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RESEARCH ARTICLE



Eliciting design principles using a data justice framework for participatory urban water governance observatories

Fenna Imara Hoefsloot ^a, Andrea Jimenez ^b, Javier Martinez ^a, Liliana Miranda Sara^c
and Karin Pfeffer ^a

^aDepartment of Urban and Regional Planning and Geo-Information Management, University of Twente, Enschede, Netherlands; ^bInformation School, University of Sheffield, Sheffield, UK; ^cForo Ciudades para la Vida, Lima, Peru

ABSTRACT

Participatory urban observatories can potentially improve transparency in infrastructure governance, offer opportunities for residents' engagement, and amplify the voice of marginalized people in urban governance. While often optimistically presented as a tool to address empowerment issues in the Global South, participatory urban observatories are critiqued for reproducing urban inequalities in the digital infrastructure. In this paper, we review the design and implementation of participatory urban observatories and dashboards in public (water) infrastructure governance and their potential to contribute to data justice. This paper responds to calls for data justice by examining how participatory urban observatories are (or are not) conducive to inclusive data practices. Additionally, we contribute to bridging the divide between data justice in theory and practice by eliciting design principles. The principles highlight the importance of creating smart city interventions collaboratively to avoid reproducing unjust systems and to imagine new ways of enacting a more just city.

KEYWORDS

Data justice; dashboard; observatory; urban; participatory; water governance; design principles

1. Introduction

Digital infrastructures are seen as important opportunities to address managerial, social, and environmental issues in the water sector (Amankwaa et al., 2021). Recognizing the many challenges in the water sector, specifically in cities where a large portion of the water consumption is 'off-grid,' digital innovations are framed within water security and justice agendas as directly relevant to reducing inequalities in the water distribution system by creating greater efficiency and accountability. While many of the steps in the datafication – defined as the increasing availability, use, and effect of data (Heeks & Shekhar, 2019) – of the water sector are government-led initiatives, frequently in alliance with multinational companies (Taylor & Richter, 2017), Jimenez, Delgado, et al. (2022) argue that, for innovation to contribute to development, datafication should seek to be a participatory process which builds on the exchange of knowledge between epistemic communities.

It is from this perspective that we are interested in the design and implementation of participatory urban observatories and dashboards in public (water) infrastructure governance and their potential to contribute to data justice. A wide range of participatory urban observatories and

CONTACT Fenna Imara Hoefsloot  f.i.hoefsloot@utwente.nl 

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dashboards have been developed within academic and non-academic settings, which, in theory, aim to amplify the voice of residents in urban governance.

This paper responds to calls for data justice by examining how participatory urban observatories are (or are not) conducive to inclusive data practices (see: Heeks & Renken, 2018; Krishna, 2021; Martin & Taylor, 2021; Qureshi, 2020). The aim of this paper is to elicit principles for the design and development of a just participatory urban observatory for water governance. By drawing from both theory (academic literature) and practice (participatory urban observatories currently in use), we hope to contribute to bridging the divide between data justice in theory and practice and set out to formulate principles applicable in the design processes. Rather than prescribing action, these principles are intended to serve as a set of considerations in developing future observatories that contribute to data justice. Following Milan and Treré (2019), we strive to relate the datafication of the water sector to bottom-up practices of data creation, which center on the knowledge and agency of diverse urban residents in water governance.

The paper structure is as follows: we will set the scene and introduce the issues relating to the datafication of the water sector in Section 2. In Section 3, we work towards developing a definition of participatory urban dashboards and observatories and elaborate on the data justice framework for reviewing participatory urban dashboards and observatories. We turn to the work of Taylor (2017) and Heeks and Shekhar (2019), specifically their conceptualizations of data justice and how it can be useful in thinking about principles for the development and design of data observatories in marginalized communities in the Global South. Following Taylor's (2017) data justice framework, we review the participatory observatories based on three pillars: visibility, engagement with technology, and non-discrimination. Section 4 provides the methodology for the structured review of academic and non-academic examples of participatory urban dashboards and observatories. Section 5 presents the results of the analysis of the academic literature, i.e. the review of the participatory urban dashboards and observatories based on their function as an infrastructure for (Section 5.1) visibility and participatory practices, (Section 5.2) embeddedness in decision-making, and (Section 5.3) non-discrimination. In Section 5, we review the observatories in the field of urban water governance to formulate design principles applicable in practice. Finally, in Section 7, we develop recommendations for the design of participatory urban observatories that work towards data justice within water governance and present our concluding remarks in Section 8.

2. Datafication of the water sector

Urban administrations have progressively implemented sensors, meters, and supervisory control and data acquisition (SCADA) systems to ensure the supply and monitoring of potable water through urban space (Kitchin et al., 2018). These systems, and the data they collect, are attractive to policy-makers because they present the messiness of urban water infrastructure in near real-time updated maps, tables, and graphs, implying a sense of insight and control. Moreover, they are typically promoted by an overwhelmingly positive vision of data governance in the Global South – a term we use with caution to refer to the plural geographical spaces and epistemological traditions that have been, and continue to be, suppressed in the colonial world order (Milan & Treré, 2019; Pansera, 2018) – as they address issues of empowerment for the most marginalized people (Masiero & Das, 2019; Taylor & Richter, 2017). From a central control room, they monitor water flows within the urban water infrastructure, from the treatment plant to the final consumer (Richter, 2018). In doing so, these digital infrastructures go a long way in determining how we conceive the city, who is part of it, and what knowledge we include in thinking about urban water governance.

The use of SCADA systems for water management fits within the ongoing development of using digital infrastructures and data technologies for the management of urban infrastructures (Barns, 2018). Since the late 1980s, a myriad of systems has been developed, often taking shape as control rooms or web and mobile phone applications built on emergent data science and digital infrastructure (Mattern, 2015). Within smart city discourses, these technologies have been referred

to as indicator suits, urban dashboards, observatories, or benchmarking systems (Kitchin et al., 2015). However, typical of most of these systems is that they integrate various data sources and visualizations intending to support governments, residents, and businesses in decision-making (Mattern, 2015). But perhaps more importantly, the urban observatories work as instruments aiming to inform planning and policy-making, increase transparency towards residents, and inspire future scenarios for urban spaces (Dickey et al., 2021; Valenzuela-Montes & Carvalho-Cortes Silva, 2015).

Despite their potential, Mattern (2021) writes how dashboards are not only tools to make visible and monitor but also actively obscure urban processes, shape our definition of the city, and black box the functioning and the creation and processing of data. Specifically, Mattern (2021) explains how seeing the city-as-computer, in which infrastructure has to be made smart to operate efficiently, limits not only the types of (digital) information flows that are executable but also the types of information and expertise we consider valuable. Observatories embody a specific regime of sight. Often, this is presented as a view from nowhere, the idea that through the numbers and graphs portrayed on the map, a contextless viewpoint can be created that allows for an objective interpretation of what is perceived (Jasanoff, 2017). This line of sight often reproduces current inequalities, excludes other city perspectives, and overlooks alternative approaches to infrastructure management. Notably, in the context of managing urban water infrastructure, this view from nowhere, as portrayed by the spatial data infrastructures such as the SCADA systems, may omit other types of data and perspectives on water governance (Hoefsloot et al., 2022).

The seamless and frictionless city the SCADA systems are designed and developed for rarely exists. Specifically, in cities in the Global South – looking at the city from the streets rather than the control room – presents a different picture of the water infrastructure. One in which water disproportionally flows in affluent neighborhoods and does not reach new informal settlements on the periphery. It also provides a different experience of how the system breaks down, is maintained, and (re)constructed by residents in strategic and improvised ways (Anand, 2017; Hoefsloot et al., 2020). By taking up these different roles, residents themselves largely overcome the gap of being underserved within the material infrastructure by, for instance, acting as the engineers, constructors, and maintainers of the water distribution system within their neighborhoods and households. Within these conditions, an important portion of urban residents is not only structurally underserved but also structurally underrepresented in the data, leading to the further peripheralization of the non-digital city (Hoefsloot et al., 2020).

Yet, as will be illustrated in the following sections of this research, these valid concerns with the use of urban observatories in infrastructure management are accompanied by a belief that digital infrastructures such as dashboards or observatories can potentially increase transparency in public governance, offer opportunities for residents' engagement, and support grass-roots data collection initiatives (Dickey et al., 2021; Viale Pereira et al., 2017).

3. Data justice and the participatory urban observatory

3.1. Defining participatory urban observatories and dashboards

We are not the first to explore the potential of data to address complex urban issues in more collaborative and participatory ways. Specifically, others have written about collaborative data projects and citizen science to democratize data practices, stimulate a sense of ownership and right to the datafied city, and foster self-organization and collective governance of urban processes (de Lange, 2019). However, we look at one specific infrastructure, the participatory urban observatory, as a tool in doing so and adopt a data justice approach to evaluate these observatories.

In the literature, the terms observatory and dashboard are both used to refer to a wide variety of organizations and technologies which function as interfaces between the person and the city (Lock et al., 2020; Mattern, 2021). A participatory urban observatory or dashboard can be characterized by its aim to redirect the use of digital technologies for participatory (spatial) knowledge generation

about the city, creating awareness, fostering dialogue, and facilitating data exchange between local governments and urban residents (Castell et al., 2015). This can come in many forms. For example, the cases reviewed in this paper range in scope from distributed sensor networks to map sounds in the city (Botteldooren et al., 2013) and semi-automated web-GIS models to monitor flood risks based on crowdsourced imagery (Ardaya et al., 2019) to comprehensive urban knowledge institutions (Acuto et al., 2021) and critical counter-mapping platforms (Mattern, 2021).

While both terms (dashboard and observatory) are often used interchangeably, in this paper, we continue with observatory since this concept encapsulates the objective of perceiving urban issues and steers away from more technocratic imaginaries of a city that can be monitored and controlled from a single digital interface. Drawing on Lock et al. (2020), we define participatory urban observatories based on three important building blocks: (1) they serve as an infrastructure to contribute to the collection and sharing of knowledge about an urban context to inform decision-making; (2) they use geo-information tools – which can range from conceptual counter cartographies to geo-information systems with a distributed sensor network and earth observation data – to monitor urban issues within a confined spatial-temporal context; and (3) urban residents participate in the development or operation of the observatory by defining, observing, understanding, validating, or contesting urban issues.

This final point is important as participatory observatories often depart from the notion that residents of urban spaces have expert knowledge about the social, cultural, and material context in which they live. Whether as datafied ‘smart-citizens’ or auto-constructing ‘expert-amateurs,’ residents are important nodes in the exchange of expertise and knowledge about the city and the development of urban infrastructure (Hoefsloot et al., 2020). It is also precisely this aspect that makes it interesting to consider participatory urban observatories from a data justice perspective. As tasks that were previously in the domain of the state (Scott, 1999), such as the collection, processing, and use of data for decision-making about public infrastructures, shift towards residents, we might notice tensions regarding visibility, transparency, and representation within the data (Taylor & Broeders, 2015). Smart city infrastructures such as participatory urban observatories occupy an ambiguous place in this transition (Offenhuber, 2017). Hence, it is important to design them in ways that contribute to data justice in the city.

3.2. The data justice framework and how it forms a starting point for evaluating the potential of the participatory urban observatories in achieving just transformations in cities

In this section, we discuss the data justice framework in relation to participatory observatories and urban datafication to build our framework for reviewing the case studies of participatory urban observatories in water management.

Data justice emerges as an approach that seeks to investigate society’s increasing datafication, which has become extremely prevalent in shaping policy, discourse, and practice (Cinnamon, 2020; Qureshi, 2020). Many interpretations of data justice exist based on concerns about ethical challenges that a data-driven society causes in both the Global North and the Global South (Dencik et al., 2016; Heeks & Shekhar, 2019). For instance, in the context of international development, Heeks (2017, p. 2) defines data justice as ‘the specification and pursuit of ethical standards for data-related resources, processes, and structures.’ This definition assumes a number of dimensions to be considered, from examining how the data is handled to the extent to which societal interests and power support fair outcomes for everyone.

Taylor (2017, p. 8) defines data justice as balancing and grappling with

the need to be represented but also the possibility of the need to opt-out of data collection or processing, the need to preserve one’s autonomy with regard to data-producing technologies and the need to be protected from and to challenge data-driven discrimination.

This conception of data justice emphasizes how data can be both empowering in the sense that it makes injustices visible and harmful, as it can increase surveillance and policing of marginalized communities and reproduce structural discrimination. Hence, according to Taylor (2017), data justice is only possible if people have access to, can engage with, and contest the data and digital infrastructures created.

Data justice has been applied to examine the datafication processes of antipoverty programs, like the Unique Identification Project (Aadhaar) in India (Masiero & Das, 2019); which demonstrates how digital platforms, designed to prevent breaches and maximize program effectiveness, actually lead to further injustices in the system. It has also been adopted to evaluate digital identity systems for refugee and displaced communities (Martin & Taylor, 2021; Schoemaker et al., 2020).

These cases demonstrate that data justice requires a multidimensional focus that considers both outcomes and processes. As a result, the data justice framework is structured along three pillars: visibility, engagement with technology, and non-discrimination. Visibility refers to the access to representation as well as the right to informational privacy; engagement with technology entails that people maintain autonomy within the data system and can take share in the benefits provided by the data; and finally, non-discrimination means that people have the ability to challenge biases and the systems work towards preventing discrimination in all its possible forms (Taylor, 2017). For each pillar, we have conceptualized what these principles might entail for participatory urban observatories.

3.2.1. Visibility, engagement, and non-discrimination

Visibility refers to the access to truthful representation within the data and the right to informational privacy, meaning the right not to be visible within the data (Taylor, 2017).

The effect of invisibility, or the omission of data on marginalized communities in governance and decision-making, should not be understated (D'Ignazio & Klein, 2020; Ricaurte, 2019). D'Ignazio and Klein (2020) show via a multitude of examples how the invisibility of marginalized groups such as people of color, women, queer, and disabled people in government and research data has not only resulted in the neglect of their needs but has also caused harm through the development of racist and sexist (digital) technologies and poor policy-making. Similarly, Ricaurte (2019) refers to 'government-enforced invisibility' to capture how government-led datafication practices often reproduce colonial and patriarchal hierarchies that lead to the erasure of marginalized communities' experiences and contributions to the creation of data and knowledge.

Hence, the word 'access' in Taylor's conceptualization of visibility is paramount. Access to visibility-making practices gives people and organizations the power to define what should be made visible and through which methods and indicators. Access also allows residents to opt-out of the system and choose not to make certain issues visible (Martin & Taylor, 2021). In other words, access goes beyond binary conceptualizations of connectivity (you are either fully connected or you are not) and refers to the abilities of people, including people from resource-deprived and marginalized communities, to participate according to differing needs, capabilities, and values (Roberts & Hernandez, 2019).

This brings us to the second pillar of Taylor's data justice framework: engagement with the technology. Taylor (2017) identifies two important components of engagement with technology. The first is the freedom to control one's engagement and disengagement with data technology (Schoemaker et al., 2020). This entails that people have the autonomy to choose to take part in the data technology or opt-out and self-determine the degree of one's visibility. Secondly, engagement with the technology refers to the use of the technology with the larger political, economic, and ecological landscape. Important in this regard is that the data should not be monopolized for capitalist gains, but all should be able to benefit from it. In practice, engagement calls for participatory methods or co-design, where actors have an active role in and ownership over the information technologies used in public decision-making (Jacobs et al., 2019). Taylor (2017) positions the data justice framework within a capability approach to emphasize how the just handling of data is not only about the functionalities of a tool but should consider an individual's agency and capability to act according to what they value and have reason to value.

Baibarac-Duignan and de Lange (2021) distill a number of productive insights for understanding (dis)engagement in the datafied city. In their work, Baibarac-Duignan and de Lange (2021, p. 5) offer a ‘controversy-based’ definition of engagement as the democratic processes of issue formation, otherwise understood as the transformation of something that was considered a matter-of-fact into a point of concern within a certain space and time. Big data and smart city applications are often decontextualized and removed from people’s everyday experiences. For engagement, it is necessary that data is made less abstract. It is also necessary that the data and the platforms are situated – localized and contextualized – in the urban and social context (Baibarac-Duignan & de Lange, 2021; McFarlane & Söderström, 2017).

If we relate this to the participatory urban observatories, visibility and engagement do not only refer to being represented or not represented in a collective database; they also refer to democratic issue formulation within the urban context. The real value of civic apps such as participatory urban observatories is that they can allow residents to voice their concerns and aspirations for the city rather than only reporting operational problems (de Mesquita et al., 2018). In line with this statement, Mattern (2021) suggests that they do not necessarily have to be ‘instrumentally utilitarian’ to give valuable insights into the experience of people in the city. She argues that observatories can also be overwhelming in complexity and design, where people get lost and deep-dive into a niche subject rather than providing a snap-shot overview. In all their messiness and complexity, these observatories most likely do a better job of representing the city than a stylized and reductionist view does (Mattern, 2021). They help us experience the diversity in knowledge that can inform urban governance.

Finally, the third pillar of the data justice framework is non-discrimination. In operationalizing non-discrimination, Taylor (2017) states that people should have the power to identify and challenge biases within the data and use it to prevent discrimination. This attends to structural inequalities that are reproduced in the data, such as the unequal representation of marginalized people and the types of knowledge presented in the observatory. Moreover, it urges us to look beyond the initial interface of the observatories and consider their features and how they are embedded in the city’s larger social and political networks (Masiero & Das, 2019). Justice in knowledge generation requires going further than visualizing structural inequalities and actively seeking to work against them (Milan & Treré, 2019).

In addition, to challenge biases, the processes of data collection, selection, curation, communication, and use should be transparent. This entails that data, algorithms, and code should be open.

Identifying and challenging biases in observatories also means challenging the ontology presented in the observatory and pluralizing it to embrace the multiplicity in ways we can understand the city (Milan & Treré, 2019). Creating spaces for equal knowledge exchange between epistemic communities and centering plurality and collaboration is especially important as colonial patterns in knowledge production manifest themselves in a variety of ways (Jimenez, Delgado, et al., 2022).

In operationalizing Taylor’s data justice framework to review participatory urban observatories, we noticed how many of the defined dimensions are dependent on two or three of the main pillars. Therefore, we have re-envisioned the framework (Figure 1), still departing from the three pillars of data justice but taking into account how transparency and participation in data practices, collaborative issue formulation, and the pluralization of ontologies only happen within the intersections of visibility, engagement, and non-discrimination. The dimensions we formulate as part of the data justice pillars or their intersections serve as benchmarks for evaluating current observatories and developing future observatories in accordance with the principle of data justice.

4. Methodology

This review has been conducted to inform the development of the *Observatorio Metropolitano de Agua para Lima-Callao*,¹ a participatory urban observatory that aims to reduce water injustices within the metropolitan area of Lima-Callao, Peru (Jimenez, Hoefsloot, et al., 2022). In order to

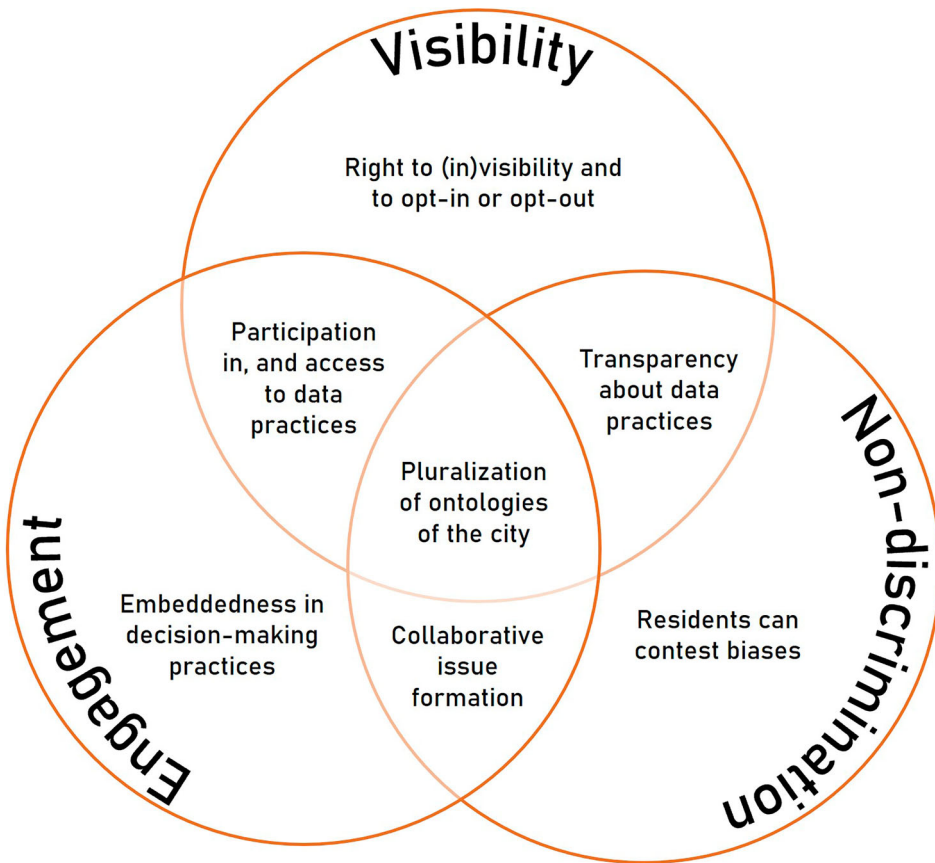


Figure 1. Applied data justice framework for participatory urban observatories. Based on the three pillars of the data framework developed by Taylor (2017, p. 9).

learn from the various kinds of observatories that have been made in the past, their features, and their impact, we systematically reviewed academic and practical cases of participatory observatories for urban governance in general and water governance in particular.

The literature review included empirical research published in peer-reviewed papers, conference proceedings, and book chapters on urban dashboards and/or observatories which included a participatory element. Literature was selected using the SCOPUS and Web of Science databases. After a secondary screening of the abstracts focusing on (i) whether or not the papers described empirical research and (ii) the observatories contained a participatory element, a list of 23 papers published between 2001 and 2021 (results returned papers within that period) remained. We conducted additional searches in SciELO and the digital library of the Universidad de Chile to include Spanish language literature. Still, none of the results from these databases matched the subject matter and were selected for the final review. See the supplementary material for the steps taken in selecting the academic case studies, including search terms and a reference list.

In addition to the structured, broad literature review on dashboards and observatories spanning different aspects of urban development, we have reviewed existing and active participatory urban dashboards or observatories. The first part of the review (i.e. the literature) was broad, including dashboards and observatories spanning different aspects of urban development. During this second part, in which we reviewed existing and active platforms, we narrowed the search and specifically focused on participatory observatories or dashboards that, at least in part, focus on

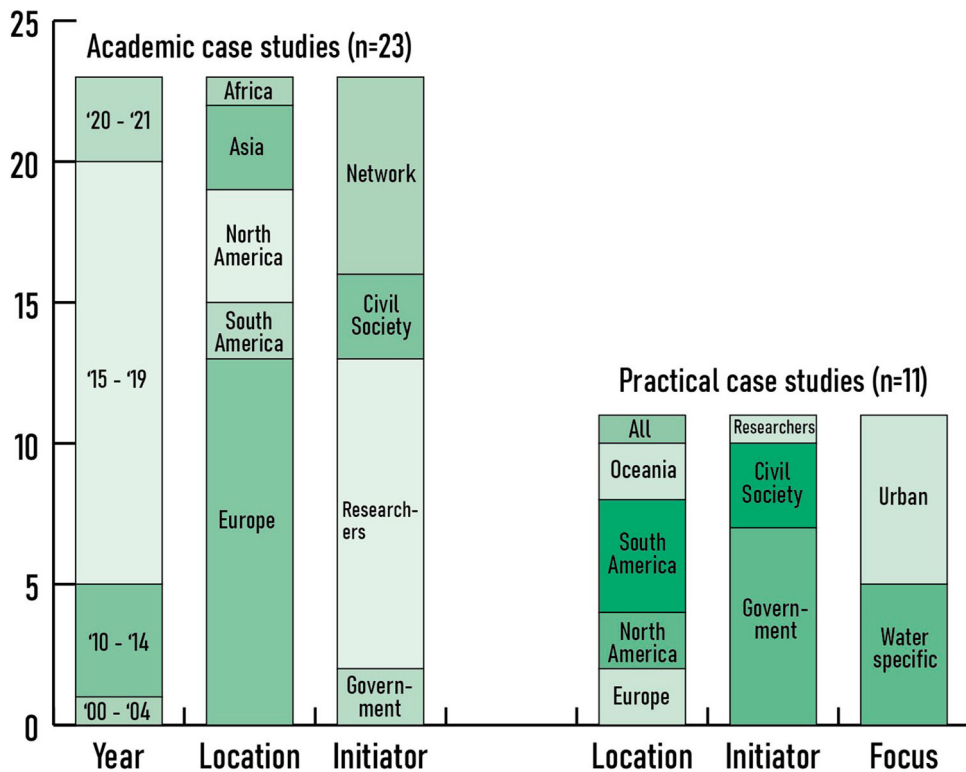


Figure 2. Overview of the publication years, case study locations, initiators, and thematic focus in the structural review of the academic literature and the observatories in the field of water. The selection did not contain any articles published between 2005 and 2009.

water issues in an urban context. We have selected active urban observatories or dashboards for review using the Boolean search function on Google. We used the incognito browser to ensure that our previous browser history did not inform the search results. Due to language constraints, we were restricted in selecting only English and Spanish platforms for this analysis, although we have come across similar platforms in other languages during our search. We have included results from the first 50 results for each search query. After a first screening of the returned results based on whether or not they (i) contained a participatory element, (ii) focused on urban issues, (iii) included topics related to urban water management, and (iv) were still in use at the moment of analysis, we remained with eight platforms. In addition, to this selection, we have included three observatories the authors were familiar with prior to the systematic search. Please see the supplementary material for the steps taken in selecting the practical case studies and the list of observatories finally selected (Figure 2).

In line with the literature review, we have specifically considered the self-proclaimed aim of the different platforms, the interactive features they contain, and their scope and contextualization in our analysis of the platforms. Information for the review was gathered from the observatories' websites. For information regarding the right to (in)visibility, we particularly reviewed the privacy policy of the observatories. Following the data justice framework, our analysis and results are structured along three sections: 5.1 access to visibility and participation in data practices, 5.2 embeddedness in decision-making as a dimension of engagement, and 5.3 on collaboration, plurality, and transparency as dimensions of non-discrimination. We continue this structure in the analysis of the existing platforms in Section 5.

5. Review of literature on participatory urban observatories

5.1. Access to visibility and participatory data practices

As we focus on the issues with (in)visibility within the literature reviewed, we find that the observatories have a wide range of tools and methods for providing residents opportunities to participate in the data practices and contribute to visibility-making or guard the right to invisibility. The participatory urban observatories taken into consideration for this review contain a wide variety of data, ranging from volunteered geographic information (VGI), passively collected data from social media or sensors drawing on Internet of Things technology, to data from public registries and community reporting. However, while there are little generalizations we can make about the type and use of data within these different observatories, we can categorize them according to the active or passive roles of users within the system. It is worth noting that participation itself is rarely defined within the studies reviewed. In general, participation refers to any contribution of residents in the data process but does not reflect on whether or not this participation is truly meaningful or if residents' participation is considered mainly an instrument for data collection and validation.

Active participation refers to the engagement of residents in various data practices, ranging from collecting measurements, entering information, and/or validating automatically generated data. For example, in the development of community indicator systems, residents were involved, from formulating the indicators that needed to be measured to setting goals, endpoints, and timelines (Hendrickson, 2010). In other cases, residents help with calibrating automatically-collected earth observation data (See et al., 2016) or are often involved in validating the results of the data collected to make sure that it represents their perception of the city (Ardaya et al., 2019). Acuto et al. (2021) detail how the observatories in Karachi, Bengaluru, Freetown, and Johannesburg focus on building long-lasting and stable relationships between diverse urban groups. In doing so, observatories do not only aim to inform decision-making but also strengthen the research and advocacy capacities of civil society and local communities (Acuto et al., 2021) and serve as platforms to connect data to action (Bixler et al., 2019). For example, in Nova Friburgo, Brazil, the data collected on flood and landslide events were validated by local community groups who also participated in the negotiation of policies for disaster risk response (Ardaya et al., 2019). These observatories require a more active and direct engagement of residents as experts in providing, interpreting, and validating data.

Passive participation refers to cases where residents share data on social media or through sensors connected to the internet and which is automatically collected. Botteldooren et al. (2013) describe this as a 'plug-and-measure' system in which residents can connect their devices like remote sensors within a crowdsourcing platform to share textual, numerical, audio, or visual data such as images or video recordings (Assumpcao et al., 2019; Castell et al., 2015). Ludlow et al. (2017, p. 18) refer to the data passively collected by residents as 'community derived inputs,' emphasizing the role of residents as data collectors rather than collaborators in knowledge generation.

The case studies discussed suggest that participatory data practices can lead to higher levels of trust and accountability in the data, the possibility of recording the residents' perceptions of the city, and better representation of residents in the data. The limitations of participatory data collection discussed are in terms of the 'tradeoff' between accuracy and participation. Generally, crowdsourced data used in participatory urban observatories is considered less accurate due to limited or skewed participation, less precision in the adherence to research protocols, or a lack of methodological training (Ardaya et al., 2019; Assumpcao et al., 2019; Botteldooren et al., 2013).

Regarding the issue of limited participation, See et al. (2016) state that the barriers to participation based on education or legal and logical access to technologies should be limited. Particularly in, but not limited to, the Global South, issues related to the unequal access to digital infrastructure to participate in the urban observatories is a concern (Acuto et al., 2021). The FLAMENCO platform explicitly aims to do so by providing a framework for participatory urban observatories that can be implemented and used by 'ICT-agnostic' people or organizations, meaning that it should be

accessible and useable for societal organizations and communities even if they do not have an extensive ICT background (Zaman et al., 2018). Another strategy to increase access to and participation in the urban observatories is to diversify how knowledge is shared. We found that in addition to visualizing online figures and maps in a web browser or mobile phone application (Ardaya et al., 2019; Botteldooren et al., 2013), various observatories share the knowledge about city processes via policy reports distributed online (Acuto et al., 2021) or in workshops and university lectures (de Queiroz Ribeiro & dos Santos, 2001). Some even share knowledge through information plaques within public spaces (Carbonari et al., 2019). Thus, while urban observatories often have the tendency to black box data practices (Mattern, 2021), their participatory counterparts often aim explicitly to increase transparency and access to data.

Nonetheless, Uson et al. (2016) explain that, despite legislation encouraging close collaboration of researchers, policymakers, and residents in defining issues related to urban flood risks, proposing solutions, and making decisions, the population is only considered as a partner to validate the data (based on their local experience), and information is not systematically and effectively shared amongst all actors. Similarly, Ardaya et al. (2019) explain how residents complained that their contribution to the validation of the data about environmental risks was not considered, hollowing out the participatory process. Moreover, while some cases reviewed propose strategies to increase the participation of residents in visibility-making, none of the studies reviewed explicitly discuss how residents can self-determine which data they would like to have recorded within the observatory and how data might be deleted or removed from a database if requested. One of the articles included in this review detailed how observatory admins could protect personal privacy by ensuring that people are not identifiable in the images collected in the observatory (Wannemacher et al., 2018), but this did not include the option to opt-out of the visibility-making practices. Other case studies only described embedded options to remove a data point for the sake of cleaning up or maintaining the database (Guillaume et al., 2016; Ladu, 2020) and was not related to the right to stay invisible.

Hence, when we look at the literature reviewed through the analytical lens of visibility and access to data, the first pillar of the data justice framework, the review shows how varied the cases are. While some examples appear to use a more goal-driven approach to participation for visibility – increasing visibility through decentralized and participatory data collection – others approach it from a more bottom-up perspective – co-determining what has to be made visible and through which methods. Or in other words, we distinguish between the observatories that approach residents as ‘sensors’ within the city and observatories that approach residents as ‘expert observers.’

5.2. Engagement: embeddedness in urban decision-making

Although all observatories reviewed contained or were built on, digital information systems, the platforms are embedded within the decision-making in various ways. de Mesquita et al. (2018, p. 192) state observatories can ‘enable citizens to express local and communal issues regarding public space to have more potentials as they can function as entry points for tailoring policy or urban design on a neighbourhood scale.’

Most participatory urban observatories have in common that knowledge exchange is seen as bidirectional and collaborative (Pihlajaniemi et al., 2017), meaning that the government can learn from residents and vice-versa. Ardaya et al. (2019) emphasize the importance of trust in this learning process. Specifically, they state that if there is mistrust between the actors in the production of participatory knowledge about urban issues, the process loses its legitimacy. From that, we distill that an essential role of the participatory urban observatory is to facilitate that bidirectional learning process by creating spaces in which residents can communicate their knowledge and experience, and governments can provide more insight and transparency over their policies and decision-making processes. However, how this role is operationalized within the participatory urban observatories varies greatly.

Some observatories are specifically localized in the sense that they are made for, and embedded in, the particular context of a specific urban environment. For instance, the observatory for the Italo-Argentinian influence on architectural heritage in Buenos Aires (Carbonari et al., 2019). Others, such as the CITI-Sense-Mob, are developed specifically for a city such as Oslo with a regular and fine-mazed bus transport system and a cycling culture but pursue the more generalizable aim of measuring and monitoring urban air quality (Castell et al., 2015). Similar to other observatories focusing on issues such as noise, air quality, and traffic, these platforms are characterized by their general rather than contextual and sectoral focus and their potential to be implemented in various cities (Botteldooren et al., 2013; Guillaume et al., 2016; See et al., 2016; Sinha et al., 2012). Taking it one step further, the FLAMENCO project is specifically designed as a framework that can be adapted and used in different contexts (Zaman et al., 2018, 2021).

The question that arises here is how do general observatories contribute to building appropriate and actionable knowledge on urban issues. Bixler et al. (2019) state that for the knowledge collected from observatories to be actionable, it is crucial that they facilitate data collection and knowledge exchange virtually and actively engage with urban actors 'in real life.'

In Rio de Janeiro, the Observatorio was developed as part of more considerable governmental reform and as a tool to facilitate the direct participation of residents in urban planning and reformulate government-citizenship relations after a period of dictatorship (de Queiroz Ribeiro & dos Santos, 2001). Its specific aim was to strengthen residents' participation and democratize information about the urban and infrastructural policy. Similarly, the observatories discussed by Acuto et al. (2021) are positioned within the broader debate on urban planning and policy-making. In their case study research on the use of urban observatories during the Covid-19 crisis, Acuto et al. (2021) illustrate how already existing observatories transitioned into crisis observatories during the covid-19 pandemic. From having a general advisory role, the urban observatories in Johannesburg, Bangalore, Karachi, and Freetown became key players in generating and mobilizing spatial knowledge about the covid crisis. In doing so, they did not only assist local governments by filling gaps in knowledge, e.g. the mapping of pandemic risk factors such as household crowding and shared sanitation, but also by taking over specific governmental roles.

5.3. Non-discrimination: collaborative, plural, and transparent

Having discussed how the observatories approach issues related to the access to visibility, engagement, and embeddedness in urban decision-making, we now review how participatory urban observatories can potentially work towards overcoming discrimination within urban knowledge practices by providing space to contest biases and fostering transparency, collaborative issue formation, and plural ontologies. By default, participatory urban observatories contain the normative notion that the city, and urban governance, can be improved by deploying the knowledge of its residents. However, whose knowledge is represented in the observatory and which narratives for the city to come are produced, are often not explicitly discussed.

de Mesquita et al. (2018) argue observatories can have dual results. On the one hand, they can increase the efficiency of urban processes by reducing 'bureaucratic fuss' (p. 185). On the other hand, they serve as tools so 'citizens can find out what is happening in their neighborhood, take ownership and become more actively engaged with local issues and within a community' (p. 186). In line with this statement, we find that we can roughly categorize the reviewed participatory urban observatory into two types: the observatories that aim to monitor urban processes and support effective management and the observatories that aim to generate new perspectives of the city. Regarding the first, the observatories are characterized by a technology-driven approach in which it is argued that, due to the advancement of IoT and geo-technologies, we have new opportunities to monitor urban spaces (Ladu, 2020). For example, the U-TEP project uses geospatial data, mainly earth observation imagery, to facilitate 'effective and efficient urban management' (Esch et al., 2017, p. 1380). Also, the DECUMANUS observatory is presented as a tool that can help

monitor and assess land, energy, and citizen health at a much higher resolution than previous systems would allow. This could potentially help residents and urban planners in decision-making (Ludlow et al., 2017). Through their focus on the opportunities of technologies and efficiency, they often reproduce dominant images of the smart, digital, or cyber city.

The second type of observatories, which focus on generating new perspectives of the city, are characterized by the often explicit aim to enhance residents' authority and autonomy in making their voices heard within urban development processes. For example, Uson et al. (2016, p. 70) state how participatory observatories can 'enhance instances for proposing alternative visions of space, knowledge and the notion of risk' within the city. They emphasize how, instead of focusing on validating knowledge, they aim to give residents the opportunity to deliberate collectively about how to define their own problems, opportunities, and solutions to issues related to urban risk. Similarly, Rio's observatory's main impact lies in how it assisted in the formulation of alternative urban policies in partnership with research institutions, NGOs, and residents (de Mesquita et al., 2018). In doing so, participatory urban observatories can help residents to address local issues, voice their aspirations for their city, mobilize knowledge to tackle challenges within their environment and enable residents to influence urban development by collecting and datafying the public perception (de Mesquita et al., 2018; Wannemacher et al., 2018).

In addition to the opportunity to pluralize narratives, we find that some observatories also facilitate the contestation of biases in the data they create or are used as tools to contest the biases in knowledge external to the observatory. As detailed earlier, this can be done by inviting residents to validate or contest the data collected on the platform based on their on-the-ground expertise (Assumpcao et al., 2019; Esch et al., 2017; See et al., 2016). In addition, some observatories explicitly profile themselves as a tool to critique current indicators for urban processes (Hendrickson, 2010), contest already existing maps and navigation routes (de Mesquita et al., 2018), or diversify the ways we value and report the significance of cultural heritage with the city (Carbonari et al., 2019).

Transparency in terms of why, what, and how data are generated through the observatories is a prerequisite for being able to critically investigate the knowledge shared via these platforms. Hence, it is a precondition for both pluralizing ontologies and being able to contest the biases in the data. Several observatories reviewed explicitly mentioned their aim of increasing transparency in policy development and implementation and public administration by facilitating the exchange of information between governments, organizations, and residents (Acuto et al., 2021; Brown-Luthango et al., 2013; Estuar et al., 2017; Ladu, 2020). Other observatories contribute to transparency implicitly by making the data more accessible for different actors and participatory monitoring of urban processes (Bixler et al., 2019; Esch et al., 2017; Guillaume et al., 2016). However, it is important to note that the aim of increasing transparency in the public administration of urban processes does not automatically correspond with the observatories being transparent about their own data practices. While the case studies in the academic literature provided clear methodological sections, it was not detailed how this information was communicated with the users of the observatories and how the observatories themselves guarantee transparency over data practices.

6. Analysis of participatory urban observatories used in practice

The review of the academic literature gives us an overview of the broad range of approaches in the design and application of participatory urban observatories and leads us to the categorization of characteristics of the data justice dimensions, as seen in Table 1. Nevertheless, the analysis of academic cases does not allow us to review how the observatories are experienced from the user perspective, nor does it give us much insight as to how the dimensions of the applied data justice framework can be translated into practice. In this section, we review a selection of participatory urban observatories to better understand these aspects.

Specifically, as we are – eventually – interested in the potential use of participatory urban observatories for water access, the observatories analyzed self-described as urban dashboards or

Table 1. Categorization of participatory urban observatories (POU) resulting from the review of cases in academic literature.

Dimensions	Characteristics	Elaboration	References
Access to visibility	Citizen as sensor	Passive citizen participation through crowdsourced data collection. E.g. the use of sensors embedded in household or mobile devices used by residents	Assumpcao et al. (2019); Botteldooren et al. (2013); Castell et al. (2015); Ludlow et al. (2017)
	Citizen as expert observer	Active participation of residents in defining what needs to be observed and in the interpretation, use, or validation of the information collected	Ardaya et al. (2019); Bixler et al. (2019); Carbonari et al. (2019); de Mesquita et al. (2018); Hendrickson (2010); See et al. (2016)
Right to (in)visibility and to opt-in or opt-out	Explicit	PUO explicitly mentions how residents can opt-out, be invisible, or only have some of their data shared	None
	Not mentioned	PUO does not explicitly state how to opt-out	All
Issue formulation	Top-down	Issues addressed in the observatory are predetermined by the initiator	Acuto et al. (2021); Bixler et al. (2019); Botteldooren et al. (2013); Brown-Luthango et al. (2013); de Queiroz Ribeiro and dos Santos (2001)
	Collaborative	Issues addressed in the observatory are defined in collaboration between different actors	de Mesquita et al. (2018); Hendrickson (2010); Zaman et al. (2021)
Embeddedness in decision-making	Embedded	POU is embedded within the broader debate on urban planning and policy-making	Acuto et al. (2021); Bixler et al. (2019); de Queiroz Ribeiro and dos Santos (2001); Hendrickson (2010)
	External	POU collects data that can potentially help residents and governments in informed decision-making	Botteldooren et al. (2013); Castell et al. (2015); Guillaume et al. (2016); Ladu (2020); Ludlow et al. (2017); See et al. (2016); Sinha et al. (2012); Zaman et al. (2018, 2021)
Contest biases	Facilitated	POU has built-in methods for residents to report and contest internal and external biases. E.g. a workshop or online form	Acuto et al. (2021); Assumpcao et al. (2019); Carbonari et al. (2019); de Mesquita et al. (2018); Esch et al. (2017); Hendrickson (2010)
	Not facilitated	There is no explicit method that allows for the reporting and contestation of biases	All others
Transparency	Outward	POU focuses on increasing transparency in public administration and decision-making	Acuto et al. (2021); Bixler et al. (2019); Esch et al. (2017); Estuar et al. (2017); Guillaume et al. (2016)
	Internal	PUO focuses on transparency about its data practices	de Mesquita et al. (2018); Sinha et al. (2012); Zaman et al. (2021)
Pluralizing ontologies of the city	Pluralizes urban narratives	POU facilitates residents to express their understanding, experience, and narratives of the city	Carbonari et al. (2019); de Mesquita et al. (2018); de Queiroz Ribeiro and dos Santos (2001); Uson et al. (2016); Wannemacher et al. (2018)
	Dominant urban narratives	POU departs from and presents a clear narrative understanding of the city. E.g. the 'smart city' or the 'right to the city.'	Esch et al. (2017); Ladu (2020); Ludlow et al. (2017)

observatories and engaged with – at least partially – issues related to urban water governance or management. For example, the city of Evanston's (USA) open data portal is a government-led data platform in which residents can consult and download data on a wide range of topics, including issues such as housing, urban ecology, transport, infrastructure, and urban (water) risks. Similarly, the platforms This is not an Atlas² and Observatorio del Derecho a la Vivienda³ (*Observatory of the Right to Housing*), share and collect information about urban transformation and the right to the city at large, including issues related to water governance.

For most of the platforms reviewed, the urban observatories serve as tools to establish communication and interaction between the water authorities and residents and increase public participation in the design and assessment of public policies to align with the ambition to promote *collaborative*

and *transparent* governance. This can either be approached from the perspective of government organizations such as municipalities or water service providers.⁴ For example, in Sevilla, Spain, the local water authority has initiated an Observatorio de Agua Sevilla⁵ (*Sevilla Water Observatory*). In addition to creating a digital platform, the Observatorio de Agua Sevilla has invited a group of organizations, ranging from private companies to civil society organizations, environmental groups, and neighborhood representatives, to participate in round table discussions about water governance in the region. Their website states that the observatory has specifically been created because of a belief that residents' participation is vital to legitimize decision-making processes and the design and adoption of public policies. These platforms are directly *embedded* in urban decision-making and facilitate residents' *engagement*. The 'external' observatories, such as the Observatorio Urbano (*Urban Observatory*) of the Peruvian NGO Desco,⁶ are generally initiated by civil society and have the ambition to influence public decision-making but operate as external, critical entities towards the government.

Three observatories explicitly indicated how users could practice their *right to (in)visibility* by providing information about how personal data can be rectified or erased. Practically, the EU and Australia-based observatories do so by referring users to legal frameworks that offer data protection or privacy rights (e.g. the EU General Data Protection Regulation or the Australian Privacy Principles). Two observatories did refer to the right to privacy but did not provide any further information about how data can be deleted or altered. The other observatories did not provide any information about privacy and data policies within the platform.

In addition to gathering information and establishing communication between the water authorities and residents, the observatories are used as tools to inform residents about challenges in urban and resource governance and the responsibilities residents have. See, for example, Connect Coliban⁷ and the Unity Water Community Hub,⁸ two platforms initiated by water service providers in Australia. The Unity Water Community Hub serves as a platform to involve residents in various projects ranging from a people's panel where residents can inform the Unity Water by answering a bi-annual survey. In addition, they aim to educate consumers about water security, responsible water consumption, and water management in irrigation and infrastructure. Similarly, Connect Coliban, the community platform of the water provider in the northern part of Victoria, Australia, has set up citizen science initiatives to monitor the condition of the waterways and estuaries in the region. They use different strategies for community engagement, including visits to the towns, citizen science projects, surveys, and online educational games about tap water.

Three of the 11 observatories stand out with regard to their efforts to increase *transparency*. The Observatorio del Agua Sevilla, City of Evanston's Open Data Portal,⁹ and Decide Madrid¹⁰ (*Madrid Decides*) all aim to contribute to outward transparency by *increasing access* to government data and granting insight into public decision-making. In addition, these platforms work towards internal transparency through their openness about their data practices, even providing an API for developers to access the data and code. The latter two also invite developers to access the platform and share their assessment of the observatory's architecture. In addition, the Connect Coliban, Decide Madrid, and City of Evenstrom's Open Data Portal contained a digital form through which users were invited to provide feedback, suggestions, or critique to the observatory. Thereby facilitating the *contestation of internal biases*.

Finally, we identified six observatories working towards the *pluralization of ontologies* about the city and water infrastructure. These platforms take diverging approaches to go beyond informing residents and increasing transparency and creating spaces for people to voice their visions, opinions, or aspirations for the city. For example, the Observatorio del Derecho a la Vivienda focuses on urban issues in Mexico and seeks to systematize the collection and analysis of information about adequate housing across municipalities to facilitate reflection and dialogue on the matter. Additionally, Decide Madrid states explicitly that its aim is to build, through participation, dialogue, and inclusion, a better, more democratic, and plural city that seeks the shared commitment of a project of a city that improves the life and well-being of its residents. Amongst the civil society, research, or

collaboratively initiated platforms. This is not an Atlas collects and shares a wide range of counter-maps, drawing on critical and participatory methods, to portray alternative experiences of space and serve as tools to communicate needs and challenges hegemonic prepositions about cities. The Observatorio del Agua Mendoza¹¹ (*Mendoza Water Observatory*) explicitly states as their objectives that they want to promote the active participation of residents, paying particular attention to the participation of women, improve communication between residents and the water authority, help planning processes and management, directly and indirectly, related to water, and gather ideas for the continuous improvement of water resource management. And finally, going one step further, the Observatorio del Derecho a la Ciudad¹² (*Observatory for the Right to the City*) organizes public assemblies during which input is gathered for policy briefs and general demonstrations to express residents' discontent with current policies. Their digital platform – the website – functions as a tool to share information and mobilize residents to participate in physical gatherings and marches on the streets of Buenos Aires.

Overall, as illustrated in [Figure 3](#), we find that when reviewing the participatory urban observatories in practice, Decide Madrid stands out in the sense that residents participate in visibility-making as experts, it is explicit about the user's rights to (in)visibility, fosters collaborative issue formulation, is embedded in decision-making practices, facilitates the contestation of biases, is transparent, and contributes towards pluralizing the ontologies of the city.

7. Towards design principles for just participatory urban observatories for water governance

Both the analysis of the academic literature and the assessment of participatory observatories in the field of urban water management showcase the diversity of approaches to the development and design of participatory urban observatories. Applying Taylor's (2017) data justice framework and reviewing the participatory urban observatories based on the pillars (in)visibility, engagement, and non-discrimination helps in eliciting principles for the future development of similar observatories for public infrastructure governance in cities ([Table 2](#)). Combining the theory-informed data justice framework with a review of participatory urban observatories currently in use helped formulate more meaningful and applicable principles. Although purposefully formulated broadly to be applicable for a wide range of urban issues, we are particularly interested in thinking through how these principles can help design participatory urban observatories that bring to the surface issues that otherwise go unseen, help formulate shared solutions for water insecurity, while preserving ontological pluralism with regard to water.

First, regarding the issues of (in)visibility making and residents' active participation, it is important to consider how the knowledge residents have regarding water management by way of daily life can be translated into an observatory. Specifically, our analysis shows we must think of how the policy actions related to the water infrastructure and the distribution of water in the city can be articulated with residents who seek water justice and have been critical in the development and management of the system for a long time. However, it is important to consider how to record the stories and needs of residents and organizations. Specifically as 'voices from the neighborhood' might be difficult or impossible to record in indexes or maps. As shown by several case studies reviewed, this can be addressed by diversifying the data collection visualization and sharing approaches in line with the needs and abilities of residents.

As we reviewed the application of participatory observatories in urban settings, it is important to note that, in cities, the limitations regarding access to digital infrastructures such as mobile devices and the internet are significantly lower than in rural communities (ITU, 2021). As a result, the results from our analysis are also limited to this context. When exploring the application of participatory observatories in rural settings, other standards for participation and access may apply.

Second, urban observatories are part of larger spatial data infrastructures and should be embedded in governance and management processes (Kitchin et al., 2015). Our analysis shows

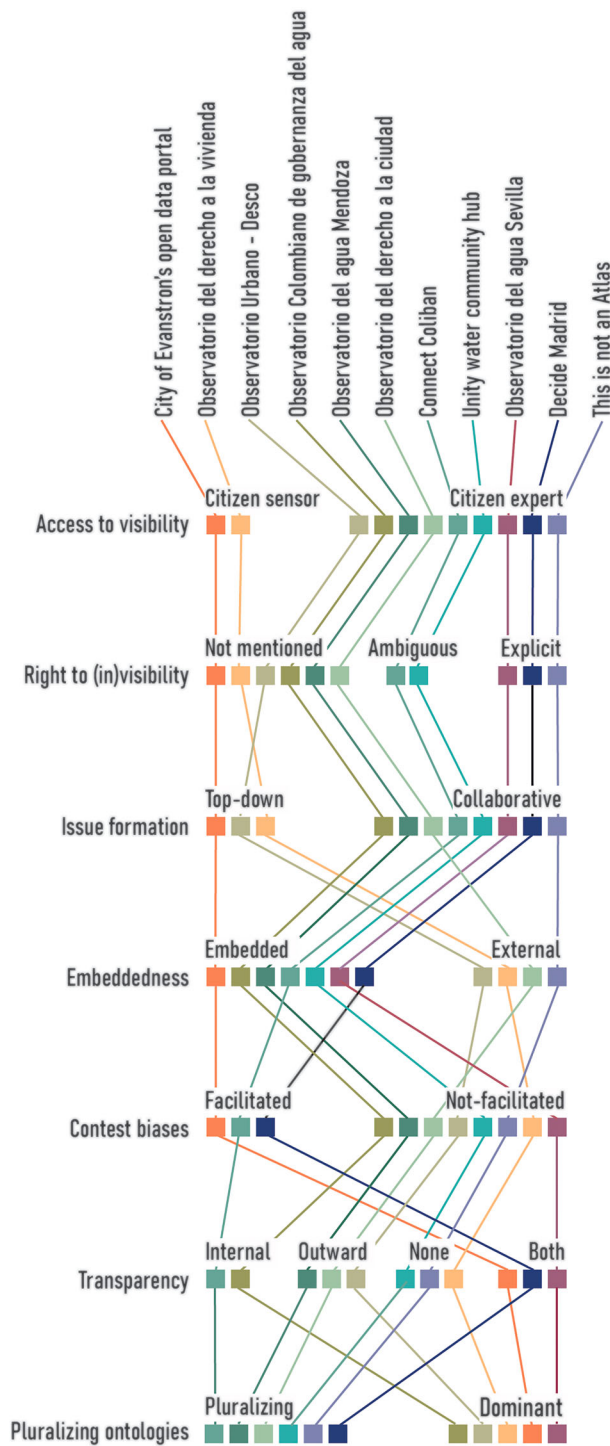


Figure 3. Analysis of urban water observatories from practice. Graph design inspired by de Mesquita et al. (2018).

how the anticipated impact of the reviewed observatories generally lies in the potential to create new partnerships and open up routes of communication between government actors and residents. Following examples of the civil society and collaborative platforms that we reviewed (Bixler et al.,

Table 2. Data justice informed principles for designing participatory urban observatories (PUO).

Data justice dimensions		Design principles
1	Right to (in)visibility and to opt-in or opt-out	PUO explicitly mentions how residents can opt-out, be (in)visible, or only have some of their data shared. Specific attention should be granted to visibilizing the experiences and perspectives of marginalized communities
2	Participation in and access to data practices	Residents are approached as expert observers within the city, stimulating their active participation in all stages of developing a PUO: from defining what needs to be observed to the interpretation, use, or validation of the information collected
3	Embeddedness in decision-making practices	PUO fosters relationships and communication between actors and feeds into public planning and decision-making processes
4	Issue formation	PUO works towards empowering residents to voice their aspirations for their city and mobilize knowledge to tackle challenges within their environment and urban governance
5	Contestation of biases	PUO facilitates the contestation of internal and external biases
6	Transparency about data practices	In addition to contributing to administrative transparency, PUO is transparent with regard to the definition and selection of indicators, and the generation, processing, and use of data. Ideally, this translates into opening the data, algorithms, and codes of the platforms
7	Pluralization of ontologies of the city	PUO facilitates the expression of plural ways of understanding and knowing the city and is part of a dialogue about the city

2019; Brown-Luthango et al., 2013; Castell et al., 2015; Hendrickson, 2010; Pihlajaniemi et al., 2017), this means working in collaboration with organizations that have been involved in community work and building on the existing structures in the city. Additionally, this implies that observatories need to consider the socio, political and geographical context to which the technology is introduced.

Third, if we trust participatory observatories to contribute to data justice, they need to open up to everyone: groups with different skills, capacities, and backgrounds should be able to participate in data practices, issue formation, and check internal and external biases. It is not just important for people to have access to participatory observatories, but that the systems are in place for them to be able to use them in ways that fit their needs considering accessibility, availability, awareness, agency, and affordability (Roberts & Hernandez, 2019). Applied to the case of urban water governance, this means that also people who are not customers of the formal water system and thus fall outside of the SCADA system should be actively included in these processes. Incidentally, this requires transparency about data practices and the architecture of the observatory.

Finally, while many observatories described in the literature and practices allow for higher levels of engagement and create spaces for residents to express their ideas about how urban infrastructure should develop, only very few of the platforms reviewed aim to, and potentially succeed in, upending the dominant ontologies of the city. Others rarely exceed the dominant indicators of infrastructure management, such as efficiency and accountability. Inspired by the observatories Observatorio del Agua Mendoza, Decide Madrid, and This is not an Atlas, which stand out in their effort to challenge hegemonic thinking and invite plural imaginaries for water governance or the city at large, we argue participatory urban observatories should go beyond the goal of improving resource preservation and the more just distribution of water within the city to enhancing the accountability of decision-making and planning processes. Steps to be taken are increasing transparency, encouraging participatory governance through residents' empowerment and engagement, and facilitating plural ways of understanding and knowing water and the city. This implies that the participatory urban observatory if contributing to responsible and just infrastructures should be part of an ongoing and two-way dialogue about the city and public values (Baibarac-Duignan & de Lange, 2021), which departs from an equal collaboration between epistemic communities (Jimenez, Delgado, et al., 2022). In this dialogue, observatories can serve as a space where knowledge is constructed, challenged, negotiated, validated, and consulted (Miranda Sara & Baud, 2014).

The principles in Table 2 help us design systems that serve to visualize water flows and allow residents to increase visibility while maintaining control, address grievances, reduce inequalities, and suggest alternative approaches and ontologies for water governance. If participatory urban

observatories want to contribute to the ambitions of a just city and create a space for residents to engage with and contribute to the governance of urban infrastructures, they will need to be designed according to the principles of data justice. However, future research should consider how we can design urban observatories that recognize the knowledge of marginalized communities and more-than-human entities.

While the design principles depart from the aim to contribute to bridging the divide between data justice in theory and practice, translating the principles into an artifact will require reviewing their value and applicability to the specific context for which the observatory is designed. For those designing participatory urban observatories, this points toward the importance of contextualization and critically considering the design principles in relation to governmental and infrastructural conditions that promote or obstruct participation and peoples' capabilities.

Specifically, with regard to design principles 2 and 3, it entails evaluating how meaningful participation and engagement can be facilitated in the socio-political and geographical context of implementation. Our analysis of case studies has focused predominantly on countries with (relative) strong democratic institutions. As these conditions vary widely across the globe, a specific issue that should be considered is the local expression of citizenship and the opportunities and risks related to active involvement in issue formulation and governance.

8. Conclusions

In this article, we reviewed the design of participatory urban observatories in academic literature and practice and their implementation in urban governance. Although these issues have been previously explored with regard to the usability of dashboards for different types of residents (Young et al., 2021), their participatory functionalities (Lock et al., 2020), and various design features (Barns, 2018; Young & Kitchin, 2020), we contribute to these discussions in two ways. First, we applied Taylor's (2017) data justice framework in practice to evaluate participatory urban observatories. This not only guides the review of participatory urban observatories and how they follow the principles of (in)visibility, engagement, and non-discrimination. It also helps understand the overlap between the three pillars of data justice. As illustrated in Figure 1, the creation of an urban observatory that contributes to participation, collaboration, transparency, and plural ontologies of the city is only possible if all three pillars of data justice are adhered to. Secondly, we translate the data justice framework into principles for the design of just urban observatories in the domain of water governance. Participatory urban observatories do not necessarily provide full coverage or 'objective data' but can play a role in communicating the experiences and views of residents currently not represented in digital data and facilitate collective knowledge creation, negotiation, validation, and contestation. This is valuable in the context of the datafication of urban infrastructural governance and, particularly, the use of SCADA systems for water governance in cities.

The principles presented in this paper draw from both theory and practice and highlight the importance of creating smart city interventions collaboratively to avoid reproducing unjust systems and to imagine new ways of enacting a more just city that recognizes plurality in ontologies and imaginaries of the city (Milan & Treré, 2019). It is important to emphasize that, while just participatory urban observatories can potentially function as infrastructure to facilitate these steps, they are implemented in the wider political-economic landscape and do not remove power asymmetries between actors (e.g. government, NGOs, and citizens). Therefore, in designing participatory urban observatories, we should continuously examine power relations and question the technology's contribution to development.

Notes

1. <https://observatoriodelagua.ciudad.org.pe/>.
2. <https://notanatlas.org/maps/collaborative-cartography-in-defense-of-the-commons/>.

3. <http://www.observatoriodevivienda.org/>.
4. <http://www.ideam.gov.co/web/ocga/inicio>.
5. <https://www.emasesa.com/conocen/observatorio-del-agua/>.
6. <https://observatoriourbano.org.pe/>.
7. <https://connect.coliban.com.au/projects>.
8. <https://communityhub.unitywater.com/>.
9. <https://data.cityofevanston.org/>.
10. <https://decide.madrid.es/>.
11. <https://www.observatorioaguamza.com/es>.
12. <https://observatoriociudad.org/>.

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ORCID

Fenna Imara Hoefsloot  <http://orcid.org/0000-0002-3373-3580>

Andrea Jimenez  <http://orcid.org/0000-0002-2166-8574>

Javier Martinez  <http://orcid.org/0000-0001-9634-3849>

Karin Pfeffer  <http://orcid.org/0000-0002-6080-1323>

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