The *Observatorio Metropolitano de Agua para Lima-Callao*: a digital platform for water and data justice

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Abstract: This paper details the development and design of the Observatorio Metropolitano de Agua para Lima-Callao (the metropolitan water observatory for Lima-Callao, MWO). The MWO is a digital, collaboratively developed observatory that aims to collect and share data about water access and infrastructuring practices within the metropolitan city of Lima-Callao, Peru. The purpose of developing the MWO has been to contribute to a fairer distribution of water resources amongst urban residents by creating an 'espacio de concertación' and collect and diffuse data on access to and quantity and quality of water for human consumption. By combining collaborative design approaches with the theory-informed data justice principles, we have been able to develop a prototype of the MWO. In general, this teaches us how to design digital platforms according to the principles of data justice in practice.

Keywords: data justice, urban development, digital platforms, water, design, Lima.

1. Introduction

In this paper, we detail the design of the Observatorio Metropolitano de Agua para Lima-Callao (the metropolitan water observatory for Lima-Callao), hereafter referred to as MWO. This is a digital, collaboratively developed observatory that aims to collect and share data about water access and infrastructuring practices within the metropolitan city of Lima-Callao in Peru. The purpose of developing the MWO has been to contribute to a fairer distribution of water resources amongst urban residents by exploring the potential of collecting and diffusing data on the access to, quantity, and quality of water for human consumption in the metropolitan area Lima-Callao.

Over the past years, SEDAPAL, Lima's water company, has implemented a supervision, control, and data acquisition system (SCADA) to manage the water flows within the city. The use of digital technologies for water management, and the focus on data-driven decision-making, have been valued in Lima. With the help of this digital infrastructure, SEDAPAL has reduced non-revenue water significantly, improved the billing system for residents, and can respond faster to break-down or leakages in the system [1]. This is vital in a city of over 11 million people built in the desert.

However, previous research has shown how the datafication of Lima's water infrastructure, understood as the quantification of flows within the water distribution system, in Lima reproduces the structural inequalities within the water infrastructure, contributes to the further peripheralization of the non-digital city, and only partially accounts for other epistemologies, and water governance approaches [2], [3]. Within these conditions, an important portion of Lima's residents is not only structurally underserviced but also structurally underrepresented in the data about the water distribution in Lima due to a lack of registration or the absence of a water meter.

These gaps in the data have significant consequences for urban water consumers. Unregistered water consumers generally have less security over the quantity, quality, reliability, and continuity of the water service and, if registered but unmetered, are rationed by the water provider. While there are a number of tools that accommodate the data collection on unplanned urbanization and clandestine water infrastructures (e.g., drones and geo-radars) used by the water company [3], to date, there is no tool that facilitates the collection of data in collaboration with, and from the perspective of, the water consumers. Therefore, the central question explored in this research and the development of the MWO is: how can we design a platform that incorporates plural perspectives regarding water management to contribute data on water access, helps raise awareness of existing inequalities, and contributes to fairer policymaking? Specifically, if we consider water justice not only as the equitable socio-economic distribution of water but also the acknowledgment of plural perceptions, experiences, and normative approaches to water governance [4], it is vital to consider what knowledge we base water management decisions on.

2. Developing citizens' observatories

The MWO sits within a larger tradition of citizens' observatories and participatory urban dashboards, which aim to generate and exchange knowledge about cities or aspects of cities worldwide. These tools, which often take the shape of digital, geo-spatial information systems for collecting and sharing urban data, range in scope, levels of participation, interface, and contextualization. They can address place-specific issues unique to a particular urban context, such as the observatory for the Italo-Argentinian influence on architectural heritage in Buenos Aires [5]. Other urban observatories take a more comprehensive focus on urban governance and management or focus on particular infrastructures or urban phenomena (e.g., sound, air quality, housing stock) across cities [6–8]. Similarly, there is a wide range of ways to involve urban residents in the data practices of an urban observatory. Citizens can contribute passively through volunteered geographical information from sensors embedded in household appliances or mobile phone devices. In other cases, citizens take up a more active role by co-defining what needs to be observed and interpreting, validating, and using the data collected [9, 10]. Yet, most citizens' observatories and participatory dashboards share the common goals of wanting to increase transparency in policymaking by facilitating the exchange of information between stakeholders, mobilizing knowledge to tackle challenges in urban governance, and empowering citizens to voice their aspirations for their city [11].

Mattern [12] and Couldry and Mejias [13] explain how despite the fact that many digital technologies that have emerged during neoliberalism reproduce the long-term asymmetries in knowledge production along the lines of coloniality and capitalism, it can be fruitful to develop critical and experimental observatories or dashboards. The contribution of these platforms may not lie directly in the accuracy of the data generated, but rather in showing the messiness and complexity of the city, and visualizing a perspective on the city that is often unrepresented [12].

We do not deny – in fact, we emphasize – that creating a digital infrastructure to critically engage with digital infrastructure is paradoxical. Our research is inspired by experiments in 'statactivism,' which mobilize statistics' power for emancipation [14], and critical data sciences which specifically generate and reappropriate demographic data to visiblize and support feminist [15] and decolonial struggles [16]. These movements use data, indicators, and coded categories – compelling tools of the modernist state – to alter policy discourse and challenge the perceived neutrality of comparative statistics [14]. Making a platform teaches us about the limitations of the current data infrastructure. It is

crucial to develop new socio-technological artifacts that can assist the act of imagining alternative narratives of data technology [13] and further theory about the role of datafication on water access.

There are many methods and approaches for designing citizens' observatories, usually following design science, collaborative design approaches, human-centered design, or emerging out of activism. This research adopted a collaborative process that follows similar principles as design science applied in action research and ICT4D. Originally stemming from engineering disciplines, design science research approaches the development of an artifact as the outcome of research, as well as the methodology to theorize about the environment in which the artifact is intervening [17]. Design science research departs from the premises that the process of design teaches us about the technological rules embedded in the artifact, how theoretical approaches are operationalized in practice, and in doing so, contributes to developing a more comprehensive body of knowledge and more useful design principles. While traditionally, design science research engages primarily with innovative solutions for business challenges, it has also been applied in cases that concern socio-economic problems and seek to contribute to technological interventions for human development [18], [19]. Sein et al. [18] and Islam and Grönlund [19] show that in aligning design science approaches with action research or ICT4D, the process of constructing an artifact is iterative. Rather than approaching the design process as a set of separated steps in sequence, the experience with design science research for action or development emphasized how the artifact developed is 'contextually situated and socio-technically enabled' [19, p. 140]

Our primary focus throughout all stages of the research is water and data justice. The reason we depart from these two central values is because water justice calls for a 're-politicization' of water governance in which not only the unequal distribution of water is made visible, but also the inequalities in political and economic power to influence water policies [20]. Hence, data on water should also be sensitive to and represent how people relate to water and participate in its governance. The current data technologies do not necessarily work towards increasing water justice but towards improving the efficiency of water distribution. It is too easily assumed that efficiency will eventually lead to water justice. Hence, while the goal of efficiency might be translated to more digital technologies and closing data gaps, the goal of water justice requires a different approach. One which acknowledges both the fair distribution of water as well as the plural ontologies of water [4].

We follow Taylor's [21, p. 1] definition of data justice as the "fairness in the way people are made visible, represented and treated as a result of their production of digital data." Specifically, Taylor [21] and Kitchin and Lauriault [22] emphasize that data need to be approached from a relational perspective, acknowledging how data infrastructures are part of the larger political, social and physical landscape and are inscribed by politics, power, and interests. In addition to explicitly paying attention to tensions and the lack of transparency in data practices [23], data justice requires fostering democratic dialogue and civic engagement [24]. It follows that the MWO does not strive towards 'objective knowledge' or a fully digital representation of the formal and informal water distribution system. Instead, it aims to engage critically with the current hegemonic representation of Lima's water infrastructure and establish itself as an 'espacio de concertación' [25] (space for concertation) or 'data subaltern' [26] to help communicate the experiences and views of residents currently overlooked. In doing so, the MWO builds on volunteered geographical information [27]. This work-in-progress paper will detail our collaborative design approach in developing the MWO and explain how the data justice design principles have been translated into the platform's design.

3. Methodology

In the development of the MWO, we bring together two knowledge bases. The first is from residents and experts in the field of water management through a collaborative design process. The second are data justice design principles formulated after a review of participatory urban dashboards and observatories in academic literature and practice. This review was conducted at an earlier stage of this research (manuscript under review). As seen in Table 1, the design principles depart from the three elements of Taylor's [21] data justice framework: (in)visibility, engagement, and non-discrimination. The design principles capture the generic characteristics the artifact should have through which the project objectives, in our case data justice, are met and dictate its technical features [28]. This offers several implications for the development of participatory observatories, their institutionalization, and the features they should contain.

The dimensions of the data justice referring to issue formulation, the embeddedness of the MWO in decision-making practices, the contestation of biases, and the pluralization of ontologies of the city, are not as much part of the design of the MWO as they are integral to the collaborative process of developing the platform. Therefore, the development of the MWO, guided by the aim to critically engage with and challenge the current representation of the water distribution system in data, has started with the collaborative formulation of the main issues and context of use that should be addressed. In the continuous conversation with the residents and civil society organizations we collaborate with, we aimed to create space to contest the biases in the development of the platform and the data collection practices. Additionally, with the current prototype of the MWO, we aim to establish further partnerships with government and non-governmental institutions in the field of water management in Lima to embed the platform within decision-making practices.

In line with the principles of design science as applied in action research and ICT4D, we structure the methodological approach into four stages: (i) problem formulation, (ii) building, intervention, and evaluation, (iii) reflection and

learning, and (iv) formalization of learning [18]. As we are yet to launch the MWO in Lima and Callao, we can only describe the first two stages in this paper. The final two stages – both essential elements of design science [17] - focus on the evaluation of the adherence to the principles and contribution to theorizing about design principles for data justice and abstracting what we have learned for understanding water governance in Lima and Callao will be the focus of future work.

The collaborative design process took place between December 2019 and December 2021 (see figure 1). The first stage is primarily characterized by the exploration of the issues to be addressed in the MWO and the building of relationships (steps 1 and 2). The second stage (steps 3 - 6) focused on the formulation of the main needs and possible interventions from the perspective of the residents, translating these insights into the design and development of the digital platform, and moved towards evaluating the prototype and exploring the options to embed it institutionally within the water sector in Lima.

We formulated the functionalities of the MWO and the goal it should achieve in close cooperation with residents and civil society organizations in Lima. We work together with residents from three areas in Lima: José Carlos Mariátegui, Barrios Altos, and Miraflores. José Carlos Mariátegui is a largely organically built, peri-urban area characterized by high degrees of informality and poverty. Barrios Altos, part of the historical center of Lima, is a lower middle class to poor community in which the majority of the households are connected to basic utilities. Finally, Miraflores is the commercial and tourist center of the city with mainly middle to upper-class residents. Together, these three areas represent Lima's diversity regarding socio-economic living conditions and diverging degrees of geographical and political centrality. The suggestions from the focus groups from these three districts for the functionalities and design of the platform were systematized and categorized based on their priority to reach the aims of the MWO and their feasibility by the research team. This formed the input to the design of the MWO, implemented by the developer and the designer in step 4.

Additionally, we evaluated the MWO through interviews with experts in water management and urban development in Lima and experts in geo-information systems and application development. During these conversations, we mainly focused on evaluating the usefulness and utility of the MWO for policymakers and explored potential collaborations with relevant institutions in the field of water management in Lima-Callao. The outcome of these evaluations has iteratively been implemented in the design of the MWO.

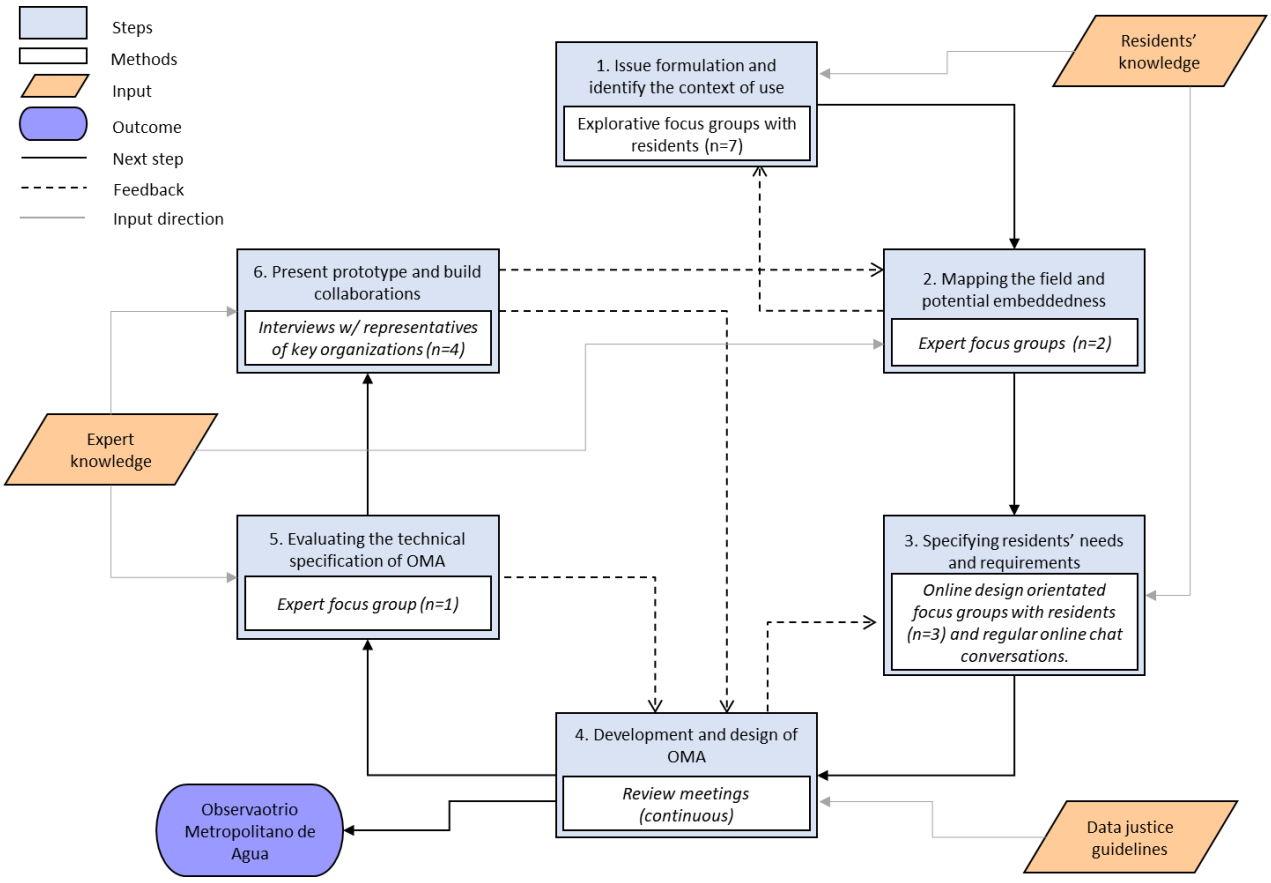

Figure 1. Workflow and methods followed in the development of the MWO. The feedback loops indicate the various iterations of each of the steps taken.

4. The design of the Observatorio de Agua Metropolitana

In this section, we mainly discuss how certain data justice design principles for Participatory Urban Observatories (PUO), specifically the right to invisibility, participation in and access to data practices, the contestation of biases, and the transparency about data practices, have been implemented in the collaborative design of the MWO. Table 1 summarises the data justice design principles and their implementation in the MWO. As indicated in figure 1, we are currently in the phase of presenting the prototype of the MWO to experts on water management or digital platforms and establishing routes for further collaborations with key actors in the field of water management in Lima.

Table 1. Implementation of data justice design principles (derived from Taylor's data justice framework [21]) in the Observatorio Metropolitano de Agua.

Data justice dimensions	Design principles	Implementation in MWO	Example of implementation
1 Right to (in)visibility and to opt-in or opt-out of the data	PUOs should explicitly mention 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.	The MWO is designed to be accessible and usable for people without advanced digital skills and people living in informality.	In addition to textual and numerical data, users can share pictures of the water infrastructure to diversify ways of visibilizing their experience. Users can send a request to have their submitted data removed or revised. We guarantee location privacy by adding 'noise' to the spatial data.
2 Participation in and access to data practices	Citizens should be approached as expert observers within the city, stimulating their active participation in defining what needs to be observed and interpreting, using, or validating the information collected.	Residents can share and download data and knowledge in multiple features and formats, allowing for diversity in ways knowledge can be shared, altered, or challenged.	The MWO includes various data sharing methods, e.g., the data input form, the chat function, uploading photos, or using dedicated hashtags on social media platforms. Data can be downloaded in Geo-JSON, Excel, and PDF.
3 Embedded in decision-making practices	PUO should foster relationships and communication between actors and feed into public planning and decision-making processes.	The MWO is a collaborative project between civil society and research.	We are currently in the process of formulating further partnerships with governmental institutions to embed the MWO in decision-making practices.
4 Issue formation	PUO should work towards empowering citizens to voice their aspirations for their city and mobilize knowledge to tackle challenges within their environment and urban governance.	We have consulted residents in the early stages of development on what the main issues covered in the MWO should be. We are working towards supporting citizens' capacity to use the MWO data for development.	Citizens' input has directly informed the questions in the data input form. We provide guidelines for using the data for advocacy and will organize a knowledge-sharing workshop.
5 Contestation of biases	Participatory urban observatories should facilitate the contestation of internal and external biases.	Externally, the MWO focuses on the biases and injustices in the water distribution system. Internally, we collaborate with various stakeholders to detect biases.	Users can access and use the data for analysis or advocacy. The collaborative approach and features like the chat function allow discussing biases within the MWO.
6 Transparency about data practices	In addition to contributing to administrative transparency, participatory urban observatories should be transparent concerning data generation, processing, and use. Ideally, this translated into opening the platforms' data, algorithms, and codes.	The MWO is built on open-source software. The data collected is openly accessible. The source code of the MWO will be shared under a creative commons license after finishing the development.	We use GeoServer, PostGis, Openlayers, and Open Street Maps as the main building blocks for the MWO.
7 Pluralization of ontologies of the city	PUO should facilitate the expression of plural ways of understanding and knowing the city	The MWO is developed to critically engage with the hegemonic datascape of the water distribution system in Lima.	The MWO works towards diversifying the knowledge about water distribution by using indicators developed by citizens, focusing on representing the needs of people currently not represented in the data,

The prototype of the MWO, i.e., a dedicated web application, includes an interactive map, layer management, a form for data input from residents, a forum for interaction between users, and social media integrations. Figure 2 shows the MWO interface layout where the interactive map with data from the 2017 census is the main component. Users can expand the map to cover the full-screen width, zoom in and out, (de)active or adjust the transparency of various data layers, switch between base maps, and click on data points for more information. A legend, scale bar, and information box have been included at the bottom of the map.

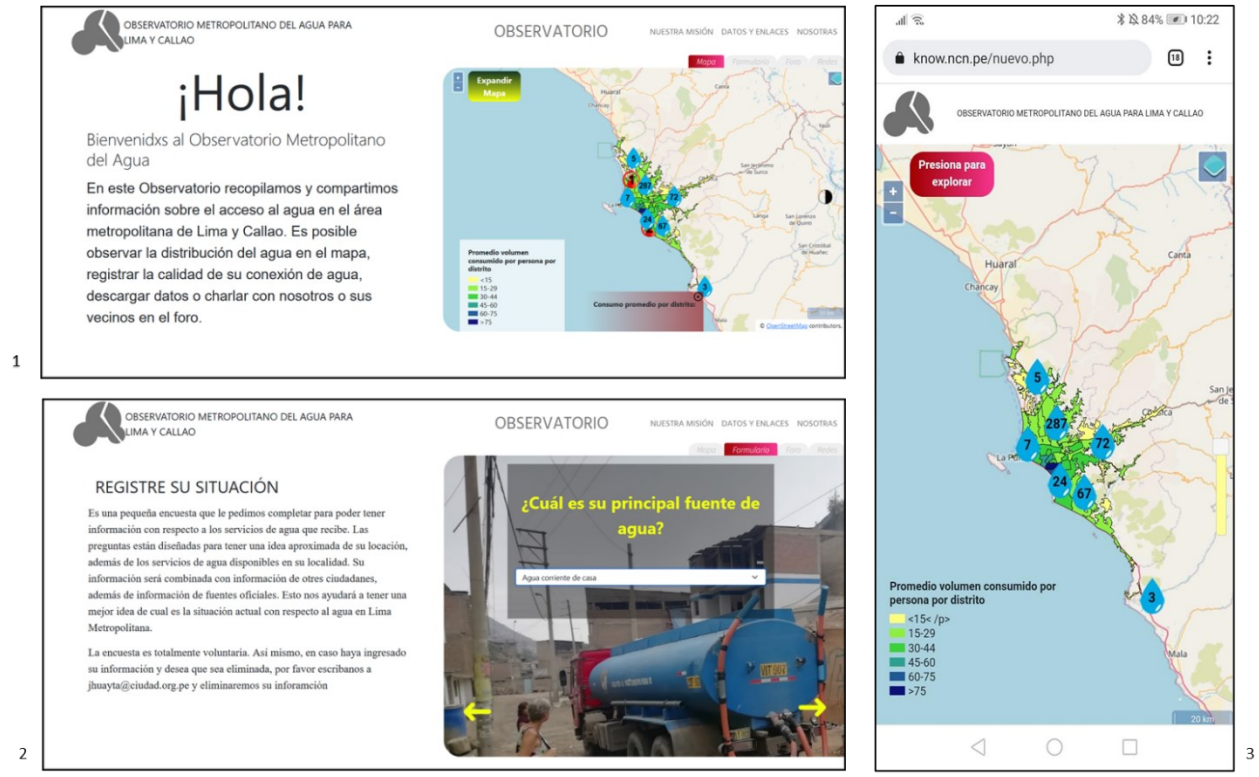

Figure 2. Screenshot of the MWO prototype. Picture 1 shows the homepage with the map presenting data in a desktop browser. Picture 2 shows the data input form in a desktop browser. Picture 3 shows the homepage and map presenting data in a mobile phone browser.

4.1 Right to (in)visibility

In relation to the principle of the right to (in)visibility, there are some critical considerations in the data input form that we would like to highlight here and how we have tried to translate that into the design of the MWO.

First of all, the right to (in)visibility refers to the ability of residents to determine what data they would like to include in the MWO database. The MWO accommodates this by offering various ways of sharing information. First, residents can start by filling in the data input form. In addition to closed questions regarding, among others, the residents' access to water, the continuity of the service, and its organization, the questionnaire also includes an open question where residents can share any further information or suggestions for improving the water distribution system and upload a photo of their water infrastructure. The questions in the data input form were formulated in collaboration with participants and reflect that people get water in various forms. To be able to get a more diverse set of experiences, we developed different questions depending on where and how respondents get water from. The list of questions automatically adjusts depending on the answer selected.

Secondly, residents can share information and experiences more directly and openly in the chat forum. This forum is accessible to all people who register with the MWO. A registration function was necessary to block bots from taking over the chat function. Nevertheless, we have made it possible to register with a name or pseudonym and password, not requiring an email address or any other personal information, to protect users' privacy and lessen participation barriers. Third, the right to invisibility is adhered to by offering residents the option to delete data they have shared at any prior moment.

4.2 Participation, access, and transparency to data practices

The MWO aims to increase the voice of people as experts within their communities, particularly to make the MWO accessible to all residents of Lima. For residents who receive water via various infrastructures, including informal systems, this has implications for the ways we collect and protect their information. First of all, to include residents who

do not have a formal residence or registered address, we offer the option to geo-locate their house in two ways. They can either allow the application to access and record their geo-location or place a point on the map themselves. This will enable residents who live in unmapped areas of the city to record their data as well. Note that providing this type of personal data is optional; users have to volunteer their geographical information in the data input form actively.

Secondly, for all residents, but in particular, for residents depending on clandestine water connections, it is paramount that their privacy is protected. Hence, aside from the location data, no personal data (data that can be traced to a natural person) is asked. Additionally, the locational privacy of the people who share their data is guaranteed by adding 'noise' to the geo-localization of the data points entered [29]. Each georeferenced data point is randomly distributed within a buffer of 20 – 50 meters wide around the original location (see figure 3). Since this noise is added automatically while entering the data, and the original location is never stored in the database, it is impossible to trace the exact location of the respondent. Hence, the addition of noise entails increasing the inaccuracy of the data to achieve a certain level of privacy. Nevertheless, a more accurate location is not needed to make visible the residential areas that are currently not yet officially mapped.

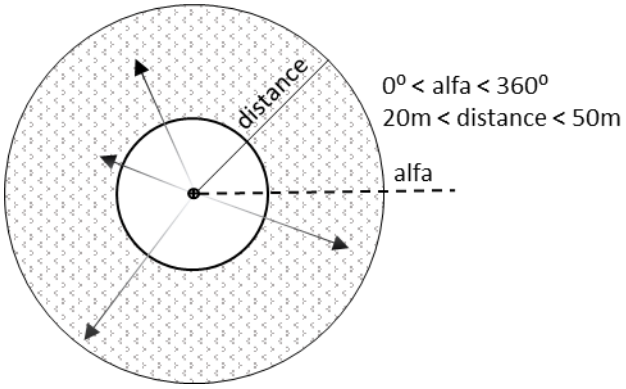

Figure 3. Schematic representation of the 'noise' added to the coordinates of the data to protect the location privacy of residents via geo-indistinguishability [29]. The original geo-location is randomly distributed within the buffer zone. Figure developed by co-author.

Additionally, regarding access, we have designed the MWO, keeping in mind the requirements of residents who are not digital-savvy or who have limited access to the internet. The direct implications this had for the design are: (i) the MWO should be accessible via a browser rather than an app since this requires less storage on a device, (ii) the MWO should be responsive in order to be accessible via desktop as well as mobile phone, (iii) we have included guidelines and plain-text explanations on all tabs and pages of the MWO, guiding the users about the use and application of the observatory, and (iv) the data from the MWO can be downloaded in different formats (geo-JSON, excel, and PDF) along with the requirements of a specific user.

In line with the ambition to increase transparency and openness in the collection and use of data about water distribution in Lima, the MWO has been designed to adhere to the principles of open science. In addition to the open data practices, this entails that the MWO is built on open-source products (including geo- and database servers), and the source code of the MWO will be made open after the launch of the platform.

5. Concluding remarks and next steps

By combining a collaborative design approach following the principles of design science with the theory-informed data justice principles, we have been able to develop a prototype of the MWO that aims to challenge the hegemonic representation of Lima's water infrastructure and help communicate the experiences and views of residents currently overlooked. In addition, the project of the MWO teaches us how to design digital platforms according to the principles of data justice in practice.

The MWO, as an artifact, took shape out of the interaction between researchers, activists, residents, and governmental organizations. The reflection and learning phase (stage iii) will mainly concern the accordance of the MWO with the criteria set: does it incorporate plural perspectives regarding water management to contribute data on water access, helps raise awareness of existing inequalities, and contribute to fairer policymaking?

For evaluating the MWO as ICT4D design science, Islam and Grönlund [19] propose asking the following questions: does the artifact research this goal? And what points to the fact that this is or is not complied with? The first question addresses the utility of the artifact. The second question guides us towards theorizing about how we can design data just platforms. Up to date, we have been able to present and test the prototype with representatives of key institutions in the field of water management in Lima. Following these recommendations, the next phase in the development of the MWO will consist of testing the observatory amongst the residents we have collaborated with. Additionally, for the MWO to

have transformative potential, even if incremental [23], it is key that the observatory becomes embedded in decision-making practices.

Sein et al [18] emphasize the importance of considering the artifact as emergent out of the organizational network and argue that to evaluate the contribution and utility of the tool in relation to the already existing SCADA system used in the water distribution system of Lima-Callao, we need to pay attention to its institutionalization within the network. For this, we will need to seek long-term partnerships with the aim to institutionalize the MWO as a space for concertation (*espacio de concertación*) [25].

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