative, thus indicating

an opportunity for more quantitative research, the review compiled a platform catalogue, highlighting some of their main features, including the platforms' location, purpose, and data characteristics. A key result has been the geographical distribution of the platforms, which showed a great imbalance towards the United States and Europe. This result can be the result of a study selection and language bias, but is also a possible indication of an uneven distribution of these platforms worldwide. Despite these limitations, we believe that the patterns and insights that emerged from this review can be used as a starting point for further research, toward the creation and analysis of a more inclusive catalogue of urban crowdsourcing platforms worldwide.

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APPENDIX I: STUDIES INCLUDED IN THE REVIEW

Study	Platform(s)	Type of Analysis	Description of Platform	Main Topic
Gebremedhin et al., 2020 [18]	Dar Ramani Huria	Qualitative	Primary Focus	Urban Crowdsourcing and Smart Cities
Crowe et al., 2016 [11]	Reusing Dublin	Qualitative	Secondary Focus	Other: Urban Planning
Poggiali, 2017 [36]	SeeClickFix	Qualitative	Secondary Focus	Other: Ethnography
Borges et al., 2016 [12]	SeeClickFix	Quantitative	Secondary Focus	Urban Crowdsourcing Platform(s)
Ballatore et al., 2021 [5]	Litterati	Quantitative	Secondary Focus	Urban Crowdsourcing and Smart Cities
Pak et al., 2017 [34]	FixMyStreet	Quantitative	Primary Focus	Urban Crowdsourcing Platform(s)
Young et al., 2021 [44]	Ushahidi	Qualitative	Secondary Focus	Urban Crowdsourcing and Smart Cities
Chang et al., 2011 [8]	Ushahidi; 311 NYC	Qualitative	Mentioning Platform	Prototype of a Platform
Hsu et al., 2019 [22]	Smell Pittsburgh	Qualitative	Primary Focus	Urban Crowdsourcing Platform(s)
Hsu et al., 2017 [23]	Smell Pittsburgh	Quantitative	Primary Focus	Urban Crowdsourcing Platform(s)
Drosatos et al., 2014 [16]	NoiseTube	Qualitative	Secondary Focus	Other: Privacy
Tempelmeier et al., 2019 [40]	MiC	Qualitative	Primary Focus	Urban Mobility
Ashby et al., 2015 [3]	SeeClickFix; Map Kibera; FixMyStreet; Cyclopath	Qualitative	Mentioning Platform	Urban Crowdsourcing Platform(s)
Aguilera et al., 2017 [2]	Zaragoza quejas y sugerencias; Bicas	Qualitative	Secondary Focus	ICT in Smart Cities
Mainka et al., 2018 [28]	Kölner Service-App	Qualitative	Secondary Focus	Urban Crowdsourcing and Smart Cities
Myrovali et al., 2019 [31]	MOTIVATE	Qualitative	Primary Focus	Urban Mobility
Desouza & Bhagwatwar, 2014 [14]	Textizen	Qualitative	Mentioning Platform	Urban Crowdsourcing and Smart Cities
Torres et al., 2016 [41]	BeCity	Qualitative	Primary Focus	Urban Mobility
Hong et al., 2020 [21]	311	Quantitative	Primary Focus	Other: Analysis of Noise

Post et al., 2018 [37]	311	Qualitative	Secondary Focus	Urban Crowdsourcing and Smart Cities
Carrera et al., 2013 [7]	StreetBump	Qualitative	Primary Focus	Urban Crowdsourcing Platform(s)
Helmrich et al., 2021 [19]	STORM	Qualitative	Secondary Focus	Other: Flood Management
Dilek & Ayözen, 2016 [15]	IBB CepTrafik	Quantitative	Primary Focus	Urban Mobility
Bulatović et al., 2017 [6]	Budi Odgovoran	Quantitative	Primary Focus	Urban Crowdsourcing Platform(s)
Radicchi, 2018 [38]	Hush City	Qualitative	Primary Focus	Urban Crowdsourcing Platform(s)
Gatica-Perez et al., 2019 [17]	Ma3Route	Quantitative	Primary Focus	Urban Crowdsourcing and Smart Cities
Traut & Steinfeld, 2019 [42]	Tiramisu Transit	Qualitative	Primary Focus	Urban Mobility
Zhou & Long, 2016 [45]	Beijing City Lab	Qualitative	Secondary Focus	Urban Crowdsourcing and Smart Cities
Atreja et al., 2018 [4]	ichangemycity	Qualitative	Mentioning Platform	Prototype of a Platform
Abu-Tayeh et al., 2017 [1]	Zueri wie neu	Quantitative	Primary Focus	Urban Crowdsourcing and Smart Cities

Table 4. Studies included in the Analysis

APPENDIX II: PLATFORMS INCLUDED IN THE REVIEW

Name	City	Continent	Type	Availability of Data	Data Format	Data Retrieval	License and Privacy	Citation
Dar Ramani Huria <sup>8</sup>	Dar Es Salaam, Tanzania	Africa	Mapping	Partly Available: Broken Links <sup>9</sup>	OSM (XML)	Direct Download	<sup>10</sup>	[18]
Reusing <sup>11</sup>	Dublin, Ireland	Europe	Mapping	Not Available: Not Public Data				[11]
SeeClickFix <sup>12</sup>		Global	Urban Reporting	Fully Available <sup>13</sup>	JSON	API	<sup>14</sup> <sup>15</sup>	[3][36]
SeeClickFix <sup>16</sup>	Oakland, United States	North America	Urban Reporting	Fully Available <sup>13</sup>	JSON	API	<sup>14</sup> <sup>15</sup>	[12]
Map Kibera <sup>17</sup>	Nairobi, Kenya	Africa	Mapping	Fully Available <sup>18</sup>	OSM (XML)	API or Direct Download	<sup>19</sup> <sup>10</sup>	[43]
Litterati <sup>20</sup>	Amsterdam, Netherlands	Europe	Urban Reporting	Fully Available (with limitations) <sup>21</sup>	CSV	Direct Download	<sup>22</sup> <sup>15</sup>	[5]
FixMyStreet <sup>23</sup>		Global	Urban Reporting	Partly Available: Depending on City <sup>24</sup>	JSON			[3]
FixMyStreet <sup>25</sup>	Brussels, Belgium	Europe	Urban Reporting	Fully Available <sup>26</sup>	JSON	API	<sup>27</sup> <sup>15</sup>	[34]
Ushahidi <sup>28</sup>		Global	Urban Reporting	Partly Available: Depending on City	JSON	API		[44][36][8]
Smell // Pittsburg <sup>29</sup>	Pittsburgh, United States	North	Other: Smell	Fully Available	CSV	API or Direct Download	<sup>30</sup> <sup>31</sup>	[23][22]
NoiseTube <sup>32</sup>		North America	Noise	Partly Available: Upon Request <sup>33</sup>	CSV	API	<sup>14</sup>	[16]

<sup>10</sup>No personal data is stored

<sup>11</sup><http://www.reusingdublin.ie/>

<sup>12</sup><https://seeclickfix.com>

<sup>13</sup>Use <http://dev.seeclickfix.com/> for API; there is a maximum of 20 requests per minute. For more information, consult <https://seeclickfix.com/open311/v2/docs>

<sup>14</sup> Open Data License (Creative Commons Attribution-Noncommercial-Share Alike 3.0 United States License)

<sup>15</sup>Personal Data is stored but not public available

<sup>16</sup><https://seeclickfix.com/oakland/>

<sup>17</sup><https://www.mapkibera.org/>

<sup>18</sup>The download and API are done through the OpenStreetMap platform; <https://www.mapkibera.org/theme/download/>; [https://wiki.openstreetmap.org/wiki/Downloading\\_data](https://wiki.openstreetmap.org/wiki/Downloading_data)

<sup>19</sup>Open Data Commons Open Database License (ODbL)

<sup>20</sup><https://litterati.org/>

<sup>22</sup>Open Data License (Creative Commons BY-SA 4.0 license)

<sup>23</sup><https://www.fixmystreet.com/>

<sup>25</sup><https://fixmystreet.brussels/>

<sup>26</sup><https://datastore.brussels/web/>

<sup>27</sup> Open Data License (Creative Commons CC-0 licence)

<sup>28</sup><https://www.ushahidi.com/>

<sup>29</sup><https://smellpgh.org/>

<sup>30</sup>Open Data License (Creative Commons Legal Code)

<sup>31</sup>Personal Data is not stored; Location data is skewed

<sup>32</sup><http://www.noisetube.net/>

MiC <sup>34</sup>	Hannover, Germany	Europe	Mobility	Not Available: Not Public Data			35 36	[40]
Zaragoza quejas y sugerencias <sup>37</sup>	Zaragoza, Spain	Europe	Urban Reporting	Fully Available <sup>38</sup>	JSON/ XML/ CSV	Direct Download	39 15	[2]
Kölner Service-App <sup>40</sup>	Köln, Germany	Europe	Urban Reporting	Not Available: Not Public Data			35 10	[28]
CycloPath <sup>41</sup>	St. Paul, United States	North America	Mobility	Not Available: Discontinued				[3]
MOTIVATE <sup>42</sup>	Greece	Europe	Mobility	Partly Available: Upon Request ??	CSV	Direct Download		[31]
Textizen <sup>43</sup>	United States	North America	Other: Citizen Engagement	Partly Available: Upon Request <sup>44</sup>	JSON	API		[14]
BeCity <sup>45</sup>	Santiago, Chile	South America	Mobility	Not Available: Discontinued				[41]
Bicicas <sup>46</sup>	Castellón, Spain	Europe	Mobility	Not Available: Not Public Data			35 15	[2]
311 <sup>47</sup>	Vancouver, Canada	North America	Urban Reporting	Fully Available <sup>48</sup>	JSON/ CSV	API or Direct Download	49 15	[21]
311 <sup>50</sup>	New York City, United States	North America	Urban Reporting	Fully Available	JSON	API	51 15	[37][8]
311 <sup>52</sup>	Boston, United States	North America	Urban Reporting	Partly Available: Upon Request	JSON/ XML	API	53 54 15	[37]
StreetBump <sup>55</sup>	Boston, United States	North America	Urban Reporting	Partly Available: Upon Request			56	[7]
STORM <sup>57</sup>	Norfolk, United States	North America	Other: Flood Management	Fully Available <sup>58</sup>	JSON/ XML/ GeoJSON	API or Direct Download	10	[19]

<sup>34</sup><https://www.mic-app.org/>

<sup>35</sup> Proprietary Dataset

<sup>36</sup>Data is Pseudonymised; Confidentiality agreement for the use of the dataset

<sup>38</sup><https://www.zaragoza.es/ciudad/ticketing/enlace/servicios/mapa-quejas-y-sugerencias.html>

<sup>39</sup>Open Data License

<sup>41</sup>Discontinued

<sup>42</sup><http://motivate.imet.gr/>

<sup>43</sup><https://www.textizen.com/>

<sup>45</sup>Discontinued

<sup>46</sup><https://www.bicicas.es/>

<sup>47</sup><https://www.311canada.ca/vancouver-bc/>

<sup>48</sup>Available at <https://opendata.vancouver.ca/>

<sup>49</sup>Open Data License (Open Government Licence - Vancouver)

<sup>50</sup><https://portal.311.nyc.gov/>

<sup>51</sup>Available upon registration; <https://portal.311.nyc.gov/article/?kanumber=KA-01336>; <https://api-portal.nyc.gov/>

<sup>52</sup><https://311.boston.gov/>

<sup>53</sup>Open Data License (part of Open311 project)

<sup>54</sup>API access available upon request; <https://mayors24.cityofboston.gov/open311>

<sup>55</sup><http://www.streetbump.org/>

<sup>56</sup>Personal data policy not specified

<sup>57</sup><https://data.norfolk.gov/Public-Safety/STORM-System-to-Track-Organize-Record-and-Map/a22j-f5hs>

<sup>58</sup><https://data.norfolk.gov/Public-Safety/STORM-System-to-Track-Organize-Record-and-Map/a22j-f5hs>

IBB CepTrafik Dublin <sup>59</sup>	Istanbul, Turkey	Europe	Mobility	Partly Available: Upon Request <sup>60</sup>	XML	API or Direct Download	<sup>61</sup> <sup>62</sup>	[15]
Budi Odgovorani <sup>63</sup>	Podgorica, Montenegro	Europe	Urban Reporting	Fully Available <sup>64</sup>	HTML/ CSV	Dashboard/ Webscraping		[6]
Hush City <sup>65</sup>	Berlin, Germany	Europe	Mapping	Fully Available <sup>64</sup>	HTML/ CSV	Dashboard/ Webscraping		[38]
Ma3Route <sup>66</sup>	Nairobi, Kenya	Africa	Mobility	Fully Available <sup>67</sup>	JSON/ CSV	API		[17]
Tiramisu Transit <sup>68</sup>	Pittsburgh, United States	North America	Mobility	Not Available: Discontinued <sup>69</sup>				[42]
Beijing City Lab <sup>70</sup>	Beijing, China	Asia	Mapping	Fully Available <sup>71</sup>	GIS Shapefile	Direct Download		[45]
ichangemycity <sup>72</sup>	Bangalore, India	Asia	Urban Reporting	Fully Available	CSV	Direct Download		[4]
Zueri wie neu <sup>73</sup>	Zurich, Switzerland	Europe	Urban Reporting	Fully Available <sup>74</sup>	JSON/ XML	API	<sup>75</sup>	[1]

Table 6. Platforms described in the selected studies selected and included in the analysis

<sup>59</sup><https://uym.ibb.gov.tr/hizmetler/ibb-cep-trafik>

<sup>61</sup>Open Data License (Istanbul Metropolitan Municipality Open Data License)

<sup>62</sup>Personal data may be stored but kept confidential

<sup>63</sup><http://www.budiodgovoran.me/>

<sup>64</sup>The website provides an interface with all the reports in an unstructured form; For more structured data, it is necessary to contact the organization.

<sup>65</sup><https://www.opensourcesoundscapes.org/hush-city/>

<sup>66</sup><https://www.ma3route.com/>

<sup>67</sup>Access through API available upon registration. [https://bitbucket.org/ma3route\\_team/ma3route-api-documentation/wiki/Introduction](https://bitbucket.org/ma3route_team/ma3route-api-documentation/wiki/Introduction)

<sup>70</sup><https://www.beijingcitylab.com/>

<sup>71</sup>Three levels of data access: free download, email request, shared among research fellows. <https://www.beijingcitylab.com/data-released-1/>

<sup>72</sup><https://www.ichangemycity.com/bangalore/>

<sup>73</sup><https://www.zueriwienueu.ch/>

<sup>74</sup>At most 1000 items per query; <https://www.zueriwienueu.ch/open311/>

<sup>75</sup>Open Data License (part of Open311 project)