RESEARCH ARTICLE

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Creating a conceptual framework to improve the re-usability of open geographic data in cities

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Abstract

Open data has a profound effect on the working environment within which information is created and shared at all levels. At the local government level, open data initiatives have resulted in higher transparency in policy, a greater engagement between decision-makers and citizens, and have changed the culture about how data analysis and evidence are used to support local governance. This article, based on data collected through an on-line survey, participatory workshops with data user communities in four cities (in Colombia and Spain), and interviews with Valencia's good-government office, identifies four elements for a conceptual framework to improve the re-usability of open geographic data in cities. The essential elements defined in this research are the definition of data user communities and their needs, the creation of the community of reuse, user-focused metadata, and reuse-focused legal terms. The definition of these indicators provides a framework for authorities to re-shape their current open data strategy to include data user requirements. At the end of this article, a roadmap for future research and implementation is presented, considering some reflections on the conceptual framework.

1 | INTRODUCTION

Many local governments around the world have adopted open data principles. Their major concern has been to establish and populate open data portals with data related to different topics and themes (Attard, Orlandi, Scerri, & Auer, 2015). For many years, the critical issue in the success of open data portals has been their accessibility and the data they contain. A number of technological solutions have been developed by national and local public bodies to create portals and rapidly populate them. This has been driven by local and national regulations to guarantee open data release processes within public bodies (Zuiderwijk & Janssen, 2014). However, there remain some critical issues and new challenges around the open data movement. This research embraces the re-usability challenge that many data authorities are struggling with after the implementation of their open data portals. Similarly, after several years of implementation, for many open data portals the communication and collaboration between data users and authorities

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has not progressed well. On the one hand, users still require more useful data or have lost confidence in the new portal, perceiving that the data provided is not suitable for their needs. On the other hand, data authorities are continually trying to empower their users and increase data reuse levels.

To start, it is useful to define what we mean by open data, open government data (OGD), and its possible impact or added value. As a contested concept, open data has no single or universal definition. The *Open Data Handbook* (http://opendatahandbook.org/guide/en/what-is-open-data/) has defined open data as follows: "*open data is data that can be freely used, re-used and redistributed by anyone.*" However, recently GovLab (http://www.thegovlab.org/), in an in-depth analysis of competing meanings, reported a different definition: "*Open data is publicly available data that can be universally and readily accessed, used, and redistributed free of charge. It is structured for usability and computability.*" This definition offers a much broader concept, where it is not just access to data that is the unique aspect of the open data "culture," but where re-usability is also considered as a key factor in any open data initiative. This concept underpins the mainstream view of open data in many countries (World Wide Web Foundation, 2017), especially in public bodies. According to Ubaldi (2013), the combination of open data and government-owned data establishes the OGD concept, and OGD is the key factor for open government initiatives (Kučera, Chlapek, & Nečaský, 2013).

Open data and OGD are closely linked to the ability of data users to use and reuse data. However, open data has no value when it is released; it only becomes useful once it is used (Janssen, Charalabidis, & Zuiderwijk, 2012). Once open data starts to be useful, the impact of its initiatives begins to be demonstrated. Having a complete understanding of the impact is a challenging task, due to its complexity and the variables included. There are some examples where open data reuse has resulted in expected benefits. Therefore, some organizations and institutions have attempted to measure impact based on compilations of use cases and qualitative analyses of their implementation. However, the generalizability of such impact indicators is limited due to the local use environment and the specificities of each case. For these reasons, Opendatabarometer.org (2015) suggested three levels to measure the political, social, and economic impact, describing how countries can contribute in each level.

The impact of open data and OGD has been studied from several perspectives. Ubaldi (2013) has defined impact as the added value and beneficiaries to stakeholders of OGD including government, citizens, civil society, the broader economy, the private sector, and public service marketplace. Carrara, Vollers, and Berends (2017a) illustrated the impact considering a survey and interviews with over 76 private organizations that use open data to develop business models. Janssen and Zuiderwijk (2014) present six business models that connect data users with data providers of open data. Worthy (2015) examines the democratic impact of open data in the UK. The social capital [defined by Putnam (2001)] and the way that open data can contribute to realistic solutions for marginalized groups is studied by Meng (2014). Finally, using the strategy outlined by the Organization for Economic Cooperation and Development (OECD, http://www.oecd.org/), Carrasco and Sobrepere (2015) studied the impact of OGD in Spain and its providences.

Currently, re-usability has an increasingly important place on the agendas of many open data and OGD initiatives; some research agendas are also seeking to get new insights, to better understand how open data can more effectively support and be supported by data users. This research has combined an openly shared on-line survey with open questions from a series of participatory workshops and interviews with data authorities and institutions in charge of open data initiatives. It has collected suggestions and observations of data users' requirements in four cities. During the study, most of the replies to the survey came from Colombian and Spanish cities, and we selected Bogotá, Medellin, and Cali in Colombia and Valencia in Spain as our case studies. The data authorities in the case study cities supported our workshops. In Bogotá and Cali, the local spatial data infrastructures (SDIs) were contacted; in Medellin and Valencia, we linked directly to the open data office. Having two kinds of perspective regarding usefulness levels and the way that data is shared provided this research with two points of view about how the open data strategy needs to be shaped. Most of the resources and outcomes were in Spanish, translated into English and lightly edited. The main aim was to study how open geographic data is reused in order to develop a generic strategy for cities and stakeholders to improve data re-usability levels.

This article is the second stage of research described by Benitez-Paez, Degbelo, Trilles, and Huerta (2018) that considered barriers to the reuse of open geo data from the user's perspective and developed a taxonomy of current reuse obstacles. This article suggests a conceptual framework to help local authorities re-define their current open data strategies and improve re-usability levels in light of user requirements. In so doing, the conceptual framework provides a "bridge" between data authorities and users to support the release of relevant data, build citizen trust, and support easy data reuse. Section 2 describes the key concepts, Section 3 illustrates the methods used to develop the framework, Section 4 defines and explains the conceptual framework and its components, and finally Section 5 provides the insights and lessons arising from the research and presents a roadmap for future research.

2 | BACKGROUND

The number and variety of open data initiatives have increased globally. Barriers, key features, implementation challenges, use and impact cases have been the focus of several studies. Peled (2013) analyzed the current issues of the first version of open data in the US after the Obama administration's open government program was released. They proposed a new label "Open Data 2.0" to include data release strategies. They also noted the potential for transparency policy bubbles; that is, situations where policies are only implemented for short periods of time. Sieber and Johnson (2015) analyzed the shifting role of the government in the open data "culture" and presented four models in which citizens, the private sector, and the authorities make changes to determine the effectiveness of future open data strategies.

The potential of open data relates not only to the government or local authority, but also to stakeholders with different roles, interests, and contributions. A critical consideration is how added value is created through the data supply and analysis chain (Carrara et al., 2017a). Kassen (2013) explored the empowering potential of open data at local levels as a platform for citizen engagement, based on a use case in Chicago. Kassen noted that bottom–top schemas at a local level can provide an effective platform to collect and understand citizen requirements. The role of the local government in the open data movement is also increasingly recognized. For example, the European Committee of the Regions noted that "*open data has the potential to become valuable assets for citizens, businesses, and public authorities*" (Carrara, Engbers, Nieuwenhuis, & van Steenbergen, 2016; European Commission, 2013).

Understanding the impact of open data presents a number of challenges. It is difficult to create a generic schema that allows open data stakeholders to assess progress or determine where they need to put more effort. Therefore, the impact of open data and its nuances have been analyzed from several perspectives. Opendatabarometer.org (2015) considers impact at three levels: political, economic, and social. However, deeper insights are needed to understand the multiple impacts of open data (Huijboom & van den Broek, 2011), including its effectiveness and reuse in order to establish successful policies. Meng (2014) investigated the social impacts of open data and analyzed how marginalized groups access data. Gurstein (2011) criticized the popular claim that "open data is for everybody" and noted that guaranteeing open data access does not equate to efficient use, as accessibility frequently focuses on specific educated groups with access to technologies. Zuiderwijk and Janssen (2014) proposed a framework to compare open data policies. The authors claimed that collaboration among authorities and organizations is the key for real and continued progress. A similar approach is used in the implementation and structure of local SDIs (Esri, 2010). The democratic impacts of the UK coalition government's transparency agenda were studied by Worthy (2015).

The current European Data Portal (https://www.europeandataportal.eu/) links all of the EU + 28 open data portals and analyzes the economic impacts and how businesses are re-using open data to get economic benefits (Carrara et al., 2017a). Janssen and Zuiderwijk (2014) described an infomediary business model that connects data users with providers. They noted the importance of identifying the roles of data users to adequately understand their needs, bridging between provider services and user needs. The identification of end users is also mentioned by Williamson and Eisen (2016) as the first step in structures for successful open government initiatives.

A large number of initiatives have sought to promote accessibility and support authorities during transitions to open data in international or national projects. Examples include the European Data Portal (https://www.europeandataportal.eu/), Open Government Partnership (https://www.opengovpartnership.org/), Open Data Institute

(https://theodi.org/), Open Data Charter (https://opendatacharter.net/), International Open Data Conference (http://opendatacon.org/), Open Data for Development (http://od4d.net/), and Open Data 500 (http://www.opendata500.com/). These examples highlight not only the need to access data, but also the importance of open data initiatives being maintained by public budgets as a vital consideration for national authorities.

For geographic data and its relationship with local open data projects, the literature is still limited. Although some authors have mentioned the importance of spatial data in open data projects or use cases, formal consideration of geographic data provision and access is still only thought of as an extension. Young and Verhulst (2016) define an open data impact taxonomy and present 3 of 19 use cases that are geographically focused, where the impacts include economic growth, the creation of opportunities, and improved services. Johnson, Sieber, Scassa, Stephens, and Robinson (2017) claimed that "spatial is special" and that the consideration of contributions from GIScience to open data research could provide insight into the assumptions and issues of open data projects. Some of the challenges listed as the most demanding stages faced by local SDIs are standardization, integration, local policies, technical integration obstacles, and institutional contributions. Harvey and Tulloch (2006) mentioned that the availability of local government data is the foundation of the current local SDIs.

Cooperation among city, municipality, and local government departments to promote and manage data-sharing processes is a relevant daily challenge for many local public bodies. Creating a framework for collaboration could be one of the ways that a local SDI can contribute to local open data projects, due to its experience developing legal, technical, and institutional agreements. Notwithstanding, local SDIs also have many barriers to overcome regarding sharing data. Carrara, Vollers, and Berends (2017b) identified the geographic data features as technical barriers to the reusability of open data initiatives. The differences between standards, formats, file sizes, and data quality standards stemming from directives like INSPIRE (https://inspire.ec.europa.eu/) create an additional effort for open data initiatives to implement the geographic data domain.

3 | METHOD

Many assessment frameworks have been developed to summarize and describe the impact or added value of open data (Welle Donker & van Loenen, 2017). The "open data ecosystem" concept (Zuiderwijk, Janssen, & Davis, 2014) has been used to determine the roles and objectives of different parts of open data systems. Despite many analyses identifying significant progress in current initiatives, the reuse levels of OGD seem to fail to live up to expectations. Welle Donker and van Loenen (2017) noted that the availability of geographic data in open data initiatives in the Netherlands was better rated than other kinds of data, indicating how the progress made by this community could contribute to current OGD projects.

Commonly, organizations like SDIs are in charge of the production, discovery, and use of geospatial information at national or local levels. Budhathoki, Bruce, and Nedovic-Budic (2008) suggested a reconceptualization of the current SDIs due to the phenomenon of volunteered geographic information (VGI), which creates middle levels where users can take advantage of integrated geographic data and new ways to get data from VGI. Van Loenen, Crompvoets, and Poplin (2017) compared open data portals with geo-portals and found that datasets published in open portals were useful and moderately easy to find. However, they claimed that the inclusion of geographic datasets in open data portals results in a broader user base. Thus, to enhance the relationship between local SDIs and open data initiatives, a "bridge" is required to combine the best of each initiative, reach a broad audience, include data users' requirements, and support the expected re-usability levels.

Considering all of the above led to the research question that is tackled in this study: *What strategy is needed to improve the re-usability level of open geographic data at a local level (cities)?* This question was addressed in the following way. Initially, a set of barriers were identified to help define a taxonomy to validate what the most critical frictions were regarding the re-usability level of open geographic data in cities from a data user's perspective (Benitez-Paez et al., 2018). Once the obstacles were confirmed, data users were consulted about their concerns and what the priorities should be that any open data initiative requires to enhance its re-usability level.

TABLE 1 The references used where authors have proposed improvements to enhance the re-usability level of open data

Improvement proposed	References
Promote the released data reuse	Janssen et al. (2012), Zuiderwijk et al. (2014), Opendatabarometer.org (2015), Johnson et al. (2017), Welle Donker and van Loenen (2017), Benitez-Paez et al. (2018)
Identification of users' and re-users' needs	Kassen (2013), Janssen and Zuiderwijk (2014), Williamson and Eisen (2016), Benitez-Paez et al. (2018)
User-focused metadata	Comber et al. (2006, 2008), Carrara et al. (2017a)
Easy-to-read terms of use	Zuiderwijk and Janssen (2014), Zuiderwijk et al. (2014), Attard et al. (2015), Beno et al. (2017)

An extended literature review was combined with an online survey and a series of participatory workshops. The workshops were organized by data authorities in each city and the findings of this study include exclusively data users' recommendations. The stages involved were as follows.

1. A literature review was undertaken to shape the concepts and critical factors to improve the re-usability level (see Table 1). The elements are disclosed that other authors have illustrated as relevant, or to be intensely developed if the goal includes the data user perspective.

2. An online survey for open data users was set up to reveal the most crucial aspects for re-using the data available in local open data portals. Only three questions were included in this study. Their findings shed some light on what users use open data for, where users work, and the reasons for users not relying on current open data initiatives. Although the survey findings validate some of the initial suggestions from the literature, this research expands on the evidence by organizing—in collaboration with local data authorities—four participatory workshops. The local data authorities were: Infraestructura de datos espaciales del Distrito Capital (IDECA, https://www.ideca.gov.co/), Infraestructura de datos espaciales de Cali (IDESC, http://www.cali.gov.co/planeacion/publicaciones/46671/idesc/), Medellin (https://www.medellin.gov.co/irj/portal/medellin) and Valencia (http://www.valencia.es/) city halls. The workshops' aim was to determine participant suggestions for improving re-usability levels based on their experiences.

3. The set of participatory workshops took place in the four case studies (Bogotá, Cali, and Medellin in Colombia and Valencia in Spain), with interviews carried out with the selected data authorities. Based on the literature review, online survey findings, and outcomes of the aforementioned workshops, a list of recommendations from the data users' side was developed (see Appendix A).

4. A final participatory workshop was organized in collaboration with the good governance office (http://gobiernoabierto.valencia.es/en/) in Valencia, to validate and select the top four recommendations that an open data authority should consider to improve the re-usability levels in its open data strategy. The workshop participants had different skills (geographic and non-geographic) and levels of experience with open data (e.g., journalists, entrepreneurs, managers, students, and professors). The list of recommendations was discussed, and a final list of elements for the conceptual framework was agreed. The aim was to collect divergent perspectives and present a conceptual framework identified through a bottom-up approach that included relevant aspects for data user communities. Such initiatives are rarely undertaken in current open data initiatives, and this is the main contribution of this study.

4 | THE CONCEPTUAL FRAMEWORK

Developing a sustainable conceptual framework that helps data authorities to improve the reuse level of released data requires key concepts that can be used for any open data initiative. Based on the directions suggested by the literature

TABLE 2 Main references used to select the impact enablers

Impact enabler	References
Local level	Kassen (2013), Carrasco and Sobrepere (2015), Carrara et al. (2016), Benitez-Paez et al. (2018)
Data users' communities	Kassen (2013), Janssen and Zuiderwijk (2014), Zuiderwijk et al. (2014), van Schalkwyk, Willmers, and McNaughton (2016), Williamson and Eisen (2016), Johnson et al. (2017), Benitez-Paez et al. (2018)
Geographic approach	European Commission (2004), Budhathoki et al. (2008), Young and Verhulst (2016), van Loenen et al. (2017), Welle Donker and van Loenen (2017), Reynard (2018)

Local level, data users' communities, and a geographic approach are the basis of the conceptual framework proposed in this research.

to enhance the reusability and implementation of open data projects, this research presents a set of three impact enablers, initially defined by the recommendations from the literature (see Table 2), and then validated with the online survey findings.

4.1 | Impact enablers

Assessing the impact of open data is considered one of the most challenging tasks in the implementation of open data projects (Opendatabarometer.org, 2015). While some studies have sought to develop critical perspectives for rigorous analysis, many evaluations of open data reuse and potential impacts have been limited, sometimes by the number of use cases or on other occasions due to the methodology applied. In this work, we present three "impact enablers" to improve the re-usability level of open geographic data, which underpin the conceptual framework presented in this research.

4.1.1 | Local level or cities

Based on the literature review (see Table 2), local open data initiatives offer a better scenario to empower data users, promote institutional integration, and overall see (in the medium term) the expected benefits of open data. First, cities can more easily and efficiently reach data user communities. Second, cities frequently work on issues that affect the daily lives of citizens (e.g., mobility, security, pollution, urban planning, and economic development, among others). Third, cities provide economic and innovation engines for many national governments. They act as stakeholders and drivers of policy transformations through their innovations (Carrara et al., 2016). Currently, there are many innovation-labs among cities. Users see these local policies as a way to get institutional and avoid bureaucratic procedures. They provide a modern environment, with fewer tax charges, technical and administrative teaching activities, and the promise to rapidly develop the proposed model business or social contribution expected. Such start-up incubators are becoming the way to encourage the current challenges, transforming the traditional economic model of many cities. During this research, two such innovation-labs were part of our workshops, due to their leading roles in the local open data initiative. In Medellin, Ruta N (https://www.rutanmedellin.org/en/) is empowering academia, entrepreneurs, and the industrial sector to work collaboratively, bringing Medellin into a new economy model based on the city's priorities and services. Valencia, through Las Naves (https://www.lasnaves.com), is another example where this kind of innovation-lab, with modern facilities supported by the local government, can empower citizens, offering lectures on current trends, several participatory workshops, and continuously working toward developing innovative projects with strong social components to provide benefits to citizens. However, in Bogotá and Cali, the local SDIs are the open data project leads. Having a geographic approach and experience in the integration of geographic data from several local departments (e.g., mobility, education, culture, security, etc.) can contribute to ongoing local open data strategies. According to Ubaldi (2013) and Carrara et al. (2016), smart city projects and open data initiatives at local levels increase citizen engagement and collaboration. To validate these claims, this research used online surveys to determine the

TABLE 3 The number of occurrences of concerns mentioned by respondents to the question about their primary concerns when using geographic data from city open data portals (1.26% did not mention any concerns)

Mentioned concerns	Occurrences	Percentage
Outdated data	45	28.30%
Confidence (about how data was created or gathered)	23	14.47%
License issues	18	11.32%
Quality of data issues	17	10.69%
Reference system or scale issues	11	6.92%
Completeness	10	6.29%
Format issues	8	5.03%
Accessibility issues	6	3.77%
Usability issues	5	3.14%
Privacy issues	4	2.52%
Metadata issues	3	1.89%
Accuracy (data/metadata record correctly described)	3	1.89%
Technical issues	2	1.26%
Discoverability	1	0.63%
Interoperability	1	0.63%

sector where most data users are currently working. We found that Local government (27.2%), Private sector (22.1%), and Education (19%) are the top three sectors in a sample of 195 valid respondents. These findings reinforce the need to focus local open data initiatives. They establish that most of the data users included in this research currently work at a local level and are familiar with the open data challenges at that level.

4.1.2 | Data user communities

This impact enabler covers especially data users' community requirements. Our approach uses a bottom-up schema where the needs of data users are central to any open data implementation. Having an effective feedback system is needed to gather information about reuse issues, and provides an integrated and effective way of getting opinions, comments, and ratings from data users to help build a "bridge" between data users' requirements and data providers' perspectives. Having a diverse range of different data user groups (e.g., journalists, developers, entrepreneurs, analysts, the academic sector, and social organizations), with their own requirements, provides the opportunity to adjust and refine ongoing open data initiatives. The inclusion of data users' communities as part of the design, deployment, and implementation stages should be a prerequisite, as it has been found to have a positive impact on the downstream results (Carrara et al., 2016; Janssen et al., 2012; Martin, Foulonneau, Turki, & Ihadjadene, 2013; Young & Verhulst, 2016) and provides a mechanism for dissemination.

This research asked data users: *What is your primary concern when using the geographic data available in the open data portals of the city?* It was an intentionally open question, and was answered by 159 valid respondents. Outdated data was the most significant concern, followed by confidence in data creation and licensing issues—*limitations to reuse, not for commercial use*, and *legal issues once the available data is included in third-party applications* were mentioned by respondents. Finally, 15 categories of further concerns were also cited by survey participants, including reference system, data quality, and adequate data descriptions (see Table 3).

Overall, most of the concerns with more than six occurrences were about metadata and how to get information about open data integration, use, or reuse in projects. This reflects the relevance and inclusion of this impact enabler:
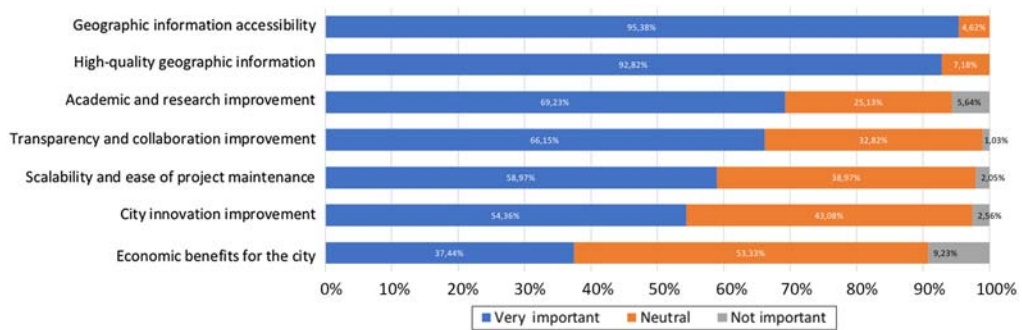
FIGURE 1 Levels of importance for different aspects of open data in cities. Accessibility of geographic data, data quality, and improvements for academic research were mentioned as very important ($n = 195$)

to have a better understanding of the main issues faced by users. A better way to promote metadata, especially metadata that can provide context to guide users in how to use the published data, is included in the conceptual framework presented below, supporting data authorities to shape their efforts toward data users' priorities. As noted by Comber, Fisher, and Wadsworth (2008), "*metadata and its specifications in standards should be expanded,*" to accommodate current de facto standards and data users' needs. Metadata should support use, not just data discovery and cataloging. Additionally, the "community of reuse" element within the framework, described in Section 4.2, proposes some tools to allow users to subscribe to any dataset, score data quality, and add comments regarding currency issues (which was reported by data users as the main issue in open data catalogs).

4.1.3 | Geographic approach

This research has found that a geographic approach in current local open data initiatives can have a positive impact on their efforts to improve re-usability levels. The geospatial domain is the most frequently consulted by data users and the business sector, having a positive influence on the success of open data initiatives according to Carrara, Chan, Fischer, and van Steenbergen (2015). In Young and Verhulst (2016), 3 case studies out of 19 in the geospatial services sector were found to improve services and promote economic growth in Denmark, the UK, and the USA. Welle Donker and van Loenen (2017) claimed that open geographic data policies can provide useful advice to other OGD initiatives. We have also noted this in our case studies, where users were more reactive to geoportals than traditional open data portals. The European Commission (2004) established geospatial data as one of the five categories with highest demand for reuse across the EU and recommend making data reuse a priority.

In this study, local data users were consulted about the level of importance of several aspects to reuse open data in cities. The question included was: *Please indicate the level of importance of each option when using open city data*. The responses indicated that Geographic information accessibility (95.38%), High-quality geographic information (92.82%), and Academic and research improvement (69.23%) were the most important categories (see Figure 1). Regarding the third category, we can say that data users consider local open data to be a very important resource, supporting better results and methods in both academia and research. Further reflection on previous results illustrates that, despite the number of geoportals and the increasing access to data through open data portals, users are still asking for better accessibility of geographic data. In a similar way, the quality of geographic data is considered a priority for open data, thus suggesting a modification to the traditional sentence in most of the open data projects: replacing *Data for everyone* by *Data for easy and effective reuse*. It is also worth noting that users were not too concerned about the economic benefits of open data, despite this being a common theme in the literature.

However, despite the benefits of including a geographic approach, there are still barriers to reuse. Some cities have been making substantial efforts regarding the integration and standardization of geographic data for a number of years, through local SDIs. The creation of tools to display integrated data (e.g., geo-viewers and geoportals) is a common goal of SDIs, as are legal frameworks and data standards that promote the sharing process among local public

TABLE 4 Vote by data users during the last participatory workshop

Recommendation	Priority				Votes	Percentage
	1	2	3	4		
F	1	6	4	3	14	73.7%
A	4	2	1	3	10	52.6%
J	4	1	1	4	10	52.6%
H	0	5	1	3	9	47.4%
I	2	0	6	1	9	47.4%
D	4	1	2	0	7	36.8%
C	2	3	0	1	6	31.6%
B	0	1	1	3	5	26.3%
G	1	0	2	1	4	21.1%
E	1	0	1	0	2	10.5%

A notification system, identification of data users, better documentation and guidelines to reuse data, linked data, and easy-to-read legal terms using a traffic light were the most voted recommendations (see in Appendix B the entire list of recommendations used; $n = 19$).

bodies (Carrera & Ferreira, 2007). Local open data projects should take advantage of such ongoing initiatives to overcome the integration or standardization barriers, frequently identified by data users as one of the major obstacles to open data reuse (Schmidt et al., 2016). In the same direction, Johnson et al. (2017) concluded that the SDI projects' experience could contribute to open data researchers getting a better understanding about how the value of both initiatives is generated.

4.2 | Framework elements

Once the impact enablers to improve the re-usability level of open geographic data were established, the next step was to define a set of elements to make more concrete suggestions that any local data authority could apply to increase the reuse of their open geographic data. Through a set of participatory workshops, this study collected suggestions that data users have considered relevant to overcome the current barriers regarding the reuse of open data. Appendix B illustrates the most cited suggestions in each city where the workshops took place.

The inclusion of linked data, a semantic web, efficient feedback tools, a new open data strategy that includes improved documentation and guidelines to reuse the available data, user-focused metadata, standardization, and better integration among the city hall departments were the most mentioned suggestions among the workshops.

Based on the suggestions mentioned above, plus recommendations from Benitez-Paez et al. (2018) to overcome current data users' barriers to reuse of open geographic data in cities, we have identified a list of recommendations (see Appendix A). This list was validated and ranked during the last participatory workshop in Valencia, in collaboration with the good government city hall office and Las Naves. With the participation of 19 data users, the aim was the selection of the top four elements that any open data strategy should include to increase the re-usability level, based on the data user perspective (see Table 4). The most voted suggestions were the following.

1. Notifications system (F); the open data portal should include the possibility that users might subscribe to particular data or sets of data, to get whatever update is required on the dataset of interest.

2. With the same number of votes, identification of data users' communities (A) and the inclusion of linked data (J) were the second most voted options. Users claimed that having the possibility to see what other's datasets are related to is fundamental to understand how the data could be reused.
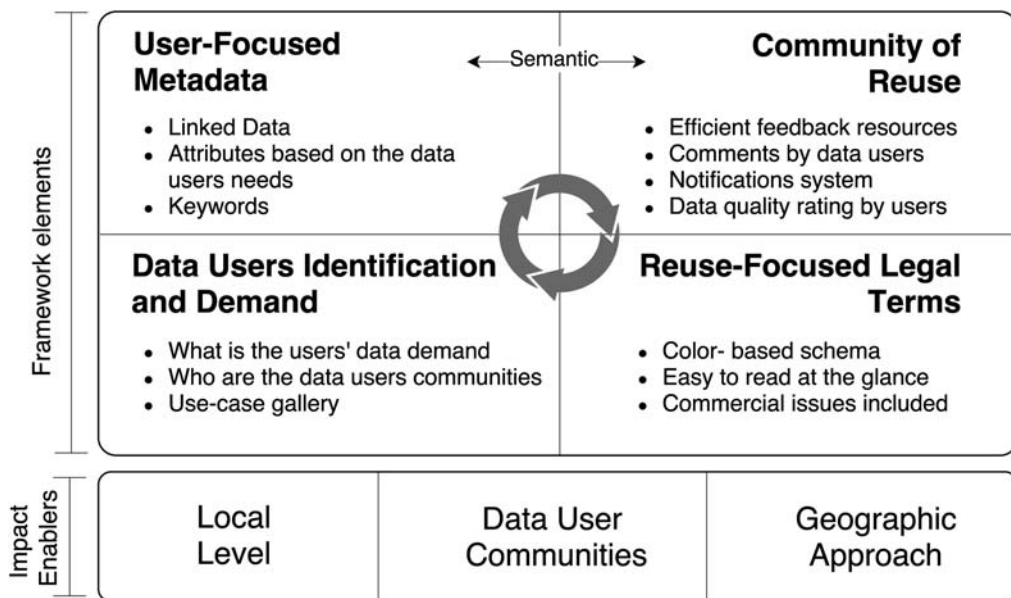
FIGURE 2 Components of conceptual framework for improving reuse of open geographical data in cities

3. Third place in terms of votes was for improved documentation, including guidelines to reuse the available data (H) and the integration of geographic tools (I) (like a geo-viewer to display related data and overlay with another dataset of interest).

4. With redefinition of the terms of use (D), it is required to have more easy-to-read legal terms, including possible limitations for commercial use. A traffic light system was promoted, to allow data users to rapidly understand if the released data is completely reusable or has restrictions.

Based on the impact enablers mentioned in Section 4.1, a literature review (see Section 2), suggestions (see Appendix A), concerns (see Table 3), and requirements (see Figure 1) from the open data user communities in four case studies (see Section 3), this research has designed a conceptual framework as presented in Figure 2. The framework elements are: (a) user-focused metadata; (b) community of reuse; (c) data users' identification and demand; and (d) reuse-focused legal terms.

The conceptual framework illustrated aims to guide local data authorities to shape their ongoing strategies to enhance the re-usability levels of the released data. Taking into consideration data users' needs, and addressing the most frequently cited obstacles, this framework has a set of four elements to increase the usefulness of open data in cities.

The four elements need to work together and the conceptual framework shown in Figure 2 presents a "round-about" in the core of the diagram representing the interaction that we suggest is required. Semantics among metadata, released data, users' comments and data authorities provide the way to interact with the four elements. Suggested by data users during the participatory workshops, it was also included by Comber et al. (2008), who claimed that "*there is embedded more valuable geographic information in data semantics than the released data itself.*" The integration of a semantic web in the current open data portals has the potential to offer context and useful meaning to published data. In the following subsections each component is described in depth, to explain its objectives and how data users have suggested it could contribute to improving the re-usability of open geographic data.

4.2.1 | Data users' identification and demand

Full identification of data users' requirements and data demands was one of the most voted recommendations by data users in the last participatory workshop in Valencia (see Table 4). Collecting users' data demands, the most used web services, the communities most likely to use open data, and likewise how data users search for data in portals should

be the initial task that any open data strategy undertakes. We have noted that most of the contacted local open data authorities do not consider the specific requirements of any particular user group. As summarized by Benitez-Paez et al. (2018) (Table 1), cities like Bogotá, Cali, and Medellin in Colombia contacted developers to establish events and projects with local universities, but beyond that, we did not find any collaboration between data users and local authorities. In fact, in Valencia the local open data technical office does not consider it relevant to collect information about who is using the released datasets.

A gallery of use cases, explaining how the available data is used by others, was often requested during the participatory workshops in the four selected cities. Only in Valencia and Medellin were the local authorities able to describe two recent collaborations. In Medellin, the local authorities started a group called "Open Data City Council," whose aim is to describe the steps of the open data strategy to data users, and get feedback from their side. In Valencia, the recent collaboration between a local university (Universitat Politecnica de Valencia, https://www.upv.es) and the local open government city hall office established a project (Catedra de Gobierno Abierto, http://catgo.webs.upv.es/) to promote citizen participation, transparency, and open government.

4.2.2 | Community of reuse

This element was a constant requirement and suggestion from all participants in the four case studies, especially in the last workshop. Valencian data users have chosen a notification system as the primary priority for any open data strategy that seeks to increase re-usability levels. This element is essentially a set of tools that allows data users to be part of the open data strategy, and provides the local data authorities with information about how the data is being used. Instead of a contact form to get feedback, comments, ratings, and suggestions, such approaches are more efficient and allow users to ask other users about a specific dataset. A subscribe tool like RSS was also suggested by users who wanted to know when some dataset was not available, or had been changed or updated, especially for developers who needed to integrate the available dataset in external applications. Likewise, creating technological tools such as forums, where users can explore, comment, highlight, and suggest success cases or relevant issues, was often promoted.

4.2.3 | User-focused metadata

Comber et al. (2008) have identified several ways that metadata could be made more relevant to data users. Experimental metadata, expert opinions of relations with other datasets, and descriptions of the social–political context of data creation were some options described. Considering the ways mentioned above, plus the suggestions listed by data users in the four use cases, this research consulted participants (in the last workshop in Valencia) over what would be the most relevant metadata. After a group discussion, participants suggested ways to enhance the current "metadata tab" in open data portals, based on their experience. The implementation of related keywords in each dataset, adding comments by data users, possible uses by data producers or publishers, and data quality ratings by users were the most popular improvements discussed.

Linked data and having information about how to exploit these data was persistently mentioned by users during this study. Linked data is the way that released data could have geographic or statistical context. Along the four case studies, only Valencia's open data portal allows users to filter the available datasets by openness score (five stars of open data, http://5stardata.info/en/). However, there are no available datasets with five stars, and only 4.2% of the released dataset in this portal is scored with four stars. Though Medellin's open data portal allowed data users to explore some "related" datasets that in reality were part of the same category inside the portal, no linked data was deployed, and users did not get any context until downloading the data and exploring for themselves.

IDECA in Bogotá understood that the way to promote the relation among several datasets is through linked data definitions. Currently, IDECA is working on the definition of a set of ontologies for the official basemap of Bogotá. At the same time, they are building a database of the semantic web for the geographic data of the reference basemap. The proposed framework has validated that data authorities need to start to develop the definition of linked data projects that include ontologies development, data vocabularies, and a semantic web, like IDECA (Bogotá) or the Ontology Engineering Group (OEG) at Universidad Politécnica de Madrid (Spain, http://www.oeg-upm.net/) are currently doing.

TABLE 5 Proposed schema, based on a color scale for the considered licenses

Reuse level	Color	License	Domain	BY	NC	ND	SA
Reusable	Green	CC BY	Content	Yes	No	No	No
	Green	CC Zero	Content and data	S/N	No	No	No
	Green	ODC–BY	Data	Yes	No	No	No
	Green	ODC–PDDL	Data	S/N	No	No	No
Limitations	Yellow	CC BY–SA	Content	Yes	No	No	Yes
	Yellow	ODC–ODbL	Data	Yes	No	No	Yes
Restrictions	Red	CC BY–ND–*	Content	Yes	No	Yes	S/N
	Red	CC BY–NC–*	Content	Yes	Yes	No	S/N

*Corresponds to any other license.

Including this component will have a remarkable impact on the way that users use, understand, and reuse the released data in cities.

Taking into consideration the metadata definition cited by Comber, Fisher, Harvey, Gahegan, and Wadsworth (2006), "*information that helps the users assess the usefulness of a dataset relative to their problem,*" this research proposes an integrated way to get that kind of information. Once open data portals have implemented the feedback resources suggested in the previous element, users will provide a particular level of usefulness of the available dataset. Determining the number or kind of uses for a specific dataset is quite difficult, or almost impossible. Therefore, combining the possible uses from a data producer perspective, plus the use case or comments provided by other users about their experience using the data, whether positive or negative, could be the way to understand if the dataset is suitable for other particular problems. Related to linked data, there was another resource suggested by data users—the inclusion of a semantic web in open data portals. The feedback provided by other users can guide newcomers to understand how the data can fit their problem. That is also the reason why Figure 2 includes an arrow between the community of reuse and user-focused metadata elements; a semantic integration will cooperate to get the information required by the user-focused metadata, and users will be encouraged to participate by writing comments and rating the released datasets.

4.2.4 | Reuse-focused legal terms

One of the main barriers to reusing open data (Benitez-Paez et al., 2018; Beno, Figl, Umbrich, & Polleres, 2017; Carrara et al., 2015) is the lack of information about what kind of license each dataset has. There is a general ignorance about the meaning of each license, or sometimes the available datasets do not have any associated license. In the latter case, the agency that makes the datasets publicly available must define the license under which that data is released, such that the rights of reuse are apparent to the potential users.

The proposed conceptual framework offers a solution to these barriers, and establishes a color scale (green, yellow, and red) to define each of the existing licenses. In this way, users can quickly determine if they can freely use a specific dataset or if it has restrictions. According to the findings of the final workshop, Valencian data users have voted for this in their priority list (see Table 4), developing a traffic light system as an easy-to-read resource to understand if the data is fully reusable, including commercial use, or presents limitations.

Starting with the definition of open—"*A piece of data or content is open if anyone is free to use, reuse, and redistribute it – subject only, at most, to the requirement to attribute and/or share-alike*"—there are licenses that fulfill the open data concept. These are: *Creative Commons Attribution, Creative Commons Attribution Share-alike, Creative Commons Zero, Open Data Commons Public Domain Dedication and License, Open Data Commons Attribution License,* and *Open Data Commons Open Database License.* Table 5 shows the equivalence of the most important current licenses with the defined color scale. Green represents reusable datasets, yellow represents reusable datasets but not for commercial use, and red represents datasets that have restrictions on reuse. This schema does not replace the current license standards, rather we are proposing an easy way to cluster the current licenses, especially in geographic data where the number of terms of reuse could be an important challenge for open data authorities.

5 | DISCUSSION AND ROADMAP FOR FUTURE RESEARCH

This research defines the elements and basic concepts to help data authorities sustainably enhance the level of reuse of their current open data initiatives and portals. It considered open data re-usability then proposed a conceptual framework. The focus of this research was empowering data user communities to participate and be part of the ongoing open data projects, as their needs should be the engine of any strategy. During this research we noted that despite many local efforts to promote the open data movement through concepts like transparency, citizen participation, and new web portals, users still consider that there is much work to be done, and importantly they do not feel that those projects are fulfilling their key role as data intermediaries.

Using the findings from an online survey and a set of participatory workshops, as well as interviews with specific local open data authorities and groups of users, four integrated elements were proposed in the framework. The proposed framework is a guide for data authorities to identify where they should focus their current efforts in shaping ongoing initiatives, including what users require and the barriers to taking full advantage of available data. A sustainable open data initiative is possible when the stakeholders are identified, when data accessibility is promoted, and finally when the usefulness and re-usability level are included in the whole open data picture.

We have presented several impact assessment methods or use cases. However, we did not find any existing frameworks that sought to improve the re-usability and usefulness of open geographic data at local levels. The inclusion of three impact enablers as the basis of re-shaping ongoing local open data efforts was defined. These promote a bottom-up approach that includes a geographic approach and its potential to improve the re-use of the released data, allowing collaboration between local departments.

The next step in our research agenda is to go ahead with the development and implementation of the conceptual framework. To achieve this goal, some preliminary tests have been conducted using a comprehensive knowledge archive network (CKAN) instance. In this way, we are proposing some CKAN extensions to fulfill all requirements submitted by the conceptual framework (Figure 3).

It is possible to sketch out a roadmap for future research. Each component proposed by the conceptual framework will be implemented using a different CKAN extension, and some of them will be reused from available extensions. In this way, we define five different extensions.

- *Data user communities*: In this first component, an extension is proposed to categorize the users or re-users of the released datasets.
- *Community of reuse*: Two extensions are expected to solve this component. The first one is a feedback extension. For this feature we reuse an extension called Disqus (http://extensions.ckan.org/extension/disqus), which includes the possibility for users to create comments and rate the data quality for each dataset inside the CKAN catalog. The main goal of this extension is to enrich each dataset with feedback from each user. The second extension is the
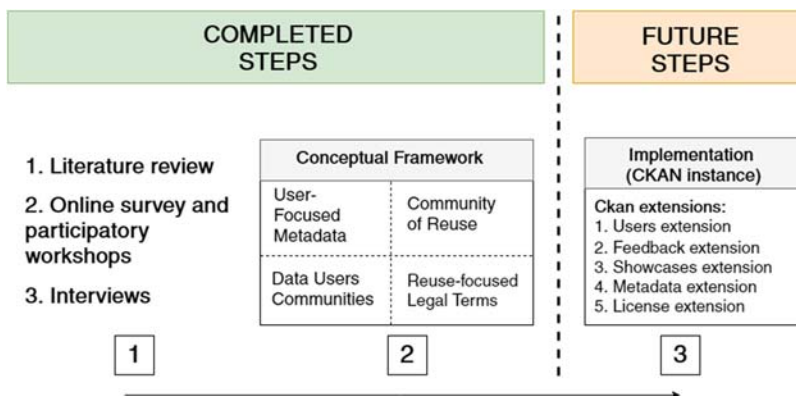

FIGURE 3 Schema showing the completed steps of our work and proposing a framework based on CKAN

showcases feature. Using this extension, users can see what datasets are being used in different sites. To do this, an available CKAN extension called Showcase (http://extensions.ckan.org/extension/showcase) can be used.

- *User-focused metadata*: Including a semantic web, the aim of this extension is to allow data authorities to link data users' comments with the metadata view available for the released data. Users will be able to filter the user-focused metadata to explore how the consulted dataset has been used by others.

- *Reuse-focused legal terms*: The last extension establishes a color legend to guide users to know if the dataset is fully reusable or has a restriction. Data authorities will easily be able to choose the most suitable from an extensible list of licenses, and the extension will determine the color chosen according to the license features.

The outputs of this research provide significantly more depth than suggestions arising from previous research into this topic. Valencia city hall and IDECA in Bogotá have already shown interest in participating in the evaluation of the conceptual framework and likewise, the functional tests that the proposed components require. A generic definition of open data ontologies that integrate geographic local data for the most important dataset in cities is required as an extension of this research. Spain has carried out similar efforts, defining a list of 100 datasets that any city might need (http://opencitydata.es/web/guest) and developing some initial dataset vocabularies. The integration of those vocabularies in the data release process in a local open data initiative following the conceptual framework presented here is another way to extend this research.

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APPENDIX A: LIST OF RECOMMENDATIONS FROM DATA USERS' PERSPECTIVE, ASSESSED DURING THE LAST WORKSHOP IN VALENCIA

Recommendations	
A	Identification of the communities, groups, organizations, and departments of a city that are using the open data, and their needs.
B	Reuse community. Gallery of use cases, fora, recent datasets, and tools of interaction between users.
C	Metadata oriented to the user. Identification of the metadata most consulted by users and their deployment.
D	Terms of reuse. Color convention in order to know if the data is reusable or has restrictions.
E	Continuous monitoring of the services that are requested in the open data initiative.
F	Notification system, which alerts when a new dataset is included, improved, or updated (e.g., RSS).
G	Gallery of examples where open data is used or deployed by the community.
H	Reuse guidelines or manuals, explaining how the published data can be reused or manipulated.
I	Geographical viewer, in order to display and overlay the published data.
J	Linked data or related data. The published data must have geographical and statistical context. Possible relations with other published data.

APPENDIX B: LIST OF SUGGESTIONS FROM DATA USERS IN CASE STUDIES TO IMPROVE THE REUSE OF OPEN GEOGRAPHIC DATA

Case study and data authority contacted	Data users' suggestions	Category
Bogotá—IDECA	Do not start from scratch. Many current initiatives ignore their predecessors. There should be at least a link to them. Linked data is required. Making visible the connections between the data and data sources	Web semantic/linked data
	Having a link between the current community project and the open data initiative	
	Data license must be available in each dataset	Legal term concerns
	Current metadata is not appropriate to understand the potential use of available data	User-focused metadata
	Standardization is required. Better communication channels with users	Data users' communities
	The identification of the data users' demand is required	
	Data opening level needs to be improved	Interoperability
	Integration between the local SDI and the open data initiative is required	
	Promote the open data initiative internally in the city hall and its departments	Open data strategy
	Strengthening the open data area	
Valencia—open government city hall office	Linked data to explore data category, illustrating the related data	Web semantic/linked data
	Web semantic is required, including keywords for efficient discoverability	
	Lack of communication among city hall departments	Open data strategy
	Released data is on a regional scale and does not allow local analysis	Accessibility
	Better integration among city hall departments	Standardization
	Duplicate data in several portals with a different publication date	
	Use case documentation	Open data strategy (documentation)
	API and examples of how to use the released data	
	Make clear the format of released data	Technical
	Make clear which data are only for visualization and which are for download	
Medellin—open data office	Allow data users' communities as part of the open data initiative, including citizen science projects	Data users' communities
	Linked data, including some examples	Web semantic/ linked data
	Better communication channels with data users' communities, including blogs, fora, and promoting the released data through social networks exploring potential use	Feedback improvements/ user-focused metadata
	Include useful feedback to make adjustments and improvements in the current initiatives of open data	
	Collection data process should be available, to allow users to explore how the data was created	User-focused metadata
	Data opening level needs to be improved	Interoperability
	Better integration among city hall departments	Standardization
Cali—IDESC	Develop better communication channels between the open data initiative and data users	Feedback improvements
	Integration with current data initiatives like local SDI	Standardization
	Dashboard to display the statistical and geographical context of the released data	Web semantic/linked data
	More emphasis on downloading the data	Technical
	Make an inventory of current data users and re-users	Open data strategy
	Promote city hall departments' integration, releasing an integrated dataset instead of having several portals with different levels of data	