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GARBAGE IN/GARBAGE OUT

The Hermeneutics of Visualisation Reading in Humanitarian Mapping and Interventions

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Abstract

Geographic information has become increasingly relied upon in supporting decision-making in public administration as well as humanitarian intervention. One domain where such information has been important is waste management, notably improving the mapping of areas with the highest waste accumulation, finding suitable locations for landfills as well as planning transport routes for collection services. The utility of geographic information here reflects the capacity of visual information to mediate between human actors (e.g. municipal authorities) and the world in which they wish to make changes . In this paper, we shall be presenting insights from five focus groups that were conducted to assess the impact of the visualisation of waste accumulation in the 'slums' and informal settlements in Nairobi, Kenya, along with factors that affected the readability and understanding of the visualisations presented in the focus groups. In this paper, we will be considering: i) the impact of design elements (e.g. level of detail and symbology) on raising problem awareness of the participants regarding the waste accumulation; and ii) the ethical and political concerns that arise from the way communities living in the DUAs are perceived from the visualisations

1 INTRODUCTION

In this paper, we analyse the use of maps in urban planning and policy intervention to improve the waste management process for vulnerable communities living in the "slums" and informal settlements of Nairobi, Kenya. UN-Habitat uses the following characteristics in classifying a 'slum household': a lack of secure housing tenure, lack of water and sanitation, overcrowding and inadequate structural quality of housing (UN-Habitat, 2018). Informal settlements are characterised by having no security of tenure (or ranging from squatting to informal rental properties), lack of formal basic services, and housing not compliant with building regulations or situated close to hazardous areas (ibid). But to go beyond looking at the individual household, Thomson et al (2020), Kuffer et al (2021) and Abascal et al. (2022) highlight the need for looking at deprivation in the surroundings of the household. This means looking at the exposure of communities to social, economic, environmental and ecological risks. Therefore, we will be referring to these areas as "deprived urban areas" (DUAs) hereafter.

Maps representing geographic information (geo-information hereon) gathered from satellites, drones, GPS devices and mobile phones have proven to be useful in waste management, as illustrated in the following examples. Oyinloye (2013) highlights the use of geo-information for logistical support in planning routes and transfer stations, along with locating and monitoring landfills in Owo, Nigeria. Richter et al (2019) explore the ranking and profiling of landfill sites and their potential for expansion in Canada, using captured regional data for data-driven decision-making. Singh's (2019) review article similarly points out the utility of geo-information in locating waste bins, making maps of land-use and socio-economic characteristics to find appropriate treatment plant sites as well as land utilisation rates.

Following this work, this paper investigates the use of geo-information in mapping the distribution of waste in four DUAs in Nairobi: Kibera, Kariobangi, Mathare and Majengo. The

choice to focus on these DUAs was based on spatial data showing the accumulation of waste gathered and provided by residents in the DUAs that were part of the Community Mappers organisation based in Kibera. These data were used as input for seven visualisations prepared for two studies involving focus groups with academic researchers and the members of Community Mappers. The purpose of the two studies was to present and assess the utility of the visualisations, each of which displayed varying levels of detail, and to find out from the participants which visualisations ranked the highest in providing an accurate representation of the waste problem. In this paper we aim to address two research questions: i) how do the visualisation techniques used raise awareness of the problem of waste in the DUAs? ii) what ethical and policy-related concerns arise from the design of the visualisations used?

In Section 1, we provide a brief outline of the contextual background of the situation in Nairobi, and the impetus behind the initiative to map out the distribution of waste in the four DUAs. In Section 2, we elaborate on the methodology used in the preparation and execution of the five focus groups. In Section 3, we explore how the varying levels of detail, symbology and competencies of the participants influence the 'reading' of the visualisations through the lens of mediation theory (Verbeek, 2008; Rossenberger, 2008; Rossenberger, 2015; Kiran, 2015; Verbeek, 2016; Ihde, 2020; Romele, 2020) and hermeneutics more generally (Dilthey, 1972; Introna, 1993; Chalmers, 2004; Friis, 2015; Gil, 2017; Rodigheiro and Romele, 2020). Mediation theory analyses how the technologies we use actively shape our self-understanding along with our understanding of the world, and simultaneously how these technologies are shaped by us as well (Verbeek, 2008; Verbeek, 2016). This 'shaping' occurs in an array of human-technology relations explored in postphenomenological literature, and in this paper we focus on the hermeneutic relations revealed in the reading of data visualisations. Using the framing of Kiran (2015), we investigate how the seven visualisations used in the focus groups hermeneutically magnify or reduce how the waste problem is interpreted and understood. Furthermore, our discussions with the participants also revealed the ethical consequences of deciding which attributes to include within the visualisations. We explore these consequences, focusing on assessing the range of responsibilities involved in the mapping process regarding: i) the role of the map designer; ii) the role of municipal authorities; iii) the extent to which the visualisations can endanger the communities within the DUAs, and iv) how the design of the visualisations can empower the communities represented within them.

2 CONTEXT OF WASTE ISSUE IN NAIROBI, KENYA

Rapid urbanisation from the late 20th century contributed to Nairobi, the capital of Kenya, becoming an attractive area for Kenyan citizens to migrate to. But the massive rural-urban influx, along with poor urban planning and lack of space for expanding the city's boundaries, left many citizens without adequate support or utilities from the municipal authorities (Hiltunen, 2010, p.17). One of the most direct consequences of this was the rise of densely populated and underserviced areas referred to as 'slums' or informal settlements (Ajami et al., 2019; Kuffer et al., 2017), which we will be referring to as DUAs. The apparent invisibility (i.e. in official censuses and maps) of these communities leaves them with a tenuous status, as they are not always considered to fully belong to the city. The responsible for mitigating these lacklustre conditions in Nairobi is the Nairobi City Council (NCC), whose policy and planning decisions influence the livelihoods of the urban poor (Hiltunen, 2010, p. 8; Kazungu, 2010, p. 2).

It is due to this lack of recognition and delivery of services to meet the needs of those living in DUAs that waste accumulation is a crucial environmental problem for the communities living in these areas. As UN-Habitat points out, "the safe removal and subsequent management of solid waste sits alongside the management of human excreta (sanitation) in representing two of the most vital urban environmental services" (UN-Habitat, 2010, xx). As waste accumulation

continues to increase and the municipal authorities of NCC offer no assistance, it became necessary for residents of the four DUAs in Nairobi that this paper focuses on to take the matter into their own hands. These DUAs are Kibera, Mathare, Majengo and Kariobangi. Community Mappers, an organisation based in Kibera consisting of residents of the DUAs, works on qualitative and quantitative surveys for spatial data gathering. They began a survey of the four DUAs, performed along with international researchers from the IDEAMAPS Network in August 2021, with the aim of mapping the waste accumulation and presenting the geo-information to municipal authorities in order to prompt increased collection services. Turning to the use of geo-information in supporting these communities has been a long-running activity, with many studies dedicated to this (Gevaert et al, 2018; Kuffer et al, 2017; Leonita et al, 2018; Mboga et al, 2017; Thomson et al, 2020). DUAs remain underserviced for a number of reasons as already mentioned, one of which is the lack of accurate and up-to-date data on their conditions. Geo-information gathering and distribution are therefore part of the mission to create greater visibility of the problems these communities face.

3 METHODOLOGY

Five focus groups were organised to gather insights from invited participants on seven prepared visualisations. These focus groups were divided into two studies, with the first four focus groups being part of study 1 and the last focus group being part of study 2. The choice to perform focus groups was made in order to gather more data from the invited participants at the same time, compared to interviews (Morgan, 1996). In Section 2.1, we elaborate on our design choices for the visualisations. In Section 2.2, we explain the design of both studies. In Section 2.3, we cover the selection and demographic data of the participants that were invited. In Section 2.4, we cover the protocol and highlight the materials used to conduct both studies. In Section 2.5, we provide a summary of the results from both studies, which will be more extensively elaborated on in Section 3.

3.1 DESIGN CHOICES

We based our visualisations on three design topics. These are: (1) the use of overlay mapping, highlighting how this technique is perceived; (2) the use of images or text, emphasising the different ways of processing in the human mind; and (3) the inclusion or exclusion of details, specifically looking at how privacy plays a role in visualising geo-information. For design topic 1, we considered how overlay mapping plays a role as a necessary component for a visualisation to stimulate engagement. For design topic 2, we assessed whether images stimulate more engagement than textual attributes. For design topic 3, we examined how the level of detail influences the readability and usability of a map, and how this affects the level of participant engagement.

3.1.1 THE USE OF OVERLAY MAPPING

It is common practice to use map layers to organise geographic attributes to perform spatial analysis (de Hoop et al., 1993). Within these map layers, overlay analysis takes place, which is one of the most powerful techniques for processing geo-information. Overlay mapping is "*a procedure that estimates the attributes of one or more features by superimposing them over other features, and figuring out the extent to which they overlap*" (Caliper, n.d.; italics in original). This indicates that multiple map layers are merged to generate one single output and create a new spatial data set (Herbei et al., 2011), which is done by comparing different geographic variables across multiple scopes. The end goal of performing spatial analysis by overlay mapping is to determine which map layer is most important and is displayed as the top layer (Herbei et al., 2011). Since overlay mapping is the main technique for performing spatial analysis, it is also highly relevant for the visualisation of geo-information for governmental

policy- and decision-making. It is for this reason that the seven visualisations we prepared have different overlays (e.g. satellite imagery, OpenStreetMaps pictographic layout, and heat maps). At the same time, as will be revealed from the discussion in Section 3, the choice of which overlay to use, which attributes to focus on and superimpose over others, also has a range of ethical consequences. Therefore, it is beneficial to gather information on how overlay mapping is perceived by stakeholders.

3.1.2 PROCESSING IMAGES OR TEXT

A study by Hahn & Berkers (2020) examined how artistic visualisations (AIVs) compare to other visual forms in communicating climate change. The study concludes that AIVs, despite their creativity, are less effective in conveying the importance of climate change than other visual methods. Similar to earlier research (O'Neill et al., 2013; O'Neill and Nicholson-Cole, 2009), the study suggests that AIVs might benefit from added clarity or supplementary descriptions, particularly for audiences without an art background, to improve their impact on public perception and engagement. In this study, they have based their designs on the encoding-decoding model of Hall (1980), which outlines a communication theory where messages are encoded by creators and decoded by audiences. According to Hall, the decoding process varies based on the audience's cultural context and experiences. This model emphasises the active role of audiences in media interpretation.

However, using imagery can also be effective in stimulating engagement. Dual-coding theory proposes that verbal and visual information are processed differently in the human mind (Paivio, 1991). It has been argued that images lead more directly to the fabrication of mental representations than text (Ganier, 2000). Mental representations have been studied in the field of cognitive science for a long time and are necessary to fathom all actions that evoke reactions from the human mind (Krcmar and Haberkorn, 2020). In light of our visualisations and decision-making, the use of imagery is highly beneficial to increase the intelligibility of the visualisations. Additionally, by looking at other visual communication research, it has been stated that images have a certain number of advantages compared to text (Dewan, 2015), namely that they are easier to recognize, process, and recall. However, Dewan does note that images and text should be used together for the most optimal result. Based on this information, it would be best to identify if text is indeed processed differently than images when looking at the visualisations and how it is perceived by different users with varying backgrounds.

3.1.3 INCLUSION OR EXCLUSION OF DETAILS

Within the field of geo-ethics, as outlined by Haarsma and Georgiadou (2017), ethical consequences surrounding privacy, accuracy, accountability, fairness and transparency are becoming increasingly prevalent (Haarsma and Georgiadou, 2017). Hence, the mapping process and gathering of information should be concerned with geo-ethical issues, yet these are widely overlooked in the current literature (Owusu et al., 2021). This absence of attention to geo-ethical issues could result in jeopardising the DUA's, such as causing stigmatisation and the risk of eviction (Gevaert et al., 2018). Therefore, it is important to perform more research on the issues raised within geo-ethics, especially in DUAs.

One such issue is the value of accuracy versus the value of truth and its relation to geo-information. According to what Tim Ingold (2021) has discussed in his work on the perception of the environment, there is a paradox at play in modern-day cartography: "The more it aims to furnish a precise and comprehensive representation of reality, the less true to life this representation appears" (Ingold, 2021, p. 242: italics in original). This paradox shows that, to present an image that is truthful and useful, an accurate visualisation will contain white lies (Monmonier, 1991). Moreover, Monmonier emphasises that inherent to the visualisation of a map are the biases of its creator. This way, a map tells only one formulation of a story and could

be used to fabricate lies. In other words, oftentimes specific details of the map are left out to make it more readable and easier to use, depending on who made the visualisation. However, according to Ingold, some critical information must not be left out since the world is full of movement and continually comes into being through the experiences of humans (Ingold, 2021). This means that maps are normally a snapshot of reality, yet Ingold argues that a map should be more focused on capturing the dynamics of life. This leads to the question of how many details should be included in a visualisation and what the consequences of this choice are - both of which will be explored in Section 3.

3.2 RESEARCH DESIGN

3.2.1 STUDY 1

We held four focus groups with 5 to 6 participants each, and the duration of these focus groups was 2 hours per session. Concerning the target group, the focus was on researchers with an affinity to geo-information technologies, policy making processes, philosophy, or visualisation techniques. During the sessions, three topics were discussed: knowledge about using geo-information for mapping DUAs, Nairobi waste management mapping and visualisation techniques, and responsible mapping.

The idea behind the first topic was to gather insights on the background knowledge of the participants regarding the topic of discussion. The purpose was to break the ice and make the participants familiar with the topic. The second topic was focused on using a tablet to explore seven visualisations of the Nairobi waste management study individually and rank them afterward. This served to gather opinions on the visualisation designs. Finally, the third topic focused on connecting the notion of responsibility with the use of specific design attributes (e.g. symbology, use of certain colours and level of detail).

3.2.2 STUDY 2

Following the initial four focus groups, we conducted a fifth focus group with the Community Mappers team that gathered the data that served as input for designing the visualisations. The purpose of this focus group was to provide the Community Mappers with the results from study 1 and also gather their feedback on some of the visualisation designs. This focus group was performed online through Microsoft Teams, as the Community Mappers were in Kenya. Concerning the target group, ten people from the Community Mappers group were asked to participate, preferably members of the survey team that gathered data in 2021.

The set-up of the focus group consisted of four topics: introduction, methodology explanation, feedback exercise, and results of the focus groups. After this introduction, the methodology of the earlier focus groups was thoroughly explained to show exactly what was done with their data. Following this, a feedback exercise was executed. This exercise was done via Google Jamboard, with a sticky note application for gathering feedback on each visualisation displayed (see for example Figure 1 below). With this exercise, the participants were asked to add green or red sticky notes to four visualisation designs. The green sticky notes concern the positive aspects of the visualisation design, and the red sticky notes concern the negative aspects. This way, a large amount of feedback was gathered in a short time frame. Finally, the results that came forward from the earlier focus groups were discussed and the participants got the opportunity to ask questions.

3.3 PARTICIPANTS

3.3.1 STUDY 1

The sample size was 22 participants, with two focus groups of five participants and two focus groups of 6 participants. This number is different between the groups due to last-minute participant cancellations because of sickness and a no-show. We gathered the participants through snowball sampling (Goodman, 1961), which indicates that participants were recruited by asking other researchers if they knew potential participants and so forth. The requirements for participation were that the participant had an affinity with geo-information, visualisation techniques, and/or policy-making. During the focus groups, we gathered several demographic factors: age, profession, and the highest level of education. The average age of the participants was 38, with a minimum age of 23 and a maximum age of 65. When looking at the professions of the participants, these can be grouped into five categories: geo-information specialists (10 participants), visualisation specialists (1 participant), philosophy specialists (2 participants), students (4 participants), and others (3 participants). For the highest level of education, each participant had completed their bachelor's degree at a university, most had completed their master's degree, and several had also completed a PhD. Regarding the ranking, two participants filled the ranking incorrectly, so those rankings could not be used. Thus, the sample for the ranking consisted of 20 participants instead of 22.

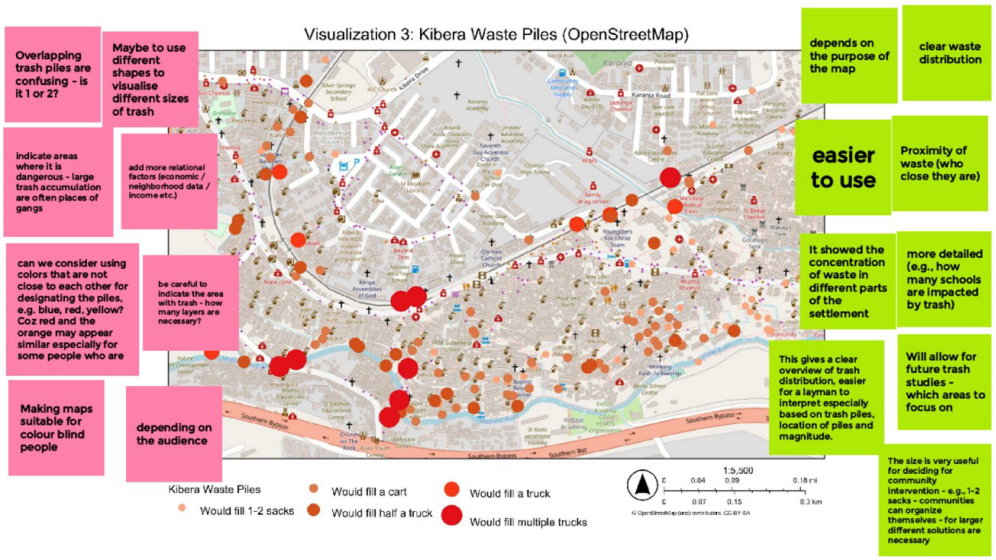

Figure 1. From the focus group with the Community Mappers, showing their feedback on visualisation three using Google Jamboard

3.3.2 STUDY 2

The participants of the fifth focus group consisted of ten members of the Community Mappers who took part in the data-gathering process of geo-information in 2021. Some of the participants were part of the mapping process in Majengo, and others in Kibera or Mathare. No other demographic factors were gathered from the participants.

3.4 PROCEDURES AND MATERIALS

3.4.1 STUDY 1

To perform these focus groups, we formulated a protocol consisting of several topics. The first topic concerned the introduction of the first two authors who conducted the workshop, the participants, the project, and an outline of the presentation. Subsequently, we asked the

participants' agreement regarding the recording of the focus group and the utilisation of its outcomes. In addition, we elaborated on relevant key definitions to get all participants on the same level of knowledge. This was followed by the first topic of discussion, which concerned knowledge of using spatial data for DUA mapping. Within this first topic, we asked the participants to write down their first ideas about this topic on post-its. This was performed to break the ice and introduce the general aim of the study to the focus group. Afterward a discussion was held on the results of the post-it exercises.

We then introduced the second topic, where we explained the background of the waste accumulation in the four DUAs and more elaborately explained the aim of the focus groups. These visualisations were designed via ArcGIS, where the geo-information that had been gathered in an Excel file by the Community Mappers was used as input. We then gave a short demonstration of navigating the visualisations and the tablets. After the demonstration, we asked the participants to rank the seven visualisations from one to seven based on three variables: the usability, readability, and accuracy of displaying the waste problem. After the participants had finalised the ranking exercise and had written down their opinions on the designs, an elaborate discussion was held on the specific visualisation and design attributes that were valued positively and negatively.

This was followed by topic three, which concerned the idea of responsible mapping and what this term entails. Here, we asked the participants which aspects they could think of when hearing the term responsible mapping and if they felt that responsibility must be an important topic when talking about DUA mapping.

We used the following materials to have fruitful focus groups. First, a conference room was needed to present the background of the waste problem and give a demonstration of the visualisations prepared. Second, all participants needed to have a tablet to explore the different visualisations. Third, basic items such as papers and pens were necessary if the participant felt the urge to write down notes for themselves. A piece of paper where the participants needed to fill in their demographic factors (i.e. name, age, research focus) and the ranking of visualisations also needed to be present. Fourth, it was beneficial for the goal of topic one to have post-it notes during the focus groups, so participants could write down elements that first came to their mind. Lastly, a recording device was necessary to generate an audio file that could be used later for the transcribing phase.

3.4.2 STUDY 2

Similarly, we formulated a protocol consisting of several topics in study 2. We began the focus group with an extensive introduction that familiarised participants with the project researchers, the project itself, and each of the participants. This introduction aimed to cultivate a comfortable and welcoming environment for the Community Mappers. Subsequently, we asked the participants' agreement regarding the recording of the focus group and the utilisation of its outcomes. We provided an overview of the focus group's discussion topics, encompassing how we used the data that had been collected in the 2021 survey, findings from study 1, and an exercise on gathering opinions regarding visualisations through Google Jamboard. Notably, there was a strong emphasis on appreciating the participants' perspectives to give back what we did with their data and to receive feedback. Participants accessed four of the visualisations via mobile links and provided constructive feedback using digital sticky notes, noting both positive and negative aspects. This exercise was based on visualisations two, three, four and five. We made the decision to focus only on four of the seven visualisations due to time constraints. Following the exercise, we had an open discussion with the participants in order to gain further explanation regarding what they had written in the digital sticky notes and any further comments or thoughts they may have had.

Since the focus group with the Community Mappers took place online, we needed different materials. We used Microsoft Teams and the Google Jamboard application, and most of the participants joined the focus group through their mobile phones. The presentation of the workshop introduction and visualisation demonstration was shown by sharing the screen during the video call. The Google Jamboard website was used to conduct the feedback exercise, which the participants joined using their mobile phones.

3.5 RESULTS

The four focus group discussions in study 1 revealed key findings regarding the use of geo-information to map DUAs. For category 1 from the code grouping, the participants showed a strong concern for understanding what deprivation meant and its impact on mapping the study areas (i.e. the four DUAs). They emphasised the need for clear definitions, avoiding generalisations, and capturing the diversity and degree of deprivation in maps. Furthermore, they highlighted the importance of ethical considerations, such as privacy and accuracy, along with the responsibility of actors in the mapping process to anticipate negative consequences.

Concerning the second category, overlay mapping was deemed essential due to the complexity of relationships and attributes involved. This indicates that many different relationships are important when looking at maps of DUAs. Moreover, the participants valued the inclusion of pictures in the map to connect with what was happening on the ground, yet they cautioned against information overload. In this way, decisions should be made on which relationships and attributes to include in the map of the DUA. Hence, tailoring the map to the context and purpose, considering interpretation issues, and assessing design choices were emphasised.

For category three, responsibility was seen as crucial in the mapping process to create problem awareness and prompt action to governmental policy- and decision-makers. More specifically, the participants indicated that different actors, including the user, designer, and data collector, have specific responsibilities in the mapping process. Again, the context and the purpose of the map were identified as key factors to prompt responsible behaviour from the map. This emphasises the diversity in many different relationships and attributes that could be integrated into the map of the deprived urban area. Yet, to generate responsible actions, decisions need to be made on what to include. Moreover, the broader responsibility of those producing the maps and socio-political context within which the maps are used was deemed important to gain insight into the environment of the mapping process. Overall, maps were recognized as powerful tools for raising awareness and accountability towards responsible actions among governmental policy- and decision-makers.

During the focus group with the Community Mappers for study 2, similar results to the focus groups from study 1 were revealed. The evaluation focused on four visualisation designs, and the Community Mappers expressed a clear preference for visualisation three. They found it useful, especially for their work, due to the additional information included on the map. Visualisation three was praised for its detail, showing waste proximity and concentration in different areas. Some participants recommended using more distinguishable colours and shapes for waste piles to accommodate various users. However, for an academic audience, visualisation five was favoured. Visualisation five was considered valuable for people who were part of the data collection process and who understood the area due to the minimal level of detail, but less effective for community communication due to its complex design. Improvements for clarity were suggested. Visualisation two received positive feedback for its professional appearance and clear representation of waste distribution. Participants suggested adding landmarks for better understanding and translating the map to Swahili for improved user interpretation. Visualisation six was seen as more suitable for academic and policy audiences than for practical use. Participants encountered interpretation issues and proposed using numbers instead of

colours for easier comprehension. Overall, the Community Mappers' feedback underscored the importance of tailoring visualisations to their target audience and incorporating relevant information for practical use and effective communication.

Theme	Description
Usability	This reflects how easy the participants could interact with the visualisations through the tablet (e.g. being able to zoom in and out)
Inclusion of pictures	Some participants commented on the importance of having pictures of the trash or residents
Proximity of waste to landmarks	A lot of remarks highlighted how showing that waste piles were around hospitals or drainage pipes would prompt more immediate actions
Colour and symbology	The use of different colours as well as symbols (e.g. using point locations of different sizes versus using a more generalised heat map)
Information level	While some visualisations were considered to lead to information overload (i.e. having too many details to comprehend) some were considered better by being more minimal and abstract
Competency of participants	The differences in ranking the visualisations stemmed partially from the different levels of competency and level of knowledge of the participants when it came to making and reading visualisations

Table 1. Summary of main recurring themes from participant responses to the visualisations

4 DISCUSSION

In this section, we further elaborate on the responses from the participants in the context of mediation theory and the hermeneutic reading of data visualisations. Data visualisations have played a recurring role in both the scientific and humanistic domains of study (Graham, 2017; de Regt, 2001; Biggs, 2002; Carusi, 2012; Carusi, 2011; Idhe and Selinger, 2004; Rossenberger, 2008; Gil, 2017; Rodigheiro & Romele, 2020; Ihde, 2020). These visualisations are "strongly related to hermeneutic relations since they represent portions of the world, and these representations must be 'read' in order to access the world" (Rodigheiro & Romele, 2020, p. 6). The reading and interpretation of these visualisations are not as straightforward as it may appear. Chalmers (2004) points out that interpretation is influenced by the content and context

of what is uttered or observed, as well as by “the individual’s pre-understanding or prejudice” of what they are interpreting and experiencing (Chalmers, 2004, p. 211). Chalmers illustrates this by comparing how researchers in the physical and social sciences represent and interpret what they study. When researchers aim to be objective or scientifically rigorous, they focus on “distanciation” and not on the situation or individuals involved. This leads to findings that are “dissociated from intention, and only displays universally shared references'' (Chalmers, 2004, p. 213). This is the kind of ‘sight’ that the physical sciences prefer, while the social sciences look to “de-emphasise distanciation” and focus on the situational and contextual aspects (ibid). Focusing on objectivity reflects “the gold standard” of scientific investigation, i.e. the numerical investigation of patterns which promises “a view from nowhere, undistorted by the inevitable cognitive limitations of individual people, or of groups of people'' (Carusi, 2012, p. 110).

Rossenberger (2008) refers to this act of distanciation as the “transformation” of the phenomena of interest into a form that can be studied. The different overlays and attributes in each visualisation used in the focus groups, transform the four DUAs from living environments into a multi-layered representation that the participants can manipulate. And the ‘reading’ of these visualisations is informed by the “hermeneutic strategy” of the individuals doing the reading, i.e. the way features of the visualisations are attended to and explained in a meaningful manner (Rossenberger, 2008, p. 65). However, data visualisations blur this seemingly clear distinction between objective and subjective, as well as quantitative and qualitative. Friis (2015) makes the assertion that the “information obtained through technological mediations is not pure” (Friis, 2015, p.215) due to many factors that interplay in the interpretation of the information that is produced from these mediations. In our case, the process of collecting spatial data, who is involved in this process, the transformation of the data into information, the background and context of those interpreting the visualisations - each contribute to a movement between quantitative and qualitative, as well as objective and subjective ‘seeing’ and ‘reading’. In this section, we show how data visualisations operate as “epistemology engines” by serving as a “material-semiotic link between embodied practice and technology” (Ihde and Selinger, 2004, p. 363).

4.1. HERMENEUTICS OF VISUALISATION READING

4.1.1. ZOOMING IN AND OUT OF THE PROBLEM

One of the first points of discussion was the capacity of the tablets we provided to the participants in Study 1 to help them better navigate and interact with the visualisations we prepared. The tablets allowed the participants to change the tabs on the web browser themselves to select the visualisations, zoom in and out of each visualisation, and select different layers in the visualisations. For instance, as one participant mentioned when referring to the heat map (Figure 2 and 3), “when it zoomed out, it looks like entire areas is trash and I don’t like that at all… [whereas] when I zoomed in and at least I could see individual points, I felt a bit better” (Participant 5, Workshop One transcript).

From this response, we observed how the manner in which an object of study is transformed can elicit reactions that may either be planned for or unplanned for. The participants expressed that the way the DUA was transformed by the heat map overlay was far more disturbing than they would have liked. This interpretation could be positively considered as prompting more immediate action, but could also be considered negatively as it makes the DUA appear beyond any possible help. As another participant noted, they found the heat map “super problematic… [as] it created this idea that this entire place is on fire” (Participant 10, Workshop Two transcript). This interpretation of the entire DUA being “on fire” could make it appear as though

the problem is beyond any chance of being rectified, which is not the goal or interpretation which the visualisation is meant to elicit.

Figure 2 and 3. Visualisation six, heat map overlay of the Kibera DUA. (Top) Zoomed out and (Bottom) zoomed in towards the North West of the DUA. Yellow colour represents the higher volume of waste and red the smaller volume. When zoomed out, the entire DUA appears highly concentrated with waste. But zooming in shows far more spread of waste.

This more negative conception, however, was not only produced from the heat map visualisation. As another participant mentioned: "[when] I zoom in on the satellite [visualisation], I see the specific house and I see the dot [i.e. waste pile]. And for me, maybe it connects to the people living there more… like, okay, and that's by your house. Like take care of it, which is not maybe what you want" (Participant 22, Workshop Four transcript). This participant alluded to correlating the proximity of the waste to particular houses as the fault of residents themselves, instead of the lack of municipal waste collection services. The use of the satellite as an overlay in this visualisation (see Figure 10) therefore presented a transformation of the DUA that we had not foreseen, namely, rather than to improve the conditions of the communities, the visualisation could be used to blame them for the condition they are in. But this also shows how certain interpretations and actions can be enabled (or impeded) from the ability to zoom in and out of the visualisations. For instance, as another participant pointed out:

"if you zoom in and you see that you have a data point and it says that this trash would fit into a truck and I would trust your judgement about how much waste it is and I would want to send a truck… Then I could look at the road" (Participant 7, Workshop Two transcript). The satellite overlay from visualisation seven (see Figure 10) in this case was considered quite positive, as it allowed more accurately locating where the waste is along with identifying the closest road networks, in order to plan a potential intervention.

4.1.2 INCLUSION OF PICTURES

For one of the visualisations we showed to the participants, we decided to make use of an overlay using Microsoft's Building Footprints data of the building density in Kenya and for each data point where a waste pile was, to include a picture. The pictures of the waste piles were captured by the Community Mappers team during the survey in 2021. An example of this can be seen in Figure 4 below, where the purple polygon shapes are projections from the housing data on which the algorithm used by Microsoft was trained. Though not used in the focus group, Figure 5 below illustrates the discrepancy between the Building Footprints data and the housing density on a satellite image. As can be observed when looking closely at Figure 5, many of the polygons are squashed together and in some cases this may fit with the building density in Kariobangi, but in some cases the data does not present a fully accurate representation. As one participant noted:

> What I really liked about visualisation one, for example, even though I put it on place three, was that you added the pictures. So, I think if pictures are in most of the designs, it would already give you some form of information about how reliable this dot is on the map in comparison to what the actual situation is on that location with the picture, for example. (Participant 8, Workshop Two transcript)

By "place three", the participant means they did not rate the visualisation very highly in terms of overall design and the accuracy of showing the problem of waste. Despite this, the inclusion of the pictures for each data point was of great value to them, in terms of increasing the reliability of the visual information they could gain from the map.

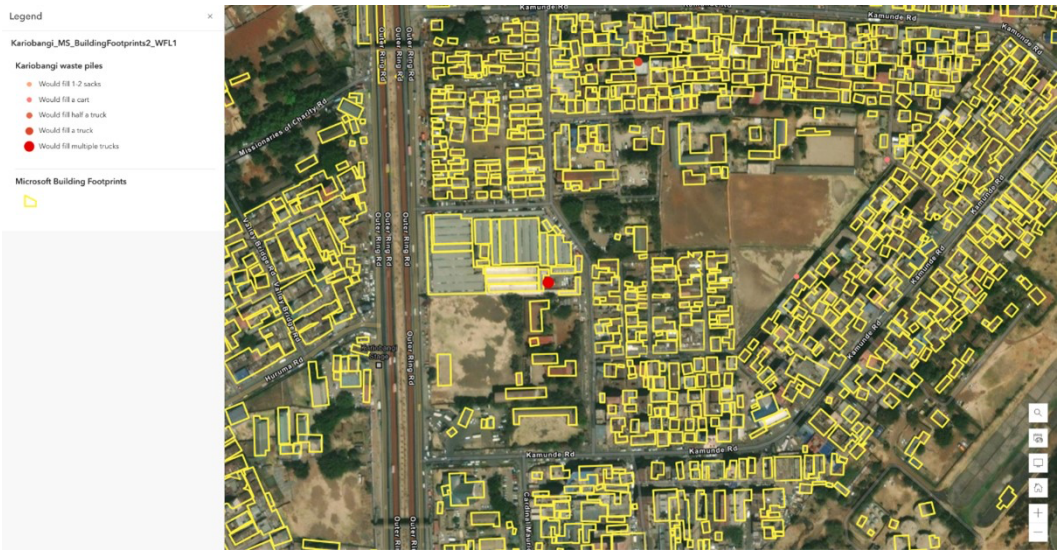

Figure 4 and 5. Snapshot of visualisation one of Kariobangi DUA. (Top) Purple polygons are from Microsoft's Building Footprints, red dots in varying sizes are the waste piles. (Bottom) The same area, but with a satellite overlay and the polygons are yellow rectangles to illustrate the inaccuracy of Microsoft's data in some parts of the DUA (e.g. some polygons show housing in areas of greenery and sand/dirt).

This sentiment of the picture rendering the problem of waste more accurately than the visualisation itself was also stated by another participant. This participant commented:

> But I mean, for me, in terms of usability, and you said that what I'm supposed to recognize is that there is a problem with waste. Then I don't need the map. I need a slideshow of the pictures. So, if I'm not supposed to go and collect that waste, all I need is a slideshow of those pictures, maybe counterposed with a slideshow of smiling people to make sure things don't get stigmatised. (Participant 10, Workshop Two transcript)

The purpose of only including the pictures in visualisation one was to weigh their value in contrast to the other overlay styles, but for this participant it was clear the pictures held the most value in terms of generating awareness of the waste problem. Moreover, the statement of including pictures of "smiling people to make sure things don't get stigmatised" also refers back to the participant above who remarked that seeing the proximity of the waste to buildings threw the responsibility of the accumulation to the residents themselves. There is also the competing immediacy of the visualisation using dots to show where the waste piles are and the pictures showing the waste piles themselves. As another participant pointed out, "I think the image adds a lot, that it really kind of illustrates the urgency of the problem, because otherwise you're just looking at the dots on the map… But then you click on it and it really hits you with reality" (Participant 22, Workshop Four transcript). In hermeneutic terms, the pictures operate "in a [far more explicit] causal relation with that which is depicted" whereas dots or other symbols operate "in an informational mode with respect to what is depicted" (Carusi, 2012, p. 108-109). The inclusion of the pictures shifts the perspective of the waste problem from a quantitative issue (i.e., this is how much trash there is here) to a qualitative issue (i.e., this is how the people living here experience the trash), as the trash is pictured overflowing in canals, blocking pathways, and clustered between houses. As such, while the use of dots and other forms of quantitatively displaying the waste (e.g., with the heatmap) present a generalised or aggregated representation, the pictures show the particular manner in which the waste is distributed and experienced at each data point. In the words of Chalmers (2014), the use of

pictures reduces the distanciation between the participants reading the visualisation and the problem being visualised, by adding situational and contextual awareness of the waste problem.

4.1.3 PROXIMITY TO LANDMARKS

Similarly, the participants also pointed out the importance of considering what the waste piles were close to. As one participant commented, "[what] I liked about visualisations three and maybe it was four … I like that it could show the relationship between the waste piles and sort of other important sites of everyday life, right?" (Participant 5, Workshop One transcript). By "important sites of everyday life" they are referring to churches, libraries and hospitals. These sites are illustrated in Figure 6 below, where we used an overlay consisting of baselayer data from OpenStreetMap which includes the road networks as well as symbols for particular landmarks. The symbols of churches, hospitals, rivers and railways emphasise that waste accumulation occupies regions of the DUA that heavily impedes not only the daily lives of residents but also creates environmental and health related concerns. Showing these icons was considered by participants quite instrumental in raising awareness of the problem. As one participant mentioned, displaying the hospitals and churches "makes it maybe easier for the solution aspect…[prompting] first focus on solving the waste piles at hospitals" (Participant 19, Workshop Four transcript).

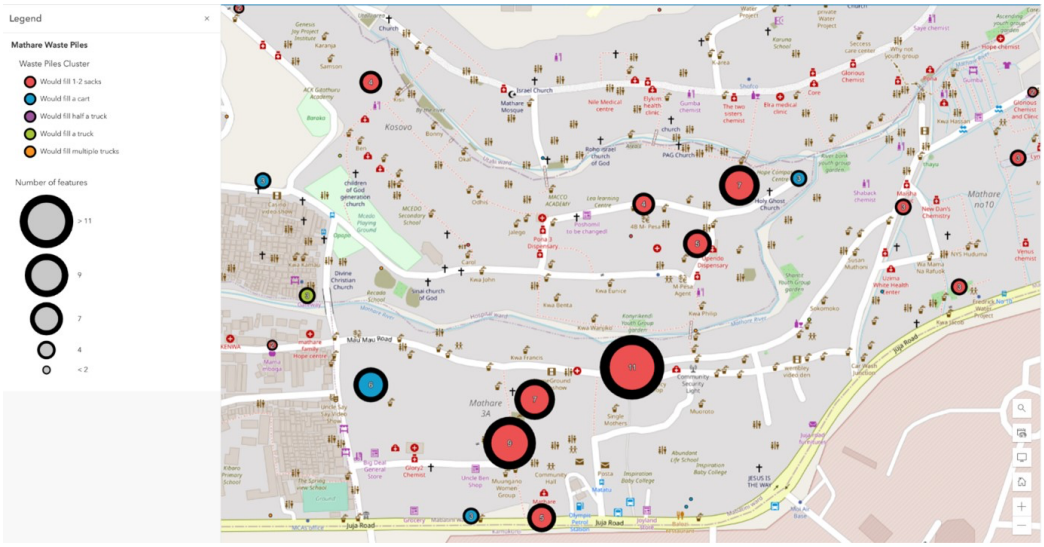

Figure 6. Visualisation four showing waste accumulation in Mathare DUA. The background base layer including landmark information is from OpenStreetMap.

Being able to plan interventions using landmarks was also pointed out by another participant, in reference to visualisation two (see Figure 7 below). This participant stated "I wanted to write that as much as [the visualisation is] clear, it's also not indicating, for example, if it's close to a river or if it's close to a railway line or if it's close along a road" (Participant 26, Community Mappers transcript). In this case, while the visualisation is praised for its clarity in showing the distribution of waste, if it were the only available visualisation that could be used for planning an intervention it would not be very helpful due to the lack of landmarks displayed. Thus, knowing which roads can be used (since road names can be seen) is not enough, since it is also necessary to know what landmarks can be encountered that may impede or warrant more resources in making an intervention.

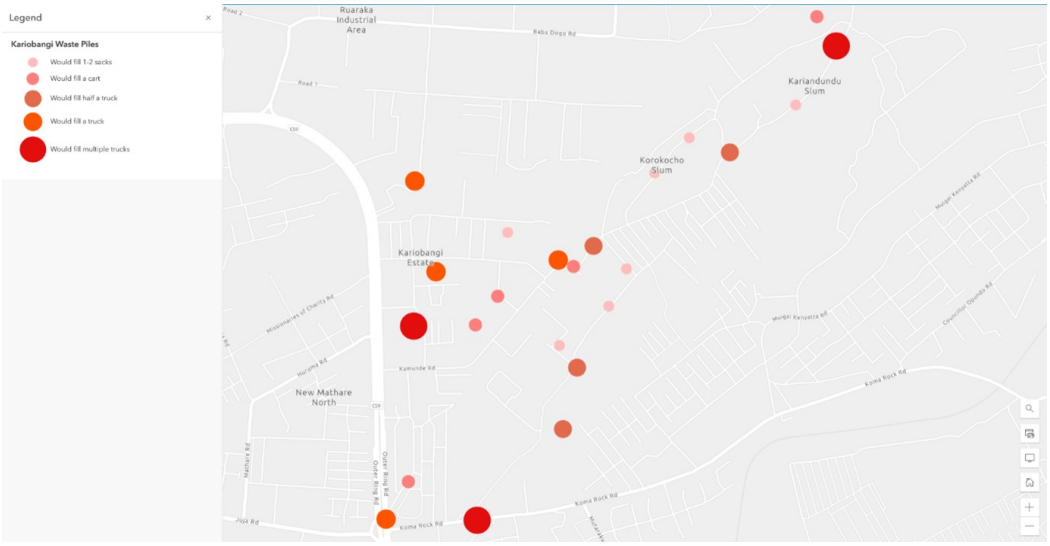

Figure 7. Visualisation two showing waste accumulation in Kariobangi. The grey base layer was chosen to test the impact of having a minimalist and more abstract representation of the DUA.

4.1.4 COLOUR AND SYMBOLOGY

The choice of different colours and symbols to represent the waste piles was also important to the participants. As one participant mentioned, they rated visualisation four (see Figure 6) the highest because "the numbers in the circles were very nice to see as a sort of a quantified metric of how much [waste] is in that area" (Participant 8, Workshop Two transcript). At the same time, another participant had an inverse response, ranking visualisation four poorly. They state "[waste is] a continuous variable but now it's visualised as a nominal variable with different colours. That doesn't work in my head because there is [supposed to be] an order in it, but now it becomes different symbols" (Participant 11, Workshop 2 transcript). These two opposing hermeneutic strategies - one focused on the quantification of waste aesthetically (i.e. clarity), the other on quantification in terms of best measurement - highlight how the same visualisation can have very contrary reactions and interpretations, which in this case is highly reflective of the particular pre-judgement and prejudices of each participant. Emphasised by the point that the symbols chosen "doesn't work in my head" as stated by Participant 11. Another concern raised by participants was the fact that certain audiences may be colour blind, which would mean choosing colour palettes that bear this in mind. As one participant noted, speaking of visualisation three (see Figure 8 below): "if you present the map, uh, they might tell you [the waste pile points are] the same. And for you, you're seeing different colours for them, they are not seeing the different colours. So I'm just thinking maybe we could use primary colours that are a bit distinct" (Participant 26, Community Mappers transcript).

These remarks made it clear that it was important to select the right kind of colours and symbols in relation to who the map was to be presented to. However, they also reflected that not all participants would be encountering the same map. As Hutchby (2001) comments, "objects and their values can also be tied in with complex sets of concepts and conventional rules governing their use" (Hutchby, 2001, p. 448). Concepts and conventional uses here, such as using red and yellow to indicate danger or priority (e.g. the heatmap), or having a gradient of colours (e.g. using varying shades of red and orange in Figure 8 compared to a more arbitrary colour gradient in Figure 6). These choices of colour and symbols had a clear impact on how the information of the visualisations was read, and the contrary interpretations reflected the need to factor in the differences in the competency or biases of the audience interpreting the information.

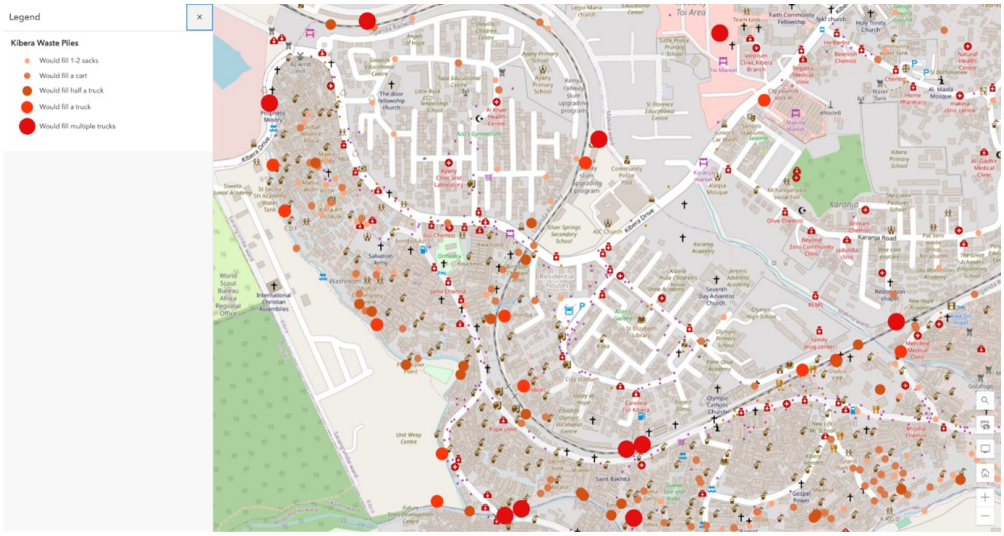

Figure 8. Visualisation three: Showing waste accumulation in North West of Kibera DUA.

4.1.5 INFORMATION LOAD AND COMPETENCY

Additionally, some participants commented on issues they had with certain visualisations because they led to information overload. For example, one participant stated: "I think the maps with satellite data… I found them the least usable and readable, because there's information overload, especially like all the tiny details are there" (Participant 9, Workshop Two transcript). As another participant also stated, they liked visualisation six (see Figure 9 below) the least "because I found it very overwhelming and hard to read and it felt like this whole area is a problem. How do we even approach fixing this?" (Participant 22, Workshop Four transcript). While participants from the CM focus group mentioned that visualisation six was difficult to interpret for a non-academic audience, as well as pointing out that perhaps the distribution would be better represented as percentage values to better illustrate the magnitude of the problem (See Figure 9 below with comments from participants via Google Jamboard).

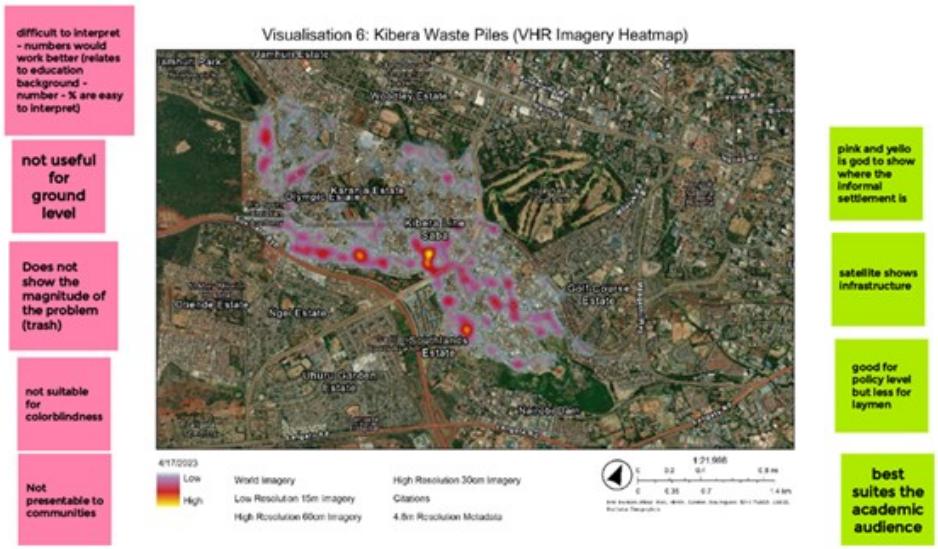

Figure 9. Visualisation six with notes from the CM focus group. Pink notes indicate negative remarks and green notes indicate positive remarks.

These responses highlight the fact that communicating something is not always a clear and linear path. Even though visualisations exemplify the kind of "hermeneutic technologies" that "have the capacity of minimising the distance between the world and its representations" (Romele, 2020, p. 18), this does not mean the representations can always be understood immediately. The communicative ability and interpretation of the visualisations depend on a number of factors. As framed by Borgmann (1999) these include: i) being "informed by" the visualisations depends on the person receiving the information (i.e. their intelligence or competency), ii) the medium used to convey the information (i.e. the sign or medium for communication), and iii) the context they are in (Borgmann, 1999, p. 22). This process, beginning with the spatial data and ending with its communication to a recipient as information, is described by Turilli and Floridi (2009) as "semanticization". Which is the "result of a set of operations performed by an agent taking raw data as input and producing well-informed, meaningful and truthful data (that is, information) as output" (Turilli & Floridi, 2009, p. 108).

However, the extent to which the information is "well-informed", "meaningful", and "truthful" for planning interventions in the DUAs depends on a number of factors. These factors include who is involved in the gathering of the raw data (i.e. their competencies, background and intention), what audience is receiving the information (what are their competencies, background and intention), and whether the information can mediate or inhibit actions that help those living in the DUAs. These factors were also highlighted by the participants from the focus groups. One participant considered the heat map a useful visualisation choice due to its ability to "convince easily because you really see that there is a huge problem" but also pointing out that convincing or prompting action depended on "what you really want to communicate, in which context it's going to be used and if it actually is a fair representation" (Participant 14, Workshop Three Transcript). This dependence reveals that one of the reasons communication of the information represented can be disturbed or broken down is if there are different "frames of reference or contexts used by sender and receiver in the communications process" (Introna, 1993, p. 172). Thus, what may be informative and meaningful for one audience may not have the same utility for another audience. These remarks highlight that it is not simply a question of making the visualisation accurately represent the waste problem, since the very notion of 'accuracy' depends on the audience, context and content of the visualisation.

4.2 RESPONSIBILITY

Another dimension that was explored in our focus groups was the ethical consequences that the participants highlighted arising from the choice of attributes. Such consequences arise from the fact that these attributes can either enable or inhibit certain actions and decisions to remedy the waste problem. Gil (2017) points out how visualisations are particularly useful thinking tools as they hold "the promise of transforming abstract issues into graspable images and translating the unseen into intelligible and actionable form" (Gil, 2017, 310). Similar to Ihde and Selinger's (2004) notion of epistemic engines, the technological design and use of the seven visualisations inspires theorising about the technologies used and the representation of the waste problem. As some of the participants expressed, the visualisations used in the focus groups can also delegate blame and responsibility to either the map designers, the communities themselves or the municipal authorities that have jurisdiction over the DUAs. This echoes Verbeek's (2008) contention that technologies can influence our moral agency and freedom as they "help to shape human actions, interpretations, and decisions, which would have been different without" these technologies (Verbeek, 2008, p. 95). Consequently, beyond analysing the "interpretive mechanism" (Friis, 2015) of visualisation reading, during the focus groups we also asked the participants about the notion of responsibility in the mapping of DUAs.

First, there were comments concerning responsibility in terms of utility and the audience for which the visualisations were prepared. As one participant noted, there is a need to be "responsible towards the audience that you are mapping. But also, if you make a map, you have some responsibility to the ones that are using the map for their daily work." (Participant 2, Workshop One transcript). The initial point, regarding "the audience that you are mapping", refers to the communities in the DUAs. These communities are not always involved in the mapping process, whether at the beginning when the data are gathered or at the end when the final map is produced. Therefore, this reduces any inclusion of their feedback or criticism regarding the mapping process, which is worsened by the potential of the final map product to contain biases (e.g. focusing on representing larger DUAs and leaving smaller DUAs invisible), inaccuracies (e.g. representing areas as DUAs that may not be) or invade their privacy (e.g. using drone imagery can show more of the lived experience of communities compared to satellite imagery) (Oluoch et al, 2022). On the other hand, it is also important to consider that the visualisations will be used by those on the ground who may be enacting interventions in these communities. As mentioned above, the choice of landmarks, colours, symbols and interactivity (e.g. zooming in and out) affect how well interventions can be planned. This therefore means these choices not only affect the aesthetics of the visualisation but can also impede or mediate actions to improve the living conditions of communities in the DUAs.

Depending on which overlay is used and which attributes are present, the role of certain actors may be more important in remedying the issues being represented. This was mentioned with particular reference to visualisation seven (Figure 10 below):

> I think it's good that you have a certain border which makes a certain area responsible. If, for example, this is a district and a district council has a responsibility for it… And as politicians usually have the urge to not do anything about things that are not in their specific area. (Participant 19, Workshop Four transcript)

The boundary drawn around the Majengo DUA (red line) in Figure 10 is used for illustrative purposes to see what impact would have on the participants. Having exact boundaries of any DUA is always a contested process. Such boundaries are usually used in humanitarian mapping to show the physical extent of a DUA, in consultation with either communities living in the area or non-governmental organisations (NGOs) representing the communities or municipal authorities. These boundary lines are not always easily agreed upon, but the remark from the participant is quite informative about how such boundaries can play a role in delegating responsibility. Specifically, delegating the responsibility of improving the conditions of communities living within these boundaries to municipal authorities.

Similarly, the participants raised the point that map designers also held responsibility in what was included or excluded from the visualisations. This is especially relevant if we consider the relationship between the spatial data, the map designer and the audience of the resulting map. This relationship can be schematised linearly as:

spatial data → map designer → visualisation → map reader

Or in the classical hermeneutic relations schema as:

map reader → (visualisation-world)

This linearity excludes any back-and-forth between what the map designer puts on the visualisation and how the map reader may respond to the map. It also assumes a singular map reader (where there may instead be a plurality) without referencing the background of the reader(s), as well as in what situation and context the map is being read. On the other hand, we can consider a more iterative mapping process that involves: i) spatial data gathering, ii) the

map designer using the data to produce visualisations, iii) the map reader(s) reading the visualisations, iv) the map reader(s) providing feedback and criticisms that influence the map designer in how to adapt the visualisations, and v) this interaction then looping back on itself a number of times. This iterative engagement showcases how the "hermeneutic circle of the 'reader' must always be paired with the circle of the designer" (Rodighiero and Romele, 2020, p. 14). The "hermeneutic circle" refers to the notion that the 'part' cannot be understood without the whole, and the whole cannot be understood without the understanding of its constituent parts (Rorty, 1979, p. 319). In the context of this paper, this notion contends that the seven visualisations prepared cannot be fully understood without understanding the waste problem as a whole. Yet at the same time, the waste problem as a whole cannot be understood without understanding the visualisations of the waste problem, the relationship between communities living in DUAs and municipal authorities, the relationship between researchers (who are typically map designers) and these communities, and other constituent aspects of the waste problem.

Figure 10: visualisation seven: Showing the waste accumulation in the Majengo DUA. The red line represents a boundary for the physical extent (or border) of the DUA, for illustrative purposes and is not the actual physical extent.

However, such an iterative design process assumes that there is close engagement between the designer and reader(s) of the visualisations, as well as begging the question: who is the accompanying reader in this "double hermeneutic circle" (ibid)? Is it the communities within DUAs (who we engage with in Study 2), or municipal authorities, or fellow researchers (who we engage with in Study 1), or NGOs? In most of the literature on mapping these areas, it is often one or two of these readers that are engaged in the design of such visualisations (Leonita et al, 2018; Thomson et al, 2020; Owusu et al, 2021). Which therefore influences who has access to the mapping process and who influences the final map products. As one participant (who works as a professional cartographer) mentioned:

> When I think about this responsible mapping it means that the onus on the map maker is to think about things like possible and likely consequences of publishing such a map. For example, if you map deprived urban areas, are you really just giving some aggressively classist government a map of where to go find the people it wants to persecute? Or are you empowering those people or are you stripping them of anonymity? (Participant 18, Workshop Four Transcript)

The first concern raised here is quite salient because in many cases, DUAs and the communities living within them are not always considered to be part of the cities they are in (Brito et al, 2020). For this reason, these communities face far less protections than ordinary citizens, which means that increasing their visibility in visualisations and maps could contribute to further marginalisation and exclusionary actions against them. Additionally, the second concern - of empowering rather than endangering these communities - depends especially on whether there is engagement between map designers and the communities being mapped. Having this engagement can help include more local context into the visualisations. As one participant in the CM focus group mentioned, "indicating the hotspot [is important] because we find the trash is associated with criminality" such as "the railway line and around the river somewhere, you might find criminal activities happening there" (Participant 23, Community Mappers Workshop transcript). This added context can be useful to guide both waste collection services and law enforcement authorities, but can only be added if communities are also involved in how such spatial data are represented. Thus, the design process involves additional ethical questions concerning: the level of inclusion, potential for further stigmatisation, responsibility on the part of map designers (in acquiring the spatial data and map design) and municipal authorities, as well as any protections that may need to be put in place on who can access or make use of the final map product to protect the communities being mapped.

Moreover, if we follow the framing of freedom as "the existential space human beings have within which to realise their existence" (Verbeek, 2008, p. 98), then geo-information is an important tool through which this space can be navigated as well as hermeneutically understood. The kind of information that is displayed, and who has access to the visualisations, affects the range of freedom to both navigate and understand this space. Data visualisations can be tools for "informational nudging", and the attributes included or excluded "changes the nature of information to which an agent is exposed [to] in order to obtain a goal" (Floridi, 2016, p. 1677). The different attributes explored in Section 3.1. shape the "informational environment" (ibid, p. 1680) to which the reader of the seven visualisations is exposed, thereby influencing the choices to be made. Kiran (2015) refers to this as the capacity for technologies to either enable or constrain certain behaviours and actions. While technologies enable us to behave and act in certain ways, they "simultaneously shape how we do these things, and thereby divert our attention from other possible ways" of behaving and acting (Kiran, 2015, p. 131). Reflecting on this informational environment and how it enables or constrains certain behaviours and actions, can also inform designing visualisations that are "pro-ethical" (Floridi, 2016). That is, can the visualisations provide a range of choices without undermining the agency of those reading the visualisations?

For instance, the use of a heat map can lead to the observation that there is a serious problem within the DUAs, and prompt more expedient intervention. This would go further than just curating the information for those viewing the visualisations. However, this depends on the hermeneutic strategy of the reader, as some participants felt overwhelmed rather than motivated to act. Likewise, having the waste visualised in numerical concentrations (e.g. in Figure 6) may lead to more resources being sent to those areas represented with the highest concentrations. But if there is underreporting or a lack of data in the visualisation, areas that may need intervention are left ignored. Map designers would be responsible for not making explicit that there may be data gaps in the final map product. In contrast, showing the landmarks (e.g., schools, churches and rivers) as in Figure 8 can foster deliberation as it is up to those using the visualisation to decide which landmarks are most important, as there is no explicit priority in the visualisation itself. Due to differing hermeneutic strategies and frames of reference, map readers will weigh the landmarks differently without direct influence from map designers. This deliberation would be an instance of a more pro-ethical form of informational

nudging, as it merely curates information and provides a range of choices, thereby allowing those reading the visualisation to decide for themselves where to go.

5 CONCLUSION

The insights provided by the participants from the focus groups reveal the value and role of geo-information in planning for interventions. These insights show that a visualisation being readable or understandable is a layered process that is affected by what is on the visualisation, who is doing the reading, and the context in which the visualisation is used. This process is further complicated by the different hermeneutic strategies that those interacting with the visualisations may utilise, as the hermeneutic strategies they employ lead to agreements or disagreements on how the information represented is interpreted. Rossenberger (2008) states that conversations between individuals may change their hermeneutic strategies until they coalesce, but in our focus groups this was not always the case. Some participants expressed solidarity in their interpretations of certain attributes and ranking of visualisations, while others maintained contrary interpretations throughout the sessions. This solidarity was based on shared frames of reference (e.g. if two or more worked in human geography, research in DUAs or cartography) and therefore these participants focused on similar aspects of the visualisations. Reflecting that understanding is initially guided by what individuals are interested in (Dilthey & Jameson, 1972), and is influenced by the factors outlined in Section 3.1. At the same time, all the focus groups emphasised the power of the visualisations in creating certain perceptions of the residents in the DUAs as well as the responsibility of those designing and using the visualisations. This emphasis illustrates that while the technical aspects of designing visualisations are important (e.g. symbology, colour, using certain metrics or scales), there should also be equal attention given to the broader impacts that stem from the design and use of the visualisations. Impacts that can only be better considered through greater iterative rather than linear engagement between map designers, the communities living in the DUAs and other prospective readers of the visualisations that can empower rather than endanger these communities.

Data Access Statement

Data supporting this study are openly available from (4TU.Research Data) at (10.4121/33a20e92-61ec-4203-9787-50ec1efe8617).

Contributor Statement

The first and second authors wrote the majority of the text - the second author conducted the coding of data from the workshops - the third and fourth authors gathered the location data that was used as input for the workshops. Data collection was done by CommunityMappers in collaboration with Dana R. Thomson (IDEAMAPS) and Monika Kuffer (Account/SLUMAP).

Use of AI

During the preparation of this work, the author(s) used AmberScript to transcribe the audio files of the focus groups. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

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Conflict of Interest Statement

There is no conflict of interest.

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